Overall, I find this chapter to be well-written and balanced, sufficiently underpinned with recent research. [Jasem Kemper, United Kingdom (of Great Britain and Northern Ireland)]

Thank you.

Point of clarification: aspects of feasibility are part of Chapter 4 and hence not included in Chapter 2. They are brought together, though, in the SPM.

Major comment on the whole chapter. Given that cities/urbanisation is one of the cross-chapter linking elements in this SR (and will be an area of particular attention in the main assessment report) it seems that more emphasis should be placed on highlighting the different SSP urbanisation projections and how these may or may not influence possible mitigation pathways and options. This is critical as cities will be a key entry point for practitioners and policy makers seeking to drive transformative change in pursuit of 1.5°C and will allow for a more comprehensive narrative to be developed in the SR. [Debra Roberts, South Africa]

Table 2.2. in the chapter context. Many figures show radiative forcing targets but the table does not relate temperature targets to forcing targets. The reader gets easily lost. [Nicola Bauer, Germany]

Taken into account. Both are important in various places as each is relevant but these are not the same. We emphasize temperature where practical.

At least one scenario that avoids an overshoot of temperature goals and CDR should be explored. Perhaps including differentiation between various CDR options. Given the major human rights implications between the scenarios. Several studies exist for a non-overshoot non CDM options. Miller, R. J., Fuglevedt, J. S., Friedrichsen, P., Rogelj, J., Grubb, M. J., Matthews, R. O., … Allen, M. R. (2017). Emission budgets and pathways consistent with limiting warming to 1.5°C. Nature Geosci, advance online publication. Retrieved from http://dx.doi.org/10.1038/ngeo3031 [Aki Kachi, Germany]

The chapter has been revised to consider non-overshoot scenarios in response to several reviewer comments. As noted in the response to other comments, sustainable development issues are treated in ch 5 but not considered directly in ch 2

Table 2.1. in the chapter context. The scenario is being used in the sense of pathways highlighted in Chapter 1. [Silvia Serrao-Neumann, Australia]

Feasibility - real-world scalability of mitigation measures is part of the Chapter 4 assessment.

The pressure and impact of energy crops on agriculture and forest exploitation can be strongly reduced by using technologies for enhanced biol fuel production. 300 EJ biomas could be replaced by only 120 EJ biomass + 100 EJ electricity for producing the same amount of approx. 100 EJ second generation biocell. The required 100 EJ electricity could be an additional way to store electricity from intermittent wind or solar electricity (with 50% energy yield) and/or could be produced from nuclear plants. Reference: Sauer, J.M., Hotzl, H., Imbach, J., Luciani, J.F. Technical and economical assessment of enhanced biomas to liquid fuels processes. Energy 35 (2010) 3587-3592 [Jean Marie Sauer, France]

The lack of transparency, and insufficient treatment of cost-benefit calculations incorporated into the IAMs on which the report is fundamentally based is unacceptable, and serves only to obfuscate and misguide policymakers who struggle to grasp the implications of models and scenarios. The importance of novel (cost, benefits, costs, trade-offs) on sustainable development are explicitly treated in Ch. 2. Chapter 2 does not assess the literature on cost-benefit IAMs.

The results of Millar et al, 2017: https://doi.org/10.1038/ngeo3031 need to be included in the next iteration. [ZACEK; PISKOU et, Poland] Agreed - this is now referenced

We believe we have harmonized these usages.

The near to midterm timeline is far more critical as guidance to addressing mitigation in the coming 5 year timeframe. [Uli Fuhr, Germany]

Noted

The question of the feasibility of soil conversion, for instance: from pasture to energy crops, is not discussed. Quality of soils and pluviosity may not be compatible with such conversion, particularly if elevated yields are expected. [Jean Marie Sauer, France]

Feasibility - real-world scalability of mitigation measures is part of the Chapter 4 assessment.

The executive summary needs to be simplified in a way that is usable by policymakers. [Carlos Garcia Soto, Spain]

Accepted - we hope the SOD ES is more accessible now and that the SPM is even better

The results of Millar et al, 2017: https://doi.org/10.1038/ngeo3031 need to be included in the next iteration. [ZACEK; PISKOU et, Poland]

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Accepted - we hope the SOD ES is more accessible now and that the SPM is even better

The entire chapter: MUCH too less discussion on the DACCS option. BECCS is nowadays known as a poor option, therefore more highlighting on DACCS is required in the entire chapter. [Christian Breyer, Finland]

Our chapter length matched that requested. We have tried to avoid duplication as much as possible so please read the SOD

The entire chapter: MUCH too less discussion on the DACCS option. BECCS is nowadays known as a poor option, therefore more highlighting on DACCS is required in the entire chapter. [Christian Breyer, Finland]

Rejected - DACS is not typically part of integrated pathway assessments. We highlight this gap, but do not streamline DACS in the entire chapter.
I would like a more detailed discussion of the way integrated assessment models operate, with the aim of stating why BECCS is the only carbon policy making. [Lili Fuhr, Germany]

The notation used for TCREE values (e.g. 1.8 ºC per 3660 GtCO2) is absurd. I think I understand what you were trying to do, preserve the numbers from the conventional units of K/EG C while changing the units for CO2 to GtCO2 for consistency with the policy side of the chapter. To someone who does not know that 3660 GtCO2 = 1000 Pg C the units for TCREE are going to be incomprehensible. I think the least-worst solution is to change to °C per 1000 GtCO2 (0.44 ºC per 1000 GtCO2). [Maddock, Andrew, Canada]

The global warming in 2016 was more than 1 degree. This chapter should provide to reach 1.5°C global warming for the earliest year and latest year clearly responded to various scenarios and pathways, especially in the summary. [Zong-Qi Zhan, China]

I would like a more detailed discussion of the way integrated assessment models operate, with the aim of stating why BECCS is the only carbon policy making. [Lili Fuhr, Germany]

Thank you for completing this very interesting FOD. I think that an important aspect for this chapter is to showcase the difficulties that needs to be overcome in order to follow a 1.5°C path, taking care that the challenges at the social, institutional and policy-making levels should not be underestimated (linking with other chapters). In particular, the consequences of the fact that no or very few models could produce a 1.5°C scenario in the context of the SDP (and some others) is an indication that substantial progress towards sustainability may not be an option but is a key requirement. If so, then it means that the challenges of 1.5°C include those associated with substantial progress towards sustainability, in addition to the challenges associated to a high rate of decarbonization. A more complete assessment of the limits of "green growth" could also be needed (potential relevant papers: Körting et al., climate policy 2016, http://dx.doi.org/10.1080/14693062.2014.999224 and Gazalh et al., Journal of cleaner production 2016, http://dx.doi.org/10.1016/j.jclepro.2016.04.032) [Philippe Martinis, Belgium]

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Agreed, we've added more discussion of socio-economic trends that lead to models being unable to produce scenarios consistent with 1.5C [Sven Harmeling, Germany]

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The fact that FOD Chapter 2 only includes pathways involving overshooting 1.5°C scenario, although only such pathways significantly reduce the risks and impacts of climate change, as mandated by the Paris Agreement. [Penny Urquhart, South Africa]

If so, then it means that the challenges of 1.5°C include those associated with substantial progress towards sustainability, in addition to the challenges associated to a high rate of decarbonization. A more complete assessment of the limits of "green growth" could also be needed [potential relevant papers: Körting et al., climate policy 2016, http://dx.doi.org/10.1080/14693062.2014.999224 and Gazalh et al., Journal of cleaner production 2016, http://dx.doi.org/10.1016/j.jclepro.2016.04.032] [Philippe Martinis, Belgium]

The fact that FOD Chapter 2 only includes pathways involving overshooting 1.5°C scenario, although only such pathways significantly reduce the risks and impacts of climate change, as mandated by the Paris Agreement. [Penny Urquhart, South Africa]

Historically, despite the strong guidance deriving from the Paris Agreement and the approved outline for the Special Report, Chapter 2 fails to discuss and present the critical issues that need to be addressed to achieve a non-overshoot pathway. In this particular instance of the Special Report on 1.5°C, the IPCC must be aware of the political implications of its own knowledge production more than ever before, must step up to its responsibility for global responses to climate change and make sure it pulls forward viable, safe, climate just and SDG compatible pathways to 1.5 degrees C that guide policy making. [Jilli Fuhr, Germany]
Draft chapter 1 correctly argues that any 1.5°C response strategy must be firmly grounded in the 2015 Sustainable Development Goals as part of the agenda 2030. The high-risk nature of overshoot pathways, including the high risks and uncertainties associated with specific engineering, technologies relied on in these scenarios, seriously jeopardizes progress made on sustainable development. They are likely incompatible with sustainable development, including the integrity and protection of ecosystems and human communities. Chapter 2 authors should make sure they apply a sustainable development perspective rigorously and consistently on the 1.5°C pathways they provide. [Lili Fuhr, Germany]

The Sustainable Development perspective is addressed in Ch 5

20120

The anchoring of any 1.5°C pathway in sustainability, human rights, biodiversity and ecosystem integrity must be taken seriously throughout the report. As it stands, draft Chapter 2 exclusively relies on dangerous overshoot pathways that include geoengineering/carbon dioxide removal technologies at large scale that are without any doubt incompatible with global sustainable development. Large-scale BECCS and afforestation, as incorporated in climate response strategies in Chapter 2, jeopardise land and land-use rights of local and indigenous communities, food and water security, biodiversity, and many other core values and principles of the international community. Later Chapters (e.g. draft chapters 3 and 5) address these sustainable development concerns of the response strategies and technologies employed in chapter 2. How can these serious concerns and contradictions leave the models and pathways in draft Chapter 2 entirely unaffected? [Lili Fuhr, Germany]

The chapter has been revised to consider non-overshoot scenarios in response to several reviewer comments. As noted in the previous to other comments, sustainable development issues are treated in ch 5 but not considered directly in ch 2

20122

Where is the explanation and discussion of input assumptions relied on in IAMs? They must be made transparent. There must also be a discussion of what input assumptions were not being made and fed into the models (such as: steady state economies or degrowth in Global North, circular economy appetites, plant-based diets...) [Lili Fuhr, Germany]

Section 2.6 contains an enhanced discussion of IAMs and their assumptions, gaps, etc.

20123

IAMs must be run with non-growth-oriented economic assumptions, absolute decreases in resource and energy consumption, and other radical emission reductions pathways. Such assumptions may yield non-overshoot scenarios and they are no more politically realistic than geoengineering options that are considered in the models. [Lili Fuhr, Germany]

20124

BECCS land-use implications could include terrestrial species losses equivalent to at least 2.8°C temperature rise (P. Williamson, Nature 530, 153 (2016)) [Lili Fuhr, Germany]

20125

Looking at the literature on the subject, I am extremely skeptical of the published ranges of global 2030 emissions under NDCs. The published estimates are not transparent (there is basically no way to trace the published number), they rely heavily on IAM, are not disaggregated to the country level, and are dependent on the scenarios used. The apparent agreement between a few publications is either fortuitous or because there is an interdependency between the studies. Rogelj et al (Nat Comm, 2017) themselves have revised the range to 47 to 63 GtCO2-eq. We have our own study (still in submitted stage because some resistance from reviewers) showing a larger emission range. It doesn’t mean that I believe 2030 emissions to be high, but simply that NDCs do not reflect our best guess of where 2030 emissions will be. In a sense NDCs are less ambitious than current policies embedded in IAM so in any case I wouldn’t attribute the 49-58 GtCO2-eq y-1 range solely to NDCs. [Olivier Boucher, France]

201381

There is no discussion of the issues raised in the media reports about Kemper project etc.). Nevertheless, models assume a mature and large-scale rollout as soon as 2030. It is irresponsible and unscientific for the IPCC to adopt these assumptions. [Lili Fuhr, Germany]

20126

BECCS (land-use implications could include terrestrial species losses equivalent to at least 2.8°C temperature rise (P. Williamson, Nature 530, 153 (2016)) [Lili Fuhr, Germany]

20128

Chapter 2 authors should ensure that environmental and social sciences perspectives and concerns are not sidelined but must be at the core of any sustainable development compatible pathway to 1.5°C. [Lili Fuhr, Germany]

The Sustainable Development perspective is addressed in Ch 5

9126

I think it would be worthwhile to consider including national scale studies. Here Oshiro et al. (under review) is one of the examples, although national studies are quite limited. I also heard that Jiang Kejun who is the LCA of this chapter has Chinese study paper which is now under review. Here I attach Japanese paper draft link.


Accepted - a dedicated box on national pathways has been included in the SOD

20129

Chapter 2 should provide a better sense of what input assumptions were not being made and fed into the models (such as: steady state economies or degrowth in Global North, circular economy appetites, plant-based diets...) [Lili Fuhr, Germany]

Section 2.6 contains an enhanced discussion of IAMs and their assumptions, gaps, etc.

201382

Key findings and big challenges/pre-requisites for achieving a 1.5°C world should be summarized in a last (additional) section at the end of the chapter. [Stéana Georgopoulos, Greece]

This is an excellent suggestion, which, however, was not implemented due to limited time for the revisions process. The ES provides an overview of these challenges, which, being situated at the front of the chapter, should also be clearly visible to readers.

4781

The global warming in 2016 was more than 1 degree. This chapter should provided to reach 1.5°C global warming for the earliest year and latest year clearly responded to various scenarios and pathways, especially in the executive summary. [Zhang Q.Zhai, China]

Global warming from observations is considered in Ch 1. This chapter discusses many potential pathways, so not possible to give single years for targets but ranges are indeed included.

692

Authors should highlight short-term radical CO2 emission reduction requirements, and address the equity dimension of failing to do so and of relying on large-scale negative emissions technologies. [Lili Fuhr, Germany]

Global warming from observations is considered in Ch 1. This chapter discusses many potential pathways, so not possible to give single years for targets but ranges are indeed included.

201352

The chapter has been revised to consider non-overshoot scenarios in response to several reviewer comments. As noted in the previous to other comments, sustainable development issues are treated in ch 5 but not considered directly in ch 2

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Comment: Given the profound uncertainties around the possible application of Negative Emission Technologies (NETs) it is clear that the chapter does not provide any clear guidance on NETs. For example, the chapter does not make clear whether it is appropriate to deploy NETs in combination with other technologies, such as carbon capture and storage (CCS), or whether NETs should be deployed as a standalone technology. It is also not clear how NETs would interact with other technologies, such as renewable energy, and how they would affect the overall cost of the mitigation effort. From the perspective of policymakers, the chapter does not provide clear guidance on how to deploy NETs in practice. For example, it does not provide guidance on how to design and implement policies to support the deployment of NETs, or how to ensure that the deployment of NETs is compatible with other policies and regulations. It is also not clear how the deployment of NETs would interact with other policies, such as those on energy efficiency and demand-side management.

Response: The chapter has been revised to address these concerns. It has been updated to provide a more detailed assessment of the effectiveness and costs of NETs, and to provide guidance on how they might be deployed in practice. It has also been updated to provide a more comprehensive assessment of the potential interactions between NETs and other policies.

Taken into account - An in-depth assessment of population projections lies outside the scope of this special report on 1.5°C. However, the chapter does now highlight its importance for achieving stringent mitigation objectives.
Comment Response

The assessment of the characteristics of 1.5C pathways for near-to-mid-term and after mid-century is useful because it allows for differentiating possible mitigation pathways for climate change, and also in this chapter it is not explored (although indeed at least some reference is made to food waste). Please consider amending the topic of sound waste management. [Sigrid Kusch, Germany]

Consider summarizing somewhere when and to what extent mitigation action between 1.5C and 2C pathways starts to differ, to simplify informed explanation -- one paragraph would be enough. [Erik Haites, Canada]

The chapter has very limited coverage of "bottom-up" studies. Several are listed in Table 2.13 but no attempt is made to indicate whether they can achieve the 1.5°C target. Most of those studies are incomplete in terms of the sources and gaves covered and the time period. Perhaps one of the IAM modelling groups could attempt to model each of those studies so they can be compared with the IAM model results that are the focus of the chapter. One bottom-up study missing is Mark 2. Jacobson et al., 2017, 100% clean and renewable wind, water and sunlight all-sector energy roadmaps for 139 countries of the world. [Jake Haites, Canada]

The content of this draft provides one key message of interest to negotiators -- IAMs indicate that 1.5°C is not feasible without overshoot. But the more relevant question of interest to negotiators -- are there any analyses that can achieve 1.5°C? -- is not addressed by the current draft. The chapter should include an assessment of all analyses that appear to be consistent with a 1.5°C stabilization pathway with no overshoot, that might include the Deep Decarbonisation Pathways, Jacobson et al (2017), etc. If any analyses are found, their characteristics should be summarized. So the messages for negotiators are: (1) there are few (no) analyses consistent with 1.5°C and no overshoot; (2) to achieve 1.5°C with no overshoot requires ... (whatever those analyses assume, which may be qualified for example as being historically unprecedented); (3) 1.5°C with overshoot after 2050 is challenging but can be achieved with negative emissions technologies. [Erik Haites, Canada]

279

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868

I found it nearly impossible to follow the detail in this chapter. Some of this reflects that the draft exists even though many scenarios are not yet published or included (as far as I can tell) in the analysis, so not sure whether we are reading something that is not complete. Even some of the scenarios that seem to be part of the 34-1.5C scenarios assessed in this chapter are in papers that are not accessible to reviewers (e.g., Rogał et al, 2017—which is listed as under review at NCC). Some of this opacity is because the figures are mind-numbingly complex and not properly captioned for example, figure 1.8 refers to a colour scheme in figure 1.17, but as far as I can tell the same scheme in 2.17 is totally different). And most distorting is the lack of hardly any attention to realism of the assumptions—nor to whether the IAM teams have ground-truthed their models. The IPCC will be savaged for this point when people start focusing on the details—this is a very serious blind spot in the report—even when the chapter turns to specific technologies there is almost no discussion of ground-truthing and realism. In a few places where there are implied comparisons with reality (e.g., p.38, line 10; p.40, line 18 discussing long-lived building infrastructure) they are so thin as to raise more questions than they answer. The discussion of building infrastructure does something that only the Trump White house could do—take a topic that is, on balance, a revenue constraint on rates of change and rebrand it as an “opportunity”. There is some discussion of second-best modeling near the end of the chapter, but that discussion is very thin and does not actually perform mutichannel of the analysis that was done in AR5 to look at how second-best affects costs. [Victor David, United States of America]

4846

On DAC make reference to the Economic and energetic analysis of capturing CO2 from ambient air Kurt Zenz Housea,b,1, Antonio C. Balcigb, Marvo Ranjangc, Ernst A. van Nesd, Jennifer Wikond, and Howard J. Hinesg. www.prx.org/biological/10.17784/10.1225/108 and the Direct Air Capture of CO2 with Chemicals from the American Physical Society (2011) to highlight the challenges of DAC and longer development path to commerciality compared to BECCS. [Wifried Maas, Netherlands]

The assessment of technology options and their potential for deployment in the real world are assessed in Chapter 4.

7154

Consider adding a box to provide up-to-date information on trends on global GHG emissions, decoupling economic and emissions growth and decarbonization, since AR 5 (2010 data). This will be very useful for addressing the question "where are we?" at the Facilitative Dialogue in 2018. [Julian Florin FLAUD, Germany]

Consider summarizing elsewhere when and to what extent mitigation action between 1.5C and 2C pathways starts to differ, to simplify informed comparisons between 1.5 and 2°C pathways [Julian Florin FLAUD, Germany]

848

The chapter has been revised to consider non-overshoot scenarios in response to several reviewer comments. As noted in the response to other comments, sustainable development measures and policy assessment of Chapter 4 should provide a kind of reality check for what is technically available. The discussion of second-best literature linked to 1.5°C can (and should) be elaborated as more studies become available.

279

The chapter has very limited coverage of "bottom-up" studies. Several are listed in Table 2.13 but no attempt is made to indicate whether they can achieve the 1.5°C target. Most of those studies are incomplete in terms of the sources and gaves covered and the time period. Perhaps one of the IAM modelling groups could attempt to model each of those studies so they can be compared with the IAM model results that are the focus of the chapter. One bottom-up study missing is Mark 2. Jacobson et al., 2017, 100% clean and renewable wind, water and sunlight all-sector energy roadmaps for 139 countries of the world. [Jake Haites, Canada]

9187

I found this chapter nearly half-heavy to read. It is not possible to read it all, it is too much. I guess Rogał et al. at 2017 will analyse the SSP-RCP1.9 (with 48 scenarios, and there will be some other literature. But, if Rogał et al. at 2017 can get the various points across in 3000 or so words, then how many more words are needed in Chapter 2? I know there is an option to go into more detail in the SR, but there needs to be a lot of focus on only writing what is necessary. [Glen Peters, Norway]

Accepted - the IPCC cannot carry out additional research for its assessments, we have included reference to the study cited here. Combining bottom up and top down modelling might indeed provide interesting insights.

7156

The assessment of the characteristics of 1.5C pathways for near-to-mid-term and after mid-century is useful because it allows for differentiating between near-term and long-term options, policies and decisions. [Julian Florin FLAUD, Germany]

The chapter has been revised to consider non-overshoot scenarios in response to several reviewer comments. As noted in the response to other comments, sustainable development measures and policy assessment of Chapter 4 should provide a kind of reality check for what is technically available. The discussion of second-best literature linked to 1.5°C can (and should) be elaborated as more studies become available.

2797

The chapter should discuss whether the baselines of the IAMs whose results have been updated since AR4. Chapter 4 notes several areas of rapid technological change since AR5, including solar, wind, batteries, electric vehicles, etc. These should reduce baseline emissions and possibly facilitate achievement of 1.5°C (which none of the IAMs currently achieve without overshoot). If the recent progress of those technologies affects the rate of future adoption of those technologies in the model, it needs to be acknowledged and any results reported need to indicate whether the baseline has been updated. If the recent progress does NOT affect the rate of future adoption, this needs to be stated (hopefully with an explanation) -- one paragraph would be enough. [Erik Haites, Canada]

Accepted - this is an important aspect, which is discussed briefly in Section 2.8.1

9474

I have had insufficient time to provide detailed comments on this chapter. However, my impression from an initial read through is that it is in good shape for a first order draft, and the Executive Summary is clearly written, understandable, and does not contain ambiguities. [David Wrath, New Zealand]

Thank you.

4980

There is a close link between occurrence of waste, sound waste management and emission of greenhouse gases. One particular example is food waste, accounting for greenhouse gas emissions higher than of most single countries (aside of US, China), see e.g. work by FAO. On the other side, sound waste management achieves not reductions in greenhouse gas emissions, but also in this chapter it is not explored (although indeed at least some reference is made to food waste). Please consider amending the topic of sound waste management. [Sigrid Kusch, Germany]

Thank you for this suggestion. However, we have not found any literature addressing the issue of sound waste in the context of mitigation pathways. In case this is a mitigation measure which would not yet be considered, then Chapter 4 will take this up.
Many thanks to the authors for this quite clear chapter. Also the linkages between the executive summary and the underlying chapter are very much appreciated. [Klaus Radenkov, Austria]

However, what is missing is a linkage to the scenarios described in chapter 3, box 3.12. The chapter is somehow unclear how we would more and more lose the option to meet the 1.5 degrees goal - because to store decarbonization - if SRM is not considered to be a viable option. [Klaus Radenkov, Austria]

What would also be important is a deeper consideration of the limits of CDR - e.g. because of lack of area, high costs, water availability etc. in the executive summary. In this context it seems important to include also in the executive summary the concept of shared socioeconomic Pathways (SSP). This concept would also help to link to chapter 3, box 3.12. [Klaus Radenkov, Austria]

It is very much appreciated that the authors will update the information of this chapter by considering the latest modelling results, e.g. of IAMs. This is so important because of the significant changes, e.g. with respect to costs of mitigation technologies (renewable energy) and the availability of new research results. [Klaus Radenkov, Austria]

Congratulations to all that have been working and collaborating in this chapter, well done. [Jorge Carascos, Chile]

Adaptation is critical to survival, period. Clearly there is compelling evidence; this is the easy part; the challenging part is getting people to change/adapt/transform pretty noticeably.

More of the same, but updated; which is fine. But policy makers/people want ideas or a how-to manual, which we all know is challenging.

It is very much appreciated that the authors will update the information of this chapter by considering the latest modelling results, e.g. of IAMs. This is so important because of the significant changes, e.g. with respect to costs of mitigation technologies (renewable energy) and the availability of new research results. [Klaus Radenkov, Austria]

Chapter 2 does not go into regional detail, and equity aspects would be aspects of Chapter 4. A dedicated box on national pathways has been included in the SOD in Chapter 2.

Chapter 2 contains some text that is more or less repeated in Chapter 4 and Chapter 5. These three chapters need to be harmonized for logical sequence. [Hong Yang, Switzerland]

There is a general concern that the FOD chapter 3, is framed as an analysis of IAM scenarios only, while I am aware that at least 3 scenarios from 2 different non-IAM models (C-ROADS and En-ROADS, both of which are well-specified dynamic systems, or system dynamics, models). Hence, the framing of the report should be generalized to reflect this broader set of model types. [Christian Holz, Canada]

The chapter has been revised to consider non-overshoot scenarios in response to several reviewer comments.

Regarding the IAMs summarized in the chapter; there is insufficient information about certain central parameters that would allow readers to evaluate the IAMs used, for example, but not limited to, the discount rate used. [Christian Holz, Canada]

Taken into account - yet not fully due to the limited scope of this special report. The 1.5°C Special Report needs to build off the assessment of the AR5 and focus on questions related to the topic of 1.5°C. An assessment of the actual modelling tools per se can thus not go much beyond AR5, and should be updated in full in AR6.

What is missing in this chapter is a discussion on the "where" question, i.e. Who contributes to the global reductions, what the contribution of developed and developing countries ought to be. It would be very helpful for policy makers to have some guidance of the reduction percentages to be achieved that reflect an equitable distribution of the global effort, just like the AR4 did for the reduction percentages for 2020. [Bert Metz, Netherlands]

Chapter 2 contains some text that is more or less repeated in Chapter 4 and Chapter 5. These three chapters need to be harmonized for logical sequence. [Hong Yang, Switzerland]

Further text discussing the response of MAGICC has been added to Section 2.6

Ch2 is in pretty good shape! One of the particularly compelling parts of Ch2 for Ch5 is your analysis of different SSP scenarios and their implications for mitigation pathways consistent with the 1.5C target. It is clear that the development trajectories significantly affect the mitigation pathways (i.e. portfolios of measures, pace of implementation) required to limit warming to 1.5C, and that these different IF pathways have differential synergies and trade-offs with the SDGs. This strengthens our claim in Ch5 that ‘development first’ approaches are required to achieve stringent temperature targets, rather than isolated climate-specific interventions. Thanks for the use of s-referencing Ch5 throughout! [Petra Tschakert, Australia]

Taken into account - yet not fully due to the limited scope of this special report. The 1.5°C Special Report needs to build off the assessment of the AR5 and focus on questions related to the topic of 1.5°C. An assessment of the actual modelling tools per se can thus not go much beyond AR5, and should be updated in full in AR6.

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Further text discussing the response of MAGICC has been added to Section 2.6

The use of scenario groups have now been better coordinated across the Chapters

Thank you, we have endeavoured to harmonize these three chapters.

We agree. Section 2.6 has been expanded accordingly

Thank you. The use of scenario groups have now been better coordinated across the Chapters

The chapter states on various occasions (e.g. p4 in the 18) that overall scenarios evaluated are overshoot scenarios, however, one of the C-ROADS scenarios submitted ("Ratchet no overshoot to 1point5"; journal article submission currently under preparation) has been specifically designed as a non-overshoot 1.5°C scenario and as such does not include any CDR. The report should reflect this information and discuss the relationship between short term mitigation ambition between scenarios with and without CDR to give policy makers and societies the relevant information in making pertinent choices. [Christian Holz, Canada]

The chapter should state on various occasions (e.g. p4 in the 18) that overall scenarios evaluated are overshoot scenarios, however, one of the C-ROADS scenarios submitted ("Ratchet no overshoot to 1point5"; journal article submission currently under preparation) has been specifically designed as a non-overshoot 1.5°C scenario and as such does not include any CDR. The report should reflect this information and discuss the relationship between short term mitigation ambition between scenarios with and without CDR to give policy makers and societies the relevant information in making pertinent choices. [Christian Holz, Canada]

What is missing in this chapter is a discussion on the "where" question, i.e. Who contributes to the global reductions, what the contribution of developed and developing countries ought to be. It would be very helpful for policy makers to have some guidance of the reduction percentages to be achieved that reflect an equitable distribution of the global effort, just like the AR4 did for the reduction percentages for 2020. [Bert Metz, Netherlands]

Comments noted, but after consultation with authors across chapters we believe the current chapter order should be retained.

Chapter 2 does not go into regional detail, and equity aspects would be aspects of Chapter 4. A dedicated box on national pathways has been included in the SOD in Chapter 2.

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Chapter 2 does not go into regional detail, and equity aspects would be aspects of Chapter 4. A dedicated box on national pathways has been included in the SOD in Chapter 2.
The possible interpretations of "well below 2°C" can be expanded in this report. Currently there is a distinction between pathways for "well below 2°C" and those for 1.5°C. However, one could interpret a "well below 2°C" pathway as being also a 1.5°C scenario - the two are not mutually exclusive. This could be reflected by showing that a "well below 2°C" pathway could also mean "below 1.5°C" with e.g. 66% probability, or a very high probability of remaining below 2°C. This would be an improvement on the current interpretation, which seems to imply that "well below 2°C" is consistent with 66% likelihood of staying below 2°C - this interpretation is not acceptable for some more vulnerable Parties. [Susana de Beauvisac-Scoot, Saint Lucia]

The chapter now looks at 1.5°C over the entire century

Editorial - References are generated automatically in the style defined by the IPCC TSU

Accepted - in the SOD we have tried to move away from merely descriptive scenario outcomes and also highlight in more detail the interactions due to the underlying scenario assumptions

Comment No: 12467
From Page: 5
From Line: 687
To Page: 5
To Line: 687
This chapter could clearly lay out two assessment periods. Not sure why characteristics are important before 2050 but properties is important after

Editorial - References are generated automatically in the style defined by the IPCC TSU

Accepted - in the SOD we have tried to move away from merely descriptive scenario outcomes and also highlight in more detail the interactions due to the underlying scenario assumptions

Comment No: 13003
From Page: 5
From Line: 6348
To Page: 5
To Line: 6349
in all the references, I suggest to delete the details "Accessed..." and web address for papers published on journals, are not necessary [Caserini Stefano, Italy]

Editorial - References are generated automatically in the style defined by the IPCC TSU

Accepted - in the SOD we have tried to move away from merely descriptive scenario outcomes and also highlight in more detail the interactions due to the underlying scenario assumptions

Comment No: 6869
From Page: 5
From Line: 6678
To Page: 5
To Line: 6679
I wrongly suggest a restructuring that brings much of the "what", where and when" material from 4.2.1 and 4.2.3 into ch2, moves the materials on "how" from ch 2.5 to ch 4 and the material on SD issues from 2.5.3 to ch 1 (see explanation in my comments to the entire report). As a result there are no references any more to ch 4 for further details. [Bert Metz, Netherlands]

Editorial - References are generated automatically in the style defined by the IPCC TSU

Comment notes, but after consultation with authors across chapters we believe the current chapter structure should largely be retained although some material has been moved between chapters 2, 4 and 5.

Comment No: 1014
From Page: 5
From Line: 7418
To Page: 6
To Line: 7419
In Chapter 1 (Box 3.1) it is described that Chapter 2 focuses largely on geophysical and technological feasibility of 1.5 degree target. We can not find this in the table of content, however. If this is in this chapter, that fact should be clearly mentioned here for readers' friendliness. Also geophysical and technological feasibility should be described in the executive summary [Mitsutsune Yamaguchi, Japan]

Chapter 2 does assess geophysical and pathway/technological aspects of 1.5°C pathway in the context of sustainable development, without making an assessment of feasibility. This should now be clarified in Chapter 1. The ES of Chapter 2 hence does not describe these aspects.

Comment No: 7419
From Page: 5
From Line: 7418
To Page: 6
To Line: 7419
Consider linking the assessment of pathways with chapter 3 and 4 (4.3.6.1, and also 3.7.2.1.1), which assess that "there is now large agreement that bioenergy potentials in 2050 are restricted to 100 EJ. [This is correct it may be relevant to the pathways used in Chapter 2 if they use more bioenergy than this level] and thus how you deal with commitments and uncertainties in Chapter 2. Please discuss this as a chapter with authors of these chapters for consistency [Bryndin Christophersen, Norway]

Accepted - this is a very important point. However, due to time constraints this integration was not yet achieved in the SOD, but can be considered for the next iteration.

Comment No: 6349
From Page: 5
From Line: 6349
To Page: 6
To Line: 6349
How would the results presented in this chapter differ if models didn't (by and large) use GWP to make trade-offs in abatement choices between different gases? For some countries and policymakers, this is a fairly important question. Note that chapter 1 has a good discussion on metrics, but chapter 2 (where GHG metrics would become most relevant) seems to completely ignore this, which is disappointing. It may be well that the literature is too limited to say anything specific to 1.5 pathways, but even so I would expect the authors to be able to make some statements based on model runs for 2 degrees rather than pretend it's not even an issue. Personally I don't expect the results to change hugely if a model were run with a different GHG metric, given the stringency of the 1.5 degree goal, but it would be so much more helpful if this chapter could put the issue to bed rather than leave it simmering by not even addressing it. [Andy Reisinger, New Zealand]

Added a short discussion on this in section 2.8.1

Comment No: 6870
From Page: 5
From Line: 6870
To Page: 6
To Line: 6870
I am very concerned about the use of the term "well below" in the chapter, as it implies a weakening of the respective temperature thresholds and the Paris Agreement as a whole. As is clear from table 2.3, "well below" is defined here as having at least a 66% chance of staying below a certain temperature level. So the "well below 2 degrees" clause from the Paris Agreement is set to be a 66% chance of staying below 2 degrees C. However, much of the literature, before and after the Paris Agreement was reached, is using the 66% chance of staying below 2 degrees as the threshold for staying below 2 degrees, not for "well below 2 degrees". In other words, the definition used here is weakening the interpretation of the Paris Agreement and there are no scientific arguments presented for doing so. I think the only reasonable way is to define "well below 2 degrees" as a 66% chance of staying below e.g. 1.75 degrees. For 1.5, 2.5 and 3 degrees the "well below" should be deleted. and replaced by the 66% probability threshold. Similarly, the "medium" should be replaced with the 50% probability threshold. The other major problem is that in the chapter often the 50 and 66% probability levels are grouped together to discuss the implications of staying below a 1.5 or 2 degrees limit. However, there are major differences between studies for a 50 and 66% probability level and there are enough studies in each category, so why do this? I strongly suggest to discuss the 50 and 66% probability studies separately. [Bert Metz, Netherlands]

Agreed. Scenario names have been revised to eliminate the use of the term 'well-below' and instead only rely upon objective thresholds and probabilities.

Comment No: 6871
From Page: 5
From Line: 6871
To Page: 6
To Line: 6871
The studies using different SSP baselines introduce a major problem in formulating key messages to policy makers on the most important actions on options, timing and equity considerations (the "where"), as the conclusions on these key messages often change dramatically depending on the SSP baseline assumed. I think policy makers should be assisted in how to interpret these findings. As result there are no references any more to ch 4 for further details. [Bert Metz, Netherlands]

Clarified how conclusions depend on larger socio-economic trends, e.g. that under some SSPs the IAMs are not able to produce 1.5°C scenarios, and highlighted these conclusions in larger messaging of chapter.
The report correctly points out that fossil fuel plus CSS will be more expensive than fossil fuel without CSS (because of the fuel and plant cost of CSS, which are not currently completely realized, however improvements in technology might occur), while the current and forecast prices for renewables effectively cancels out CSS in favour of the latter. Indeed, the report explores the potential of BECCS much more than fossil fuel plus CSS. However, it seems strange that a cost-minimization procedure generates a lot of BECCS and so little renewables. Possibly this is the result of overestimation of current and projected costs for renewables, cost underestimation for BECCS (in particular the cost of reliable storage for centuries) and a high discounting rate (which may distortly show cheaper BECCS in the remote future but, with its time coming, BECCS becoming impossible expensive as a means of producing electricity). To provide clarity, the report should explicitly mention the price interval used for renewables and BECCS and the discounting rate used by the models surveyed. If the literature is opaque and does not reveal key results, it should be discarded from consideration or at least segregated explicitly. A forecast model that does not reveal key assumptions is useless for taking well-thought decisions. (Valentino Planas, Italy)

We agree and more specifically address Millar et al. and the carbon budget in Section 2.2, although we think a box is unnecessary. We have made several new figures to support this discussion.

The recent controversy and transformation/interpretation of the Millar et al paper suggests that the authors should construct a box in which they carefully discuss and present different carbon budgets (most of this text is already there), but include a discussion of the extent to which actual recent observed temperatures should or shouldn’t affect remaining carbon budgets (which in my view will have to amount to a critique if not criticism of the Millar et al paper), what scientific changes would change carbon budgets (in my view, a change in TCRE or non-CO2 including aerosol forcing, or changes in natural emissions or forcing - but NOT a specific observed trend unless this justifies revising TCRE or any of those other factors), and relating different ways of expressing uncertainty (i.e. a single budget number for a percentage probability to remain below X degrees of warming - vs a range of budget numbers that would be related to a given temperature). Policymakers need to know whether the budget is more uncertain than they thought, and to what extent findings that lie within the uncertainty range change the overall conclusions. At the moment ars in light of public and media interpretations of Millar et al, the current FOG is probably not strong and clear enough on those points. No fault of the authors I hasten to add, but you need to take the lesson nonetheless and avoid that this chapter may get similarly misinterpreted or discredited if it leaves some important perspectives untouched. (Andy Reisinger, New Zealand)

We have revised to consistently use ‘carbon budget’.

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IPCC WGI SR15 First Order Draft Review Comments And Responses - Chapter 2

<table>
<thead>
<tr>
<th>Comment</th>
<th>Response</th>
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<tr>
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<tr>
<td>7421</td>
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<tr>
<td>4862</td>
<td>The large scale application of net-negative emissions may be problematic. Would also recommend considering MIT Joint Program Report 247 of July 2012, What GHG Concentration Targets are Reachable in this Century? (Wijffels Mea, Netherlands)</td>
</tr>
<tr>
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<tr>
<td>6382</td>
<td>Accepted - figures have been revised with this suggestion in mind</td>
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<tr>
<td>21157</td>
<td>We have reviewed to use the SSP labels following those given in Box 1.1 (in Ch 1), but as we have revised to consistently use ‘carbon budget’.</td>
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<tr>
<td>12737</td>
<td>This chapter has to be more consistent in how it treats the SSP scenarios. Sometimes they are referred to as “scenarios1/2/3” (i.e. Fig 2.5) and sometimes scenarios beyond the SSPs we must also on occasion refer to them simply as scenario 1, 2, etc., e.g. in Figure 2.7.</td>
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<tr>
<td>8433</td>
<td>Noted, however the question of what would be required and whether the pathways explored in chapter 2 are ‘obtainable’ is addressed in Chapter 4, not chapter 2.</td>
</tr>
<tr>
<td>2012</td>
<td>Accepted - this is a valuable comment. However, because the scenario database underlying this assessment has not only been finalized late in the timeline of the SOD preparation, this has not yet been taken into account.</td>
</tr>
<tr>
<td>2012</td>
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<td>10327</td>
<td>Accepted - figures have been revised with this suggestion in mind</td>
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A gaping omission is the lack of consideration of solar radiation management. While Chapter 1 gives an indication of why IPCC are wary of including any SRM options, given that the mitigation scenarios leading to 1.5°C are so difficult to achieve, relying on SRM as a back-up. Of all the chapters available, I would have thought this one the most logical place to put a box on SRM governance as arguably SRM is another option for a mitigation pathway. Sticking a discussion in Chapter 3 (which way overlaps its remit) is very odd (Title is “Impacts on natural and human systems”) as it misses out completely on why SRM has been considered in the literature. The box on Chapter 1 on SRM is currently very badly written and does not reflect the literature. [Jim Haywood, United Kingdom (of Great Britain and Northern Ireland)]

While the executive summary is well written and conveys a clear message, the whole chapter gives too many details about the few scenarios and pathways available, which appear based too much on speculations. There should be an effort to find a better balance. [Marco Mazzotti, Switzerland]

The entire chapter relies to a large extend on papers from only 3 authors: (Rogelj - 78 citations), (Riahi - 57 citations) and (Clark - 51 citations) on 10 countries – leaving out the reality of around 190 countries), while the overall nuclear capacity plateaued and starts to decrease as reactor come at end of industry. Not one “renewables only scenario” is documented. This is particularly unfortunate as the renewable industry dominates the global power supply side. They are thus considered in the section which takes a deeper dive into the supply-side transformation of the energy system (Section 2.4.2).

The language on negative emissions is not sufficient across the chapter. Either define it clearly and use this consistently or define each time what is exactly meant by negative emissions. [Maria Jose Saro Sanchez, Spain]

The scenario evidence base has been expanded for the SOD. The indicated models, however, are not used in the actual energy sector and therefore never used from the energy industry and/or energy experts. Request: Include energy models - especially those with a 100% RE targets (world, region, country level) and energy industry and/or energy experts. Request: Significantly scale down citations of “Clark et. al. and as more references from other experts, especially those from the energy sector. [Sven Teske, Australia]

While there is an excess number of self-citations across the whole chapter. For example, a single author has almost 100 citations of their own (including co-authored papers) on in this chapter. This may damage the credibility of an independent critical assessment. I am not questioning the importance of those papers, but would recommend using self-citation only when really necessary. [Alexandre Strapasson, Brazil]

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GENERAL: The entire chapter only covers those models which are widely used by climate scientists (MESSEDE, ER2 etc.) are analyzed. However these models are not used in the actual energy sector. The reason why those models are not used is rather simple: They do not at all reflect the reality of the energy industry. Clark et. al. energy models are entirely disconnected from the actual energy sector and therefore never used from the energy industry and/or energy experts. Request: Include energy models - especially those with a 100% RE targets (world, region, country level) and significantly scale down the presentation of results from the models used in AR5. [Sven Teske, Australia]

GENERAL: Through-out the chapter, only models which are widely used by climate scientists (MESSADE, ER2 etc.) are analyzed. However these models are not used in the actual energy sector. The reason why those models are not used is rather simple: They do not at all reflect the reality of the energy industry. Clark et. al. energy models are entirely disconnected from the actual energy sector and therefore never used from the energy industry and/or energy experts. Request: Include energy models - especially those with a 100% RE targets (world, region, country level) and significantly scale down the presentation of results from the models used in AR5. [Sven Teske, Australia]

The chapter assesses integrated mitigation pathways, and it therefore draws on the literature that provides such pathways. The energy-system-specific models indicated by the reviewer are valuable to understand one part of the overall transformation, the decarbonisation of the energy supply side. They are thus considered in the section which takes a deeper dive into the supply-side transformation of the energy system (Section 2.4.2).

The IAM scenarios are developed on the basis of Riahi et al. 2017 which is cited 57 (1 times throughout chapter 2. My fundamental criticism in regard to the chosen SSP scenario categories is based on figure (3.8) on page 7 Riahi et al. 2017, which classifies scenarios either as coal, oil + gas or Renewable-Nuclear driven. As a matter of fact, 100% renewable energy scenarios are being developed by numerous scientific institutions around the world, without nuclear. The results of these renewable and efficiency based scenarios are increasingly accepted in the energy sector. The energy-system-specific models indicated by the reviewer are valuable to understand one part of the overall transformation, the decarbonisation of the energy supply side. They are thus considered in the section which takes a deeper dive into the supply-side transformation of the energy system (Section 2.4.2).

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The language on negative emissions is not sufficient across the chapter. Either define it clearly and use this consistently or define each time what is exactly meant by negative emissions. [Maria Jose Saro Sanchez, Spain]

The entire chapter relies to a large extend on papers from only 3 authors: (Rogelj - 78 citations), (Riahi - 57 citations) and (Clark - 51 citations). The lead author cites his own paper 78 times. Request for SOD: Divinely sources/references. [Sven Teske, Australia]

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The large majority of all cited climate models are under the "ADVANCE initiative" and very Eurocenteric. I suggested to diversify the models and include specific energy models rather than models which are used in most previous IPCC publications. The lack of realistic assumptions in those models - and their misleading results which have been proven wrong over the past decade - are subject to criticism over several years now and to open up this topic to other institutions (beyond SRES and P5) would add to the global ownership of this publication. [Sven Teske, Australia]

Chapter 2 has 28 Figures. Some of them are very complicated (often with several panels) and contain the information that needs a long text to elaborate. It would be good to simplify some of the Figures by presenting only the key messages. [Hongyang Yang, Switzerland]

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Chapter 2 has 28 Figures. Some of them are very complicated (often with several panels) and contain the information that needs a long text to elaborate. It would be good to simplify some of the Figures by presenting only the key messages. [Hongyang Yang, Switzerland]
The executive summary needs a lot of work to deliver a set of concise, policy-relevant messages and to ensure it uses appropriate uncertainty language rather than the current descriptive narrative. The fact that this was not done for the FOD is unfortunate since it makes it impossible for reviewers to comment on proposed key findings. Remember the executive summary will be a key source for statements in the summary for policymakers. I suggest those key messages should include a focus on how the mitigation challenge differs between 1.5 and higher warming pathways, in addition to characteristics of 1.5 pathways per se. The text does not extend to the extent to which the assumption of a global carbon price gives an unrealistic picture of real-world mitigation potential and costs. There is information needed about what all 1.5 pathways give an overshoot—is this economic optimisation relative to a late 21st century goal, or technical or social infeasibility of early emission reductions? In other words, what (some) policy makers will want to know is if it simply impossible to avoid an overshoot of 1.5 (given specific assumptions about what phase change of is or isn’t possible), or if it just that the models are set up such that an overshoot appears more plausible/less costly? Also a clarification about the extent to which the findings in this chapter would differ with different discount rates. [Andy Reisinger, New Zealand]


Many revisions along suggested lines in SOD.

Material on non-overshoot added. Discount rates discussed more fully in chapter.

The concept of feasibility is an overarching concept to the entire report, which is introduced in Chapter 1.

Noted. Limitations of CDR and BECCS discussed in both chapter and ES.

Noted. The assessment of BECCS, its synergies and trade-offs is coordinated throughout the report. Chapter 4 provides an assessment of sustainable levels of bio-energy (Section 4.3) and Chapter 5 provides an assessment of the interaction of a variety of mitigation measures with sustainable development, including poverty alleviation. These insights are integrated in the pathways assessment of Chapter 2 in its section 2.5.3. The SOD now includes a dedicated and elaborated mitigation measures-sustainable development interaction table (Table 5.1). This table provides the basis for the sustainable development assessments in the integrated pathways in chapter 2. Any contributions to literature that can further be included in this table are welcome.

Accepted. - The ES has been entirely overhauled to ensure a cleaner structure and more intuitive flow. Also the layout specifications, as suggested by the expert reviewer have been applied in the SOD.

See response to comment 2130.
20132
4 1 4 25

20133
4 1 4 25

8085
4 1 6 47
It would be preferable that in all executive summaries (like in chapter 1 and 4) the paragraphs are introduced with two or three short sentences containing the main message (instead of a short title). E.g. for Paragraph 4 line 17-31 this could read (in bold letters): Pathways holding warming below or close to 1.5°C in 2100 all exhibit overshoot of that temperature level around mid-19 century. The carbon budget until carbon neutrality in mid-21 century is about 40% lower than the budget in 2°C pathways. [Urs Neu, Switzerland] Accepted. - The layout of ESs has been harmonized.

15785
4 1 6 47
The Executive Summary should address the role of SLOR/SLOP in causing temperature rise to overshoot the 1.5°C threshold in the near-term period. The more rapid crossing of the threshold due to the role of SLOR/SLOP is an important dimension that should be addressed. [David Waskow, United States of America] All forcers are given adequate attention in the ES

18818
4 1 6 47
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10973
4 1 6 47
More needs to be said on methodological aspects, partly to address concerns about heavy reliance on BECCS. For countries, I think some statements that may be too obvious to modellers need to be spelled out. This may not be correct but to illustrate the idea a) there are no published scenarios that limit warming to 1-5 (overshoot and non-overshoot) without the use of CDR techniques, b) the extent to which CDR is used depends on socio-economic assumptions and the extent to which other options (renewables etc) are exercised. [Siakim Jim, United Kingdom (of Great Britain and Northern Ireland)] Agreed, more added on methods and limitations of IAMs as well as non-overshoot scenarios.

20134
4 1 4 25

4865
4 1 6 48
The pathways presented in the chapter rely extensively on one technology - CCS, yet the Executive Summary doesn’t make this clear. This needs to be stated boldly and clearly given the poor state of CCS deployment at the moment. [Wilfried Maas, Netherlands] The ES now highlights this aspect in more detail.
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<td>20790</td>
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<td>48</td>
<td>The executive summary lays out some of the main CO2 policy options but there is little discussion of the methane. HFC (Kigali) options and the degree of effort needed to decrease these. And what are the conclusions on impacts? Different scenarios are diversified from the other implications to livelihoods, health and other aspects of sustainable development. This is a discussion about relying only on CO2 measures and how the implementation of SLCF mitigation can reduce the need to reduce CO2 as much, but this is not further developed in the summary and I would have thought that implementing SLCF mitigation will be much more palatable than biomass and CCS! This could be touched upon. There is also the issue of the rate of reduction of HFC emissions to reach Kigali targets and more rapid reductions could help - so this summary is not giving strong evidence for which strategy makes most sense and is most easily implemented. [Johan Carl Ivar Kuylenstierna, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Agreed, added specific section on non-CO2 to ES.</td>
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<td>20843</td>
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<td>48</td>
<td>The executive summary lays out some of the main CO2 policy options but there is little discussion of the methane. HFC (Kigali) options and the degree of effort needed to decrease these. And what are the conclusions on impacts? Different scenarios are diversified from the other implications to livelihoods, health and other aspects of sustainable development. This is a discussion about relying only on CO2 measures and how the implementation of SLCF mitigation can reduce the need to reduce CO2 as much, but this is not further developed in the summary and I would have thought that implementing SLCF mitigation will be much more palatable than biomass and CCS! This could be touched upon. There is also the issue of the rate of reduction of HFC emissions to reach Kigali targets and more rapid reductions could help - so this summary is not giving strong evidence for which strategy makes most sense and is most easily implemented. [Johan Carl Ivar Kuylenstierna, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Agreed, added specific section on non-CO2 to ES.</td>
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<td>This opening paragraph must be written much more clearly. First of all, isn't this chapter going to compare and contrast the requirements for the phase-out of all greenhouse gas emissions between 1.5 degree non-overshoot and 2.0 degree non-overshoot pathways? It should. It could also compare and contrast the relevant issues affecting overshoot versus non-overshoot pathways for 1.5 degrees C, but this is less interesting. [Richard Rosen, Germany]</td>
<td>This chapter does indeed compare 1.5 and 2C non-overshoot scenarios now.</td>
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<td>From Figure 1 of Chapter 1 we have already reached 1.5°C following the GISS data. I believe that this is not a good observable since it is determined by too many stochastic variables, like El Nino, Sea ice disipation pace etc. It would be much safer and cleaner to come back to the radiation forcing like in the ROP method. Furthermore recent discussions on the existence or not of the &quot;hiatus&quot; between 1998 and 2014 show that it is difficult to have a consensus on the way to define the GMST [Hervé Milenicker, France]</td>
<td>Setting of global ambition based on GMST was a political choice made by nations signing the Paris Agreement (as well as prior agreements under the UNFCCC). This report answers an explicit request of the UNFCCC to assess issues related to 1.5°C of global warming. The framing of the chapter, and the report as a whole, in terms of GMST is thus not something which can be changed.</td>
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<td>That is a really good start. Poising key questions and orienting the reader where the substance to the answer of these questions is. Well done! [Felix Crespaut, Germany]</td>
<td>Thank you</td>
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<td>Or one could use SRM. This is a major omission. I wrote this comment above on Chapter 1. Personally, I find this absurd. And if it does not fit in with previous IPCC reports, who cares. This is a mere report, and we can change, nil? For example, to say that SRM cannot be treated as a mitigation option is ridiculous. Clearly, the goal is to mitigate climate change, and if SRM can share of 0.1C or 0.0C or whatever, then surely that meets that goal? And, SRM will be traded off with other options, if we do some SRM, it may be that we do less CDR or less conventional mitigation. So, in principle, SRM must be in Chapter 2 (not could be, but must be). It may be that there is no literature, fine, but that is a different issue... [Elen Peters, Norway]</td>
<td>We agree that SRM must be in the SR1.5, but feel that the choice of where is editorial and elect to continue with prior decisions (i.e. that it's not in Ch 2).</td>
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<td>This statement seems totally unjustified - careful studies (e.g. by Edmonds et al., in preparation) have found no practical paths of emissions reductions that would keep the rise in temperature below 1.5°C when also giving full consideration is given to the effects of associated changes in aerosol loading and greenhouse gases other than CO2, and the warming that will result as the ocean lag effect is overcome. The present commitments for fulfilling the Paris Accord only get us to over 3°C of warming. It very much seems to me that &quot;needs&quot; require to be changed, especially given the first word in the sentence is &quot;Limiting&quot; implies not exceeding 1.5 C (it might well be more appropriate to say returning the global average temperature below 1.5 C …). I think the first sentence should make that point that we are presently far from being on a path to 1.5 C and getting on such a path will require much, much more commitment and effort. [Michael MacCracken, United States of America]</td>
<td>Revised to include description of current trajectories and then what would be required for 1.5C scenarios.</td>
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<td>Statement is probably overly strong - rapid phase out of CO2 emissions? Surely there are some scenarios in which CO2 emissions are not zero (indeed, statements on p.35 imply as much) because CCS deployment is high and negative emissions are high, etc. [Victor David, United States of America]</td>
<td>Refers to net emissions, which must be brought down in these scenarios (e.g. via negative emissions, as the reviewer suggests). Clarified in revision.</td>
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<td>The executive summary of chapter 2 leaves the reader with the impression that the range of scenarios discussed equals the range of possibilities. This is not the case, as becomes clear from table 2.5: many possibilities, especially demand side measures, are not included in the scenarios. This should be made transparent in the summary. [Astrid Schulz, Germany]</td>
<td>Agreed, more on this added.</td>
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<td>To make the summary more policy relevant, a discussion on (technological) path dependencies, lock-in effects and trade-offs between technological choices should be added. [Astrid Schulz, Germany]</td>
<td>These topics are included in the ES.</td>
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<td>Consider adding a paragraph in the ES to explain the risks posed by feedback-loops and how other goals might influence the carbon budget, for example (drawn from page 13 para starting at line 34): &quot;Large uncertainties remain in some Earth system feedback processes that can impact remaining carbon budgets compatible with 1.5°C or 2°C, for example, permafrost feedbacks. Carbon budgets would also be greatly reduced if multiple geophysical climate targets beyond global mean temperature rise were to be simultaneously taken into account (2.2.2.2).&quot; [Byrdi Christophersen, Norway]</td>
<td>Added.</td>
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<td>As currently drafted this sentence is not correct. While it would clearly not be desirable, it might prove possible to limit warming to 1.5C using SRM alone. Also, the problem is CO2 emissions from fossil fuels: there are clearly routes to a 1.5C world in which CO2 emissions from, eg, algae biofuels persist (see eg p62, lines 32&amp;33). I would suggest that a more accurate opening sentence would read: &quot;Limiting warming to 1.5°C above preindustrial levels would be achieved through a rapid phase-out of global CO2 emissions from fossil fuels and deep reductions in non-CO2 greenhouse gas emissions; such cuts might be supplemented by the use of solar radiation management (SRM).&quot; [Olivier Morton, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>We believe it is important to begin the ES with statements of the larger conclusions, then later to elaborate additional details. We have therefore added language pointing out that this chapter does not assess SRM later in the opening paragraph.</td>
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<td>Consider adding a new paragraph in the ES to make these more relevant and understandable to policymakers and the public, for example, something like: “For the energy, transport, buildings, industrial, or agriculture sectors, the assessment in this chapter shows that multiple options and choices are available in each of these sectors to pursue a 1.5°C pathway. Because the overall net emissions for a pathway is limited by a geophysical carbon budget, choices in one sector affect the efforts that are required from other sectors.” The long-term mitigation pathways are particularly uncertain due to the uncertainty about the ways mankind will use energy and land areas in the second half of the 21st century. The pathways will depend on long-term population trends, levels in economic growth and income convergence, behavioural change and technological progress. Although model-based assessments already project drastic near-, medium- and long-term transformations in 1.5°C scenarios, projections also often struggle to capture potential and ongoing transformative changes and their associated dynamics; including disruption, innovation, and nonlinear change in human behaviour.” [Byrdith Christensen, Norway]</td>
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<td>Response</td>
<td>Much of this material is now included in the ES, though not precisely as presented here.</td>
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<td>All “this chapter” This reads as an introduction to the chapter. I would rather write it as a bit that can be read independently of the main text. [Ton Wildenberg, Netherlands]</td>
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<td>Generalized as suggested.</td>
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<td>It mentions non-CO2 GHG emissions - what about black carbon? That is not a GHG, it is a particle, and is it not part of the solution? [Johan Carl Ivar Kuylenstierna, United Kingdom (of Great Britain and Northern Ireland)]</td>
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<td>In the spirit of the previous suggestion, the second sentence here might usefully be amended thus: “This chapter assesses 1.5°C mitigation pathways to achieve this purely by limiting or reducing atmospheric GHG levels; it does not consider the possible role of SRM.” [Oliver Morton, United Kingdom (of Great Britain and Northern Ireland)]</td>
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<td>I think “it in” this line should be “is it” - since it is phrased as a question? [David Varriol, New Zealand]</td>
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<td>Response</td>
<td>Revised as suggested.</td>
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<td>The question is only placed in terms of CO2 - what about methane, HFCs, BC, ozone etc? [Johan Carl Ivar Kuylenstierna, United Kingdom (of Great Britain and Northern Ireland)]</td>
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<td>Response</td>
<td>Added. Thank you.</td>
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<td>Response</td>
<td>Added. Thank you.</td>
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<td>Comment</td>
<td>I am uncomfortable with the dominated framing of this chapter on the cumulative carbon budget. The carbon budget is good to distinguish across scenarios spanning a range of temperatures. When it comes to limiting to 1.5C, the budget is of limited help given the budget becomes smaller than the associated uncertainties (e.g. the starting point, pre-industrial temperatures, current emissions in land-use change, emissions from non-CO2 GHG). [Corinne Le Quéré, United Kingdom (of Great Britain and Northern Ireland)]</td>
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<td>Response</td>
<td>We do not see a good alternative optimal constraint to use, but we both present multiple characteristics of the scenarios examined in the chapter (see, e.g., the large table in section 2.2) and have added additional mention of the uncertainties associated with C budgets in the ES to clarify this valid point.</td>
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<td>Comment</td>
<td>This chapter urgently needs to address non-overshoot of 1.5 to follow through the conceptual frameworks set up in Chapter 1. Understood that there may be no non-overshoot scenarios in the database, but need to explain why (what questions were the assessed pathways addressing) and use other types of literature to get to the non-overshoot issue which will be of huge interest to some countries Not saying we will please countries but we must not gloss over issues. [Steve Jim, United Kingdom (of Great Britain and Northern Ireland)]</td>
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<td>Response</td>
<td>Non-overshoot scenarios now included.</td>
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<td>Comment</td>
<td>Executive summary is a whole is well written and readable for policy makers. In this chapter, total budget in comparison with 2 degree case, and balance of emission and absorption among some representing pathways (e.g. between case of early emission reduction and case of high overshoot) is important for decision making. A simple illustrative figure to show those differences is recommendable. [Shuho Nishihara, Japan]</td>
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<td>Response</td>
<td>Thank you. No figures are included in the ES, but such a figure will be included in the chapter.</td>
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<td>Comment</td>
<td>The key question on “how can the [carbon] budget be distributed over the coming decades…” feels to close to the top-down approach of Kyoto Protocol. [Brianna Shoah-TEHRAN, Japan]</td>
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<td>Response</td>
<td>Sentence revised to clarify that the issue discussed in this chapter is distribution over time, not across jurisdictions. So not policy prescriptive or top-down.</td>
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<td>Instead of “transformations”, better to say “transitions” or “system transitions”, or use both “transformations and transitions” as a compromise. [Farhan Akhtar, United States of America]</td>
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<td>Response</td>
<td>Agreed, revised.</td>
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<td>Various assessment models (e.g. Vassilis Dasogho, Netherlands)</td>
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<td>Response</td>
<td>Added question in opening paragraph about models.</td>
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<td>Comment</td>
<td>I think it is important to caveat the results from analysed 1.5 degree pathways with the fact that many levers available to reduce emissions are not covered by the models used. Table 2.5 is a great illustration of this. For example, no demand reduction levers outside energy efficiency have been studied, when they could deliver very material emissions reductions. As such, the conclusions drawn from this chapter could quite conservative (e.g. we might not need to cut the budget in the mid-term if all those levers were also used). It could be done through a short sentence in the executive summary highlighting that given the field of literature is only emerging, most models have an incomplete coverage of the levers available for reduce emissions and therefore results presented in this report are likely to be conservative. (see other comments for more detail around possibly material levers not covered by models) [Amelie Deni-Ryan, Australia]</td>
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<td>Response</td>
<td>Generalized as suggested.</td>
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<td>Comment</td>
<td>The para suggests that IAMs are the only basis for assessing mitigation pathways compatible with 1.5 deg. Assess non-IAM literature as well [Harald Winkler, South Africa]</td>
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<td>Response</td>
<td>Added. Revised to state that both types of literature are assessed.</td>
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<td>Comment</td>
<td>Exactly which “quantitative descriptions of the energy-land-emissions developments” are included in the database? Give a list. Change this wording from a declarative statement to a question - it is very clutzy. [Richard Rosen, Germany]</td>
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<td>Response</td>
<td>There are many tens of scenarios in the database, so it is impractical to list these in the ES.</td>
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<td>You need to define the terms “carbon budgets” and “forcers” first in this paragraph. [Richard Rosen, Germany]</td>
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<td>Comment</td>
<td>Please clarify, whether or not any non-overshoot 1.5°C pathways have been studied. If not at all or just a very limited number of them, please clarify that. Note that this does not imply that pathways do not exceed the 1.5°C limit are infeasible (specify appropriate feasibility definition as laid out in 2.4.1) [Michael Schaeffer, Netherlands]</td>
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<td>Response</td>
<td>Non-overshoot scenarios now included.</td>
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<td>Comment</td>
<td>With this definitive statement that all scenarios overshoot 1.5°C, then going back line 3, opening with the phrase “Limiting warming to 1.5°C is thus clearly inappropriate and this should say something like “Due to delays in enacting emissions reductions, there are no plausible scenarios for keeping global warming below 1.5°C throughout the full 21st century; scenarios that bring warming back down to below 1.5°C by 2100 will require...” [Michael MacCracken, United States of America]</td>
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<tr>
<td>Response</td>
<td>Agreed, non-overshoot scenarios now included.</td>
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Comment No | From Page | From Line | To Page | To Line | Comment | Response
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3143 | 4 | 17 | 4 | 19 | You say available pathways. What does available mean? If it refers to pathways that just happen to have been put into the IAASA database, this is ridiculous. There are many other pathways in the literature. You can't just rely on the new runs put into the IAASA database for this chapter. For example, Mark Jacobson of Stanford University has published many works on other pathways, which are basically, non-overshoot pathways. Thus, the authors of this chapter have the moral and scientific responsibility to search the literature for relevant non-overshoot pathways. Furthermore, as we will discuss below, the authors of this chapter have to determine why the IAASA database only has overshoot pathways in it. Could the IAASAsed on various input assumptions changed such that non-overshoot scenarios would result? [Richard Rosen, Germany] | Literature used has been expanded (though we are of course only able to cite published studies) and now includes non-overshoot pathways.
1876 | 4 | 17 | 4 | 19 | First, as mentioned above, it is highly problematic that non-overshoot scenarios are not addressed more in detail, although non-overshoot is discussed in chapter 1.2.3.1. However, here it is said that available pathways all exhibit overshoot of that temperature level, while chapter 2.4.2, page 56, says that "almost all 1.5°C pathways in the literature overshoot." Either it is all or almost all, but both can not be right. [Sven Harmeling, Germany] | Non-overshoot scenarios now included, hence text revised.
19311 | 4 | 17 | 4 | 19 | It is now no longer possible to avoid exceeding 1.5°C: all available pathways holding warming below or close... [Birgit van Munster, United Kingdom (of Great Britain and Northern Ireland)] | Non-overshoot scenarios now included, so text at this point reflects this.
20124 | 4 | 17 | 4 | 19 | IAMs based on the IAASA database only produce overshoot scenarios. Chapter 2 authors must resort to non-IAM literature to build non-overshoot pathways. Chapter 2 authors have an ethical and scientific obligation to not only include, but to prioritise non-overshoot pathways. There is plenty of relevant literature in the various disciplines, e.g. Miller et al. 2017 Emission budgets and pathways consistent with limiting warming to 1.5°C, in: Nature Geoscience, published online: September 18, 2017. [Lili Fuhr, Germany] | Agreed, non-overshoot scenarios now included.
19359 | 4 | 17 | 4 | 19 | This description assumes the criterion for limiting warming to 1.5°C is to be below or close to 1.5°C in the year 2100. While this seems a reasonable choice, it is not obvious it should be the only choice. It would be useful to have more discussion on how relaxing this criterion to a return to 1.5°C by 2105, 2110... would affect the carbon budgets. [William Collins, United Kingdom (of Great Britain and Northern Ireland)] | The chapter now discusses both pathways that stay below 1.5°C and overshoot it until 2100. Beyond 2100, the chapter has no pathways available.
7424 | 4 | 17 | 4 | 31 | We find the current description of the carbon budgets slightly confusing, please consider a more thorough description. 280/330 GtCO2 seems to correspond to 75% or 85% probability of overshooting the relevant carbon in Table 2.4), rather than 66% and 50% as it is stated here. If the budgets derived from Tab 2.4 are to be used, consider including an exempt from the table. [Birgit van Munster, United Kingdom (of Great Britain and Northern Ireland)] | Added text on overlap between scenario classes pointing out that 1.5°C scenarios also have high probabilities of keeping below 2°C.
6623 | 4 | 17 | 4 | 31 | There is large uncertainty about the climate sensitivity and its effects on the projections of temperature rise, carbon budgets and so on are significant. This is very important caveat and should be mentioned here on the impact of this uncertainty. [Shigeki KOBAYAH, Japan] | Added.
709 | 4 | 17 | 4 | 32 | Here again reference to the GMST discusses the question. For politicians one needs a clear picture of overshooting in 2100 to less than 1.5°C (60% probability at the relevant country in Tables 2.4), rather than 66% and 50% as it is stated here. If the budgets derived from Tab 2.4 are to be used, consider including an exempt from the table. [Birgit van Munster, United Kingdom (of Great Britain and Northern Ireland)] | CO2 budgets are clearly given in this paragraph along with associated GMST. Non-overshoot scenarios now included, so text at this point reflects this.
7425 | 4 | 17 | 4 | 31 | Consider describing the probability range of each budget to exceed not only for 1.5°C but also for 2°C pathways, to highlight the "fat tails". This information might contribute to inform policymakers better that there is always a risk of exceeding a temperature threshold, even in low emission pathways. [Birgit van Munster, United Kingdom (of Great Britain and Northern Ireland)] | Added.
6072 | 4 | 17 | 4 | 31 | The chapter now discusses both pathways that stay below 1.5°C and overshoot it until 2100. Beyond 2100, the chapter has no pathways available. | Agreed, done.
16157 | 4 | 20 | 4 | 20 | The phrasing here is needlessly misleading--there is no holding of warming below 1.5°C. There is a return to temperatures below 1.5°C by 2100. Not making clear that, because of emissions to date, the world will exceed 1.5°C is irresponsible and misleading. [Michael MacCracken, United States of America] | Text revised to reflect that we now discuss both scenarios holding T below and returning to a given threshold.
901 | 4 | 20 | 4 | 20 | The 66% and 50% likelihoods calculated for seem rather low; should estimates not be calculated for greater confidence limits? [David Infield, United Kingdom (of Great Britain and Northern Ireland)] | Added text on the implications of choosing higher probability values.
17300 | 4 | 20 | 4 | 20 | why present 'at least 66%' here? The Paris Agreement says 'pursuing efforts to limit to 1.5C', which I would not describe as either 66% or 50%. In my view the framing needs to be broader. [Corinne Le Quéré, United Kingdom (of Great Britain and Northern Ireland)] | Added text on the implications of choosing higher probability values.
7158 | 4 | 20 | 4 | 21 | Decision 1/CP.21, para 17 indicated that the 2020 level will provide the level of global emissions reductions in 2030. This value is provided as a range (25-41 GtCO2e/yr) [also in table 2.7]. Could an average value be provided (e.g., 33 GtCO2e/yr) so that it can be compared with the 40 GtCO2e/yr indicated for the reduction level in 2030 corresponding to 20C? [Marian Pflanz, Germany] | Added sentence on overlap between scenario classes pointing out that 1.5C scenarios also have high probabilities of keeping below 2°C.
6865 | 4 | 20 | 4 | 22 | The remaining budgets for staying below 1.5°C given here (280 GtCO2 and 330 GtCO2 for 66%, resp. 50% probability) do not correspond with the numbers presented in table 2.2, or in the text of section 2.2.2. This is a problem. It also needs to be explained which budget definition is used and why. [Bart Holtz, Netherlands] | Revised to ensure harmonized values.
4881 | 4 | 20 | 4 | 22 | Reversion to the budget stated here with the worked presented later in the chapter is unclear. [Wilfred Mees, Netherlands] | Revised to ensure harmonized values.
3144 | 4 | 20 | 4 | 26 | These sentences are far too complex for the Exec Summary. First of all "likelypath" would have to be defined, and it is not a probability, so I would leave it out. Use mid-range values only. The fact is no one knows probabilities. You can explain distributions of model results later in text. Make clear that the 330 figure is for a non-overshoot pathway, and the 780 result is for an overshoot scenario. Describe the difference. Omit term "interchangeable". [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)] | Terms simplified where practical, but we believe it is important to include ranges and not appear overly confident in mid-range values.
7426 | 4 | 21 | 4 | 21 | Please consider including Net in front of "... CO2 emissions emitted..." [Øyvind Christophersen, Norway] | Net now included in definition.
12969 | 4 | 21 | 4 | 21 | The numbers 280 (150-360) and 330 (250-490) are available in Table 2.4, but are not discussed in the text. I suggest providing a detailed explanation in the text of section 2.2.3.2 [Cesareni Stefano, Italy] | Revisied to ensure harmonized values.
16158 | 4 | 21 | 4 | 22 | This report will be coming out in 2018. The numbers here seem to count emissions only through 2019 when we already know what the 2018 emissions were and can estimate the 2017 emissions to a degree that will not broaden the indicated uncertainty ranges at all. This needs to be done to really clearly indicate the imminence of overshooting the budget. Indeed, I would urge that the sentence also include what the current emissions are (or a range from past couple of years) so there is context provided for the remaining balances. [Michael MacCracken, United States of America] | To-date emissions/budgets now included.
For clarity, a sentence should be added after the description of 280 and 330 GtCO2 budgets: “No pathway compatible with these emissions budgets was available for discussion in this report” [Nael Lecocq, Belgium]. Such pathways are now included.

4610 4 22 4 22 Efforts to net-zero emissions are very important to attain stringent emission targets. To strengthen this concept, sentences: “Limiting global mean temperature to any level of global CO2 emissions at some point in the future. At the same time, current (year: 2015) global annual CO2 emissions are of the order of 41 billion metric tons of CO2 per annum (GtCO2 yr⁻¹). Reducing these emissions from their current levels to net zero will require large-scale transformations of the global energy-economy-land system, affecting the way in which energy is produced, agricultural systems are organized, and the extent to which energy and materials are consumed” should be cited from Sec. 2.3.1. [Masato TAKAGI, Japan]

Sentence removed during revisions.

4940 4 22 4 23 This sentence is not really accurate as written. Once one gets to zero emissions there is further warming due to the ocean thermal lag effect. So, this sentence needs to make clear there is a lag time. [Michael MacCracken, United States of America] Sentence removed during revisions.

13665 4 22 4 26 Not clear for the non-specialist reader – eg is this saying net zero emissions will stop warming, active removal of CO2 will happen spontaneously [Evelia Polacizevskaia, Germany] Sentence removed during revisions.

20379 4 23 4 23 Until peak or “until their peak” [Oliver Boucher, France]. Revised.

16159 4 22 4 23 This sentence is not really accurate as written. Once one gets to zero emissions there is further warming due to the ocean thermal lag effect. So, this sentence needs to make clear there is a lag time. [Michael MacCracken, United States of America] Sentence removed during revisions.

16160 4 23 4 26 The meaning of this sentence is not clear. Please improve the wording. What are the 1.5°C scenarios referred to and where do these numbers come from? [Michael MacCracken, United States of America] These are discussed further later in the ES where CDR is covered. Revised and clarified.

6139 4 23 4 26 No overs-complicated long sentence is completely unintelligible (and I'm a native English speaker). It needs to be entirely re-written. This peak is confusing as until now there has been no mention of a 'peak'. [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)] Revised and clarified.

12970 4 24 4 26 As above these figures are available in Table 2.4 but are not discussed in the text. I suggest providing a detailed explanation in the text of section 2.2.3.3 [Casarini Stefano, Italy] Section 2.2.2 on the carbon budget has been revised to discuss the values more fully.

6968 4 25 4 25 Suggest to replace "CO2 is actively removed" by "CO2 has to be actively removed" [Stai Ming Lee, China] Wording changed during revisions so no longer applicable.

2199 4 25 4 26 This is imprecise. The mitigation pathways feature active CO2 removal from 2030 (median 0.5 Gt/yr). Perhaps what the authors want to explain is that there is a net negative global CO2 balance in the second half of the century [Kenneth Möllersten, Sweden] Agreement, clarified as suggested.

7427 4 26 4 26 The outline states that both pathways for 1.5°C and 2°C should be included/compared in this chapter. Therefore we suggest that you insert a similar text for 2°C as you have for 1.5°C. This could be done at this place in the para, or you could add a stand alone para about 2°C carbon budgets. [Sylvind Christophersen, Norway]

Relationship between budgets for 1.5°C and 2°C is given, but more details are left to section 2.2 rather than here in the ES.

4941 4 26 4 26 As carbon budgets here various definitions, use of a more scientific expression is recommended. [Masato TAKAGI, Japan] Clear definition added.

11611 4 26 4 27 Again, unclear. Perhaps change "is about" to "needs to be about" – and on line 26, change "the carbon budget" to "CO2 emissions" and I don't understand how the phrase "carbon neutrality" fits in. [Michael MacCracken, United States of America]

Revised to clarify and neutrality changed to zero net CO2.

3145 4 26 4 31 These sentences are incomprehensible, and should be omitted or greatly simplified. [Michael Rosen, Germany] Sentences simplified somewhat, but many reviewers called for additional details and caveats so we've attempted to balance accuracy/completeness with simplicity concerns.

9492 4 27 4 28 Carbon neutrality is the term which confuse readers, as "Carbon neutral" is well used for biomass. More scientific wording, ex. global net zero CO2 emissions is recommended. [Masato TAKAGI, Japan]

Revised as suggested.

16162 4 28 4 28 The phrase "1.5°C pathways" is really misleading–these are pathways that allow the temperature to overshoot 1.5°C and come back to below 1.5°C by 2100. Such pathways are worthy of 1.5°C pan in terms of impacts through the century. And it also needs to be said somewhere here that this overshooting could lead to nonlinear effects that contribute to warming (e.g., permafrost thawing; ice sheet collapse, etc.) that have traditionally been thought about as consequences of pathways with greater warming. The correct name for such scenarios should reflect the maximum temperature increase during the 21st century and this is well above 1.5°C. This report cannot cover up such situations–it needs to be very clear, and misleading scenarios is really unfortunate obfuscation. [Michael MacCracken, United States of America] As noted in reply to similar previous comment, non-overshoot now included. Text added to ES on possibility of feedbacks coming into play that would be likely to reduce C budgets.

11114 4 28 4 30 It is clear that methane, nitrous oxide and HFCs need to be reduced in addition to stringent CO2 reductions. But why is black carbon mentioned here? This sentence focuses explicitly on 1.5°C pathways, in which co-emitted BC largely disappears under stringent CO2 reductions, and it seems clear that separate or accelerated black carbon reductions do not make a difference at all. See Rogelj et al (2014a). [Michael Schaeffer, Netherlands]

BC is one of the warming agents that need to be reduced, so belongs here. Many BC sources are eliminated in low-C scenarios, but there is no guarantee all will vanish due to low-C2O2 priorities so important to point out that BC reductions needed (via whatever pathway).

Revised sentence to clarify. Text on non-CO2 controls added to "properties of transitions" section later.

7428 4 30 4 31 This sentence focuses explicitly on 1.5°C pathways, in which co-emitted BC largely disappears under stringent CO2 reductions, and it seems clear that separate or accelerated black carbon reductions do not make a difference at all. See Rogelj et al (2014a). [Michael Schaeffer, Netherlands]

Methane is a precursor to tropospheric ozone, and is included. A more general statement would not be accurate as NOx was estimated to have an overall cooling effect in AR5.

8136 4 30 4 30 The radiative forcing during the 21st century due to tropospheric ozone is, for BAU scenarios, about half of the CO2 induced forcing from 21st century emissions (so roughly comparable to methane forcing from 21st century methane emissions), so this list needs to include "precursors to tropospheric ozone"–while it may be that these are roughly proportional to CO2 emissions or something else, it is conceivable to reduce the precursors (or change their ratio) separately from emissions of other species, and a precursors to tropospheric ozone need to be mentioned. [Michael MacCracken, United States of America]
This comment is not clear. First, I don't understand this phrase "carbon budget" would it not be better to say "cumulative carbon emissions"?

Second, there is really no discussion of the time constant here--is this assuming GWP=100 and referring to the temperature change over a year at the end of this period, or is this referring to the temperature change in 2100, or what? Third, without saying roughly how much warming is presently associated with non-CO2 forcers, it is hard to judge how important reductions in emissions of these species could be. I would think the sentence would say something like: "Reducing cumulative emissions of non-CO2 forcers by 5% would be likely to reduce the average increase in global average temperature through the century by about 0.5 C, roughly equivalent to a decrease in cumulative CO2 emissions of about 1000 Gt CO2." (numbers here are of course only illustrative, in making such a statement, however, context is needed for what the projected cumulative emissions changes would be in the CO2 emissions. The earlier sentences give what emissions need to be for a scenario of returning to 1.5 C by 2100 but do not give a sense of how large the reductions in CO2 emissions have to be to get there from, say, the emissions projected to occur based on the commitments under the Paris Agreement. Somehow, the role that cutting non-CO2 emissions needs to be put in context, and this is not at all apparent here. Given numbers available that several hundred GtCO2 is all that is left for emissions, giving the number 2000 GtCO2 for the non-CO2 gases gives to me the mis-impression that cutting such emissions would allow for much more CO2 emissions while staying under 1.5 C, and this is just not correct. [Michael MacCracken, United States of America]

The role of Non-CO2 GHG should be explained in more detail. What is the range of Non-CO2 emissions in the evaluated pathways? Do the given CO2 budgets assume a certain amount of Non-CO2 emissions as unavoidable? [Jakob Wachsmuth, Germany]

Time being discussed now given explicitly. [Agreed, text revised.]

Surely there are problems in equating short term forcers to CO2 using CO2 equivalents? This statement assumes that the time dimension of warming is the same, even though it is not. Does this sentence refer to mitigation of non-CO2 climate forcers in 2050?? It is not clear what this means [Johan Carl Ivar Kuylenstierna, United Kingdom (of Great Britain and Northern Ireland)]

Surely there are problems in equating short term forcers to CO2 using CO2 equivalents? This statement assumes that the time dimension of warming is the same, even though it is not. Does this sentence refer to mitigation of non-CO2 climate forcers in 2050?? It is not clear what this means [Johan Carl Ivar Kuylenstierna, United Kingdom (of Great Britain and Northern Ireland)]

Time being discussed now given explicitly. [Agreed, 'robust' deleted. Numbers not appropriate given specific issues addressed (e.g. degree of uncertainty).]

This is confusing and not a helpful statement for a summary. I suggest to delete:

(1) It is unclear to which carbon budgets this applies to: the section includes 2 types (2016 to 2100; and 2016 to peak warming).
(2) From the section itself it is also unclear if this non-CO2 is accounted for in the budgets provided above.
(3) Finally, it is simply unclear what this sentence contributes to this summary section: indicate additional potential? If so, how & how much? [Serge Farago, Hungary]

This sentence "Non-CO2 - to them" is not interesting for an executive summary. I suggest deleting it [Caterina Stefano, Italy]

Agreed. Time periods involved here.

Paragraph on non-CO2 now included, values expressed per tenth degree.

To mitigate non-CO2 climate forcers CO2eq budgets need to be reduced by 2000 Gt CO2eq... [Toni Winkelbog, Netherlands]

Notes.

Saying such actions would only "quickly exhaust a large share of the compatible carbon budget" is far too optimistic--such actions would quickly wipe out any possibility, without resort to climate intervention or very large carbon removal (points that should be made), of returning global average temperature to below 1.5 C by 2100. The situation is really much more dire than indicated by the wording here. [Michael MacCracken, United States of America]

Saying such actions would only "quickly exhaust a large share of the compatible carbon budget" is far too optimistic--such actions would quickly wipe out any possibility, without resort to climate intervention or very large carbon removal (points that should be made), of returning global average temperature to below 1.5 C by 2100. The situation is really much more dire than indicated by the wording here. [Michael MacCracken, United States of America]

The paragraph on non-CO2 now included, values expressed per tenth degree.

The term "carbon budget" is unclear; this estimate seems to apply to "the threshold return carbon budget" as discussed in section 2.2.3. [Serge PLANTON, France]

Clear definition added.

Don't use the word "robust" unless you define it first, which is hard. Give approximate figures for these sentences. How much? What is the quantitative difference between an overshoot and non-overshoot scenario? [Michael Rowan, Germany]

Agree, 'robust' deleted. Numbers not appropriate given specific issues addressed (e.g. degree of uncertainty)."
The National Determined Contributions (NDCs) submitted by Parties to the Paris Agreement include the national contributions (INDCs and NDCs) specified in relation to the Paris Agreement. (Explanation: in many cases there are still the INDCs submitted before the adoption of the PM and which will be replaced after 5 years.) (Tito Farago, Hungary)

Text mentions that models cannot produce scenarios that are compatible with limiting warming below 1.5°C. However, this is not necessarily an issue of model bias but it is related to the rather limited, but still significant, cumulative impact of the current NDCs. Perhaps the text can be rephrased to clarify this. (Degar Saygin, Turkey)

replace "result in" with "are estimated to result in" [Harald Winkler, South Africa] Agreed. done.

Both now used.

Please check if this is consistently for the GWPs used in the underlying study for the 1.5°C studies. The NDC studies use mainly GWPs based on SAR, whereas the 1.5°C pathways may use other GWPs (Michel den Elzen, Netherlands)

We refer to current pledges which is accurate. Increased ambition is discussed in the chapter.

Topic for 2.3, not the ES, but agreed. This will be dealt with in the cross-chapter box on NDCs, where the 1.5°C GWPs will be consistent with all other 1.5°C pathways.

The first two sentences are supposed to really be one. Wording needs to be adjusted. (Michael MacCracken, United States of America) Sentences revised, but kept as two to prevent an overly long one.

This conclusion strongly impacts on everything on climate policies. It should therefore be highlighted (Milton Nogueira da Silva, Brazil) Section on 'urgency' in revised ES highlights these conclusions.

4 sensitive so needs to be presented carefully (Jonathan Lynn, Switzerland) Noted.

It is correct the use INDCs acronyms instead of NDCs? Please check it out for consistency between sections and chapters (Meralin Moreno, Venezuela)

Both now used.

41 The 49-58 GtCO2-eq yr⁻¹ emission range does not necessarily imply emissions reductions at the global scale given that 2010 emissions are about 50 GtCO2-eq yr⁻¹. Olivier Boucher, France

The 49-58 GtCO2-eq yr⁻¹ emission range does not necessarily imply emissions reductions at the global scale given that 2010 emissions are about 50 GtCO2-eq yr⁻¹. (Olivier Boucher, France) Agreed, text revised.

We refer to current pledges which is accurate. Increased ambition is discussed in the chapter.

With temperature 'overshoot' and large amounts of negative emissions (790-900 GtCO2), the intended reduction of about 40 GtCO2 between now and 2050 may be increased by about 2.5 times. (Michel van Munster, United Kingdom of Great Britain and Northern Ireland)

This number is based on the wider literature including the study by the UNFCCC secretariat. Legally, the US has not yet left the Paris Agreement

UNFCCC in its updated synthesis report on the aggregate effect of NDCs until 2030 estimates the global emission levels of 52.9-59.3 GtCO2 eq in 2050. Is the difference due to different methodology? Has the impact of the US pulling out of the Paris Agreement taken into account? (Himangana Gupta, India)

This number is based on the wider literature including the study by the UNFCCC secretariat. Legally, the US has not yet left the Paris Agreement

The 15°C pathways may use other GWPs (Michel den Elzen, Netherlands)

Both now used.

It needs to be indicated how the CO2-eq is being calculated. If this is with GWP-100, as has been traditional, this gives a quite misleading indication of the situation being faced over the next few decades. The values here would better be based on making the calculations using GWP-20, which will better give an indication of how important the role of non-CO2 climate forcers. And it would be helpful to have a chart showing the various contributions to CO2-eq when based on GWP-20. (Michal MacCracken, United States of America)

We refer to current pledges which is accurate. Increased ambition is discussed in the chapter.

More efficient ways to produce CO2-eq may be used in the chart. (Mervin Mejia, Colombia) Agreed, text revised.

Stated.

The rest of this exec. Summary is far too long and technical. Provide a simple summary of the results described in Chapter 2 keeping in mind that the chapter has to be much shorter than it is, a lot of material must be left out. (Richard Rosen, Germany)

Text simplified where practical, but most reviewers have asked for additional details rather than saying there is too much. The chapter itself will be consistent with the aspects indicated in the approved chapter outline.

Topic for 2.3, not the ES, but agreed. This will be dealt with in the cross-chapter box on NDCs, where the 1.5°C GWPs will be consistent with all other 1.5°C pathways.

The 49-58 GtCO2-eq yr⁻¹ emission range does not necessarily imply emissions reductions at the global scale given that 2010 emissions are about 50 GtCO2-eq yr⁻¹. (Olivier Boucher, France) Agreed, text revised.

Seems already implied by section. Also now stated at start of ES. (Andy Reisinger, New Zealand)

Carbon prices in this sentence mean the marginal abatement costs. If this is correct, "carbon prices" should be deleted because the "mitigation costs" can include the "carbon prices." (Koichi Akitomo, Japan)

Text revised to reflect that mitigation costs can include both carbon pricing and investment costs.

Sentences revised, but kept as two to prevent an overly long one. (Andy Reisinger, New Zealand)

Taken into account.

The models include estimates of technological innovation, but agreed forecasting is not perfect. (Andy Reisinger, New Zealand)

The models include estimates of technological innovation, but agreed forecasting is not perfect. (Andy Reisinger, New Zealand) Agreed, text revised.
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<th>Comment No</th>
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<tbody>
<tr>
<td>14210</td>
<td>4</td>
<td>49</td>
<td>4</td>
<td>49</td>
<td>The phrase 'carbon lock-in' is used without being defined. Given that the commitment to emitting carbon is defined differently by different people, I think a specific definition is better here. [Jason Done, Canada]</td>
<td>The models use various definitions of carbon pricing, and the overall point here is only that these are pushed in the same direction with delayed policies, so we feel no need to use a good definition of carbon in the summary.</td>
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<td>7307</td>
<td>4</td>
<td>49</td>
<td>4</td>
<td>49</td>
<td>Delete the test &quot;promote carbon lock-in.&quot; [Eileen Kilfe, Austria]</td>
<td>As space is severely limited in the ES, we believe this is better left to chapter sections.</td>
</tr>
<tr>
<td>13172</td>
<td>4</td>
<td>51</td>
<td>4</td>
<td>51</td>
<td>Branded investments are mentioned here, but they are neither quantified nor the chapter mentions them again. It may be helpful to refer to some literature on their potential magnitude to put the sentence in context. [Deager Sarguin, Turkey]</td>
<td>Taken into account. The ES was made fully consistent and with a direct line of sight to the underlying chapter.</td>
</tr>
<tr>
<td>19336</td>
<td>4</td>
<td>51</td>
<td>4</td>
<td>53</td>
<td>It also leads to generally higher cumulative CO2 emissions until carbon neutrality and therewith a higher and longer exceeding of the 1.5°C temperature limit, and a higher risk to reach tipping points. [Birgit van Munster, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Tipping points are a topic for ch 3 (impacts not addressed in Ch 2).</td>
</tr>
<tr>
<td>900</td>
<td>4</td>
<td>55</td>
<td>6</td>
<td>47</td>
<td>Surprisingly, nuclear energy is completely left out of the mitigation pathway, whereas massaera energy is the only decarbonized electricity production technique that can produce very large amounts of energy whenever it is needed without demanding huge ground areas as hydroelectricities does. With the breeders, the available uranium is sufficient for millennia of electricity production. [Jean Polou, France]</td>
<td>This is one of the lower carbon sources of energy that is discussed. We've added text to make this clearer.</td>
</tr>
<tr>
<td>17217</td>
<td>4</td>
<td>56</td>
<td>5</td>
<td>5</td>
<td>Delete 'and after' [Hasmina Gupta, India]</td>
<td>Done.</td>
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<td>13173</td>
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<td>3</td>
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<td>6</td>
<td>It may help for the reader to mention the ranges for the carbon budget somewhere in the Executive Summary. [Deager Sarguin, Turkey]</td>
<td>Accepted. They are now included.</td>
</tr>
<tr>
<td>1840</td>
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<td>It’s extensively discussed in Chapter 5. Therefore, such a reference could be here. ”...implications for sustainable development, that is also comprehensively discussed in Chapter 5. (...) [Tibor Farnaq, Hungary]</td>
<td>Revised to state that these transitions are ‘critical parts of 1.5°C scenarios.’</td>
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<tr>
<td>6970</td>
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<td>3</td>
<td>Suggested to replace “show large reductions” by “require large reductions” [Tie Ming Lee, China]</td>
<td>Revised to state that these transitions are ‘critical parts of 1.5°C scenarios.’</td>
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<tr>
<td>3714</td>
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<td>3</td>
<td>You state blandly that there 1.5 scenarios require “large reductions of per capita energy demand”. That may be fine where people are over-consuming, but for countries where large parts of the population have no access to modern energy services, and very low levels of consumption, this is a heartless statement. Assess the literature on achieving mitigation and increasing affordable energy access; and please review here and in the underlying section [Harald Winkler, South Africa]</td>
<td>Clarified to address consumption levels.</td>
</tr>
<tr>
<td>10837</td>
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<td>4</td>
<td>Better specification needed: reduction in per capita energy demand - final energy or primary energy? For a drastically increase in renewables the per capita final energy demand decreases - we see that in our most recent research (not yet published) [Christian Breyer, Finland]</td>
<td>Clarified (see new section on demand-side &amp; behavioural measures).</td>
</tr>
<tr>
<td>19304</td>
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<td>6</td>
<td>The issue of the size of the global population should be mentioned also here, as it is in the body of the chapter. [Maurizio Massioti, Switzerland]</td>
<td>Added to ES.</td>
</tr>
<tr>
<td>16169</td>
<td>5</td>
<td>3</td>
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<td>3</td>
<td>It seems to me that “show” is jargon—what needs to be said that such emissions paths will require large (even very large) and rapid reductions in per capita use of fossil fuels (and associated CO2 emissions). On the issue of reduced energy demand, it seems to me that this is the wrong way to phrase this as it implies a very large reduction in energy services. Actually, with the increased affordable energy from renewables and with the great potential for increased efficiency to sustain energy services using a lot less energy, I’d suggest revising text to give a better indication that there are at least a few reasons of hope instead of the present phrasing. [Michael MacCracken, United States of America]</td>
<td>Revised to state that these transitions are ‘critical parts of 1.5°C scenarios.’</td>
</tr>
<tr>
<td>16170</td>
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<td>4</td>
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<td>6</td>
<td>This seems like a pretty vague statement–how much greater and more rapid? [Michael MacCracken, United States of America]</td>
<td>Both greater and more rapid. Details on this given in chapter sections but too complex for ES in our opinion.</td>
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<tr>
<td>11117</td>
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<td>The transitions are more and greater than in 2°C mitigation pathways &quot;particularly&quot; in the coming decades and up to mid-century, or ONLY in those periods? from the data in the chapter it seems 2°C ultimately needs transitions &quot;as great&quot;, but later. So it’s more rapid, but not greater in the coming decades. Figure 2.6 suggests the only exception is the building sector, but even then over 2100 1.5°C scenarios are still distinct from 2°C, which perhaps is worth highlighting in this summary参, adding substance to the overly generic statement now [Michiel Schaeffer, Netherlands]</td>
<td>This initial discussion of the transitions is designed to give general changes across transitions within scenarios. Additional quantification for specific transitions given in paragraphs below: the evidence for the claim that demand reductions in IAMs are supported by detailed bottom-up studies in the referenced sub-chapters is rather weak. Alternatively provide additional evidence in those sub-chapters or weaken the statement here. (Jakob Wachsmuth, Germany)</td>
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<td>16171</td>
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<td>This phrasing is very strange—&quot;the phrasing would better be to the effect that ‘To get on an emissions path that would allow reducing below 1.5°C by 2100, there must be significant reductions in the use of fossil-fuel derived energy from all end-use sectors, including ...” Just because a scenario shows significant demand reductions has nothing to do with whether it will occur—the text needs to be explaining what must happen, not show what an integrated assessment model shows is necessary. [Michael MacCracken, United States of America]</td>
<td>Revised to state that these transitions are ‘critical parts of 1.5°C scenarios.’</td>
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<td>6971</td>
<td>5</td>
<td>8</td>
<td>5</td>
<td>9</td>
<td>Suggest to replace “show significant demand reductions” by “are required to decrease demand significantly” [Tie Ming Lee, China]</td>
<td>Text revised along lines of suggestion.</td>
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<td>3148</td>
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<td>You use the word “show”, which implies that the demand reductions are calculated. I think they are input (assumed in the models for these two types of scenarios). Not from the models. [Richard Rosen, Germany]</td>
<td>They are calculated in the models. Text revised to say the models include these.</td>
</tr>
<tr>
<td>21100</td>
<td>5</td>
<td>8</td>
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<td>9</td>
<td>Demand reduction: given that the chapter appears to refer to “Energy end-use sectors” without explicitly writing the word “energy”, I have the impression that this could be “energy demand reduction”. Please clarify, considering that both energy demand reduction (including tough efficiency improvement) and final product demand reduction might be in these scenarios - the question is whether or not some or all scenarios include a limitation in the consumption of (material) products, in particular for the most wealthy part of the populations or countries. [Philippe Marbaix, Belgium]</td>
<td>Thank you, clarified in new section on demand-side and behavioural changes.</td>
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<td>11050</td>
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<td>The evidence for the claim that demand reductions in IAMs are supported by detailed bottom-up studies in the referenced sub-chapters is rather weak. Alternatively provide additional evidence in those sub-chapters or weaken the statement here. [Jakob Wachsmuth, Germany]</td>
<td>Strengthened in section.</td>
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<td>16172</td>
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<td>Again, phrasing is unfortunate. Rewire to say something like “integrated model results for 2030 and 2050 indicate that reductions in emissions from (x) sources must continue to occur throughout the century” or something similar— indicate what the models indicate is needed, not what they show will supposedly happen. [Michael MacCracken, United States of America]</td>
<td>Text revised along lines of suggestion.</td>
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<td>20384</td>
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<td>11</td>
<td>Do you really mean “demand reductions” or “energy demand reductions”? Are these lower GDP scenarios? [Oliver Bacher, France]</td>
<td>Thank you, clarified in new section on demand-side and behavioural changes.</td>
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<td>It is not clear to recognize what the scope and how the reductions in demand will be achieved. For instance, is recycling included for the industry sector? [Deager Sarguin, Turkey]</td>
<td>Additional details on demand-side measures are in the chapter subsections.</td>
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<td>add ‘carbon capture and storage’ after ‘switching to lower-carbon fuels’ as it is one of the key technical options. [Isabelle Czernecki-Laurent, France]</td>
<td>Added.</td>
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<td>Key technical and behavioural options are sector specific, but generally include a portfolio of efficiency improvements, demand reduction, CCS and switching to lower-carbon fuels. [Wilfried Maas, Netherlands]</td>
<td>Agreed, text revised.</td>
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14211 | S | 14 | S | 14 | 5 | 14 | It may be better to say: "lower sources of carbon emissions than lower carbon fuels." This would then include wind, solar, geothermal, hydro, tidal and nuclear along with biofuels. 'Fuels' have a technical meaning that is not represented here (water, for example is not a fuel, but a flow). [Jason Donen, Canada] | Accepted - Edit has been implemented |

7429 | S | 14 | S | 15 | 5 | 15 | This is a very relevant finding. Please consider explicitly specifying that the electrification mentioned is assumed to involve a shift/elimination from flexible fuels to play a major role. Please consider to include replacing fossil fuels after "End-use electrification". This is highly policy relevant in countries where a large portion of electricity already comes from renewables. This is also more consistent within the Buildings section in this chapter. [Myrdal Christophersen, Norway] | Revised as suggested. |

3149 | S | 14 | S | 15 | 5 | 15 | You say that end-use electrification plays a major role. Isn't that an understatement? Doesn't end-use electrification play the major role in eliminating fossil fuel use from all 1.5 degree C scenarios, because ALL end-uses are ultimately electrified, or as with airline fuels, the fuels are made using electricity as the energy source. [Richard Rosen, Germany] | Rejected - end-uses are not ALL fully electrified |

9811 | S | 15 | S | 24 | 5 | 15 | I would also present when all GHGs reach zero, and not only CO2 emissions [Michel den Elzen, Netherlands] | Rejected - this speaks to the energy sector only, including all gases for all sectors would make the ES too long |

13175 | S | 17 | S | 17 | 5 | 17 | It may also help to mention what happens to the energy demand emissions [Deger Saygin, Turkey] | Taken into account - this is highlighted later |

9207 | S | 17 | S | 17 | 5 | 17 | Assume that global CO2 and not just CO2! Does every country need to be zero 2030 to 2060? [Olen Petersen, Norway] | Accepted - this is global indeed and has been clarified |

4168 | S | 17 | S | 29 | 5 | 17 | This mitigation pathway is based on two assumptions that carbon capture and storage will be implemented around 2020 but does this take into account the reliability of CCS. According to a report by the Global Warming Policy Foundation-Gordon Hughes the Boundary Dam project in Sask has operated at full capacity. Rather it has operated closer to 40%. This is just one example, but it begs the question: "Can we achieve the mitigation pathway if the technology isn't reliable in its current state?" Additionally, most renewables currently rely on gas or coal as a back up. Until stable storage options or low-carbon baseload like hydro or nuclear are the back up for renewables they will not serve as sufficient mitigation pathways alone. In Germany, for example, most of the wind is backed up by brown coal with most of the fossil fuel imported into the country. [Michelle Leslie, Canada] | Rejected - the mitigation pathways do not rely on CCS being implemented by 2020 |

6972 | S | 17 | S | 17 | 5 | 17 | Suggest to add "have to" before "decline" [Sai Ming Lee, China] | Accepted - the entire sentence has been reworded in order for it to be clear that models are providing us with this insight. |

5707 | S | 17 | S | 17 | 5 | 17 | net' is missing [Hong Yang, Switzerland] | Accepted - change has been implemented |

6141 | S | 17 | S | 17 | 5 | 17 | energy supply is ambiguous. Does this mean 'electricity supply' ? Or do you mean primary energy ? [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)] | Taken into account - energy supply refers to all activities providing energy in all its forms, both electricity and other |

11023 | S | 17 | S | 18 | 5 | 18 | Language should be clearer here. "continued large decreases" means that emissions have to turn negative [Oliver Geden, Germany] | Accepted - the sentence has been edited to clarify this |

16178 | S | 17 | S | 18 | 5 | 18 | Again, phrasing is backward-say what models say is needed to be on this particular type of scenario -don't phrase as if this is going to be happening if the choice is made to be on or (or try to be on) such a scenario. [Michael MacCracken, United States of America] | Accepted - the sentence has been reworded |

6514 | S | 17 | S | 18 | 5 | 18 | Clarify: Is this referring to negative emissions? If yes, please say so. [Michel Schaeffer, Netherlands] | Accepted - the sentence has been edited to clarify this |

602 | S | 17 | S | 18 | 5 | 18 | The "continued large decreases" imply significant negative emissions - this should be made clear in the text as some readers may find this surprising. [David Infield, United Kingdom (of Great Britain and Northern Ireland)] | Accepted - the sentence has been edited to clarify this |

20385 | S | 17 | S | 18 | 5 | 18 | CO2 emissions from energy supply become negative after 2060? [Oliver Boucher, France] | Yes - for the cases indicated here |

1016 | S | 17 | S | 24 | 5 | 17 | It is silly that not a single word is added of the emissions from industry sectors and transport here. At least technological feasibility of zero emissions from iron and cement sectors as well as shipping and aviation should be touched upon here. [Mitsutane Yamaguchi, Japan] | The ES highlights the most robust and important insights in two pages. The iron and cement sectors' assessment was not selected to be amongst those. |

15027 | S | 17 | S | 29 | 5 | 17 | These two paragraphs should also comment on other baseload energy sources, particularly nuclear and CCS/CCUS. What is the balance in 1.5°C scenarios for the energy sector between BECCS, CCS/CCUS, and nuclear (as well as other carbon sequestration methods when looking outside the energy sector)? [Farhan Ahtah, United States of America] | Rejected - this information is not available from the sectoral assessment in section 2.4 |

6951 | S | 17 | S | 48 | 5 | 17 | All other sources of energy currently in use are mentioned except nuclear energy. RE should be mentioned in this paragraph - See Table 2.8 where annual increase of nuclear power is on average 3.5%, exceeding that of the biomass in relative terms. [Ville Tikku, Finland] | Accepted - nuclear is now mentioned as part of the low-carbon portfolio |

710 | S | 17 | S | 30 | 5 | 17 | CO2 concentration stabilization in 2070 without need of CCS, and a CO2 concentration of 370 ppm in 2100 with some BECCS at the end of the century. An improved version (however not published yet) allows a stabilization of the CO2 anthropic cumulated emissions at 800 Gt as soon as 2050, without need of CCS, with option to reach the 1.5°C limit in 2100 with a modest BECCS of 200 Gt. [Harri Nilfrenraker, France] | Noted |

6973 | S | 18 | S | 18 | 5 | 18 | Suggest to replace "increases" by "have to increase" [Sai Ming Lee, China] | Accepted - change has been implemented |
As stating in my overall comment, there is a framing problem here. Renewable energy is an energy that can renew itself. The important aspect that we are looking for in our primary energy portfolio is "low-carbon". This distinction on renewable energy, but for people who need to be convinced to take action on climate change this is a further wedge dividing the population. Many people in the ideological sector use this fascination on "renewable energy" as proof that the climate community doesn’t understand people’s needs for energy. I realize the foolishness in bending to the will of the fossil fuel industry, but we must be rigorous in how we approach this. [Jason Donev, Canada]

This is an example of a generic problem throughout this chapter and report. Here where it says that renewables increases rapidly and becomes the dominant source of energy by 2050 in most scenarios, you need to explicitly distinguish between statements that apply to non-overhoot and overshoot 1.5 degree scenarios. After all, in non-overshoot scenarios, renewables have to provide roughly 100% of the energy long BEFORE 2050. Thus, I suggest the all the discussions of scenarios in Ch.2 be clearly differentiated clearly for the reader between these two basically different types of 1.5 degree scenarios. As you know, the near term implications of these two types of scenarios are very different for the next 10-15 years, and the reader needs to be very clear about that. This whole point of this chapter, and the entire report, should be to compare and contrast those two types of 1.5 degree non-overshoot scenario, along numerous aspects and dimensions. Thus, all subsections of chapter 2 need to be completely re-organized so the differences and similarities of those three basically different types of scenarios are clear!! [Richard Rosen, Germany]

Suggest to replace "starts" by "have". [Sai Ming Lee, China] Editorial - this statement has been removed

Is the 1.1 EJ yr-1 correspond to primary energy from coal? [Olivier Boucher, France] Yes

Coal usage is phased out rapidly - I assume by phase out you mean zero - by when? Chapter seems to refer to 7% in 2050. [Harald Winkler, South Africa]

The unit "EJ yr-1" is not entirely appropriate for measuring installed capacity, as it makes implicit assumptions regarding the load factor (hours/yr) of the technology. [Kenneth Möllersten, Sweden] Rejected - this information is not available at this level of detail

I miss substantial debate, also in this chapter on the very limited available biomass resource, in particular for BECCS; more references to doi:10.1111/gcbb.12235 and DOI 10.1007/s13412-017-0445-6 [Christian Breyer, Finland] Accepted - this has been included

One would expect EMISSIONS from coal power to be close to completely phased out after 2050. The sentence here is not useful enough, because it does not reflect the chapter insight "As for coal, scenarios with higher natural gas demand require higher penetration of CCS, while lower demand scenarios are able to achieve 1.5°C with lower rates of CCS utilisation". This leaves the urgent question of what is the Eyr, or share of global energy supply from residual coal plants without CCS in 2050? This is very relevant and cannot be derived from the current headline message "In case coal use is not yet entirely phased out by 2050, 40-100% of it is combined with carbon capture and storage..." - because the 40% could be correlated with very small share of coal (no CCS & CCS) and the near-100% number with larger shares. [Michiel MacCracken, United States of America] Taken into account - this assessment is part of the Chapter 4 assessment and should come together in the SPM.

This is reporting on what the models include, and in cases in which coal is not fully phased out they utilize CCS. The sentence is preceded, however, with the statement (in the SOD) that "Coal usage is phased out rapidly in pathways consistent with 1.5°C", so we believe the text is consistent with this review comment already.

Suggest to replace "is phased out" by "has to be phased out". [Sai Ming Lee, China] Editorial - rejected

Are the CCS deployment rates "soon after 2020" realistic in the real world? This is extremely important since mitigation pathways with components that are potentially unrealistic have limited value. [Kenneth Möllersten, Sweden]

This notion that "carbon capture and storage" will be cost effective in the near term seems quite fanciful--that this has yet to be achieved needs to be highlighted. [Kenneth Möllersten, Sweden]

The emphasis on bioenergy is a well justified model for APS. This chapter should address all technological options for contributing to emission reductions, including CO2 recycling and associated technologies rather than reiterating fossil fuels. Diversification should not be the result of the model being the right answer. [Hans Poertner, Germany] Accepted - a statement on what is included and excluded in mitigation pathways has been included

Wide range of futures for natural gas, with and without carbon capture and storage. [Wimfit Massa, Netherlands] Accepted - this clarification has been made

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The rates of change of energy infrastructure and fossil fuel investments are critical for understanding climate change. The decrease in fossil electricity investments is important, as it suggests a reduction in the need for new power plants. However, the decline in this sector should not lead to complacency. Additional investments are needed in renewable energy sources, such as solar and wind power, to ensure a smooth transition towards a low-carbon future. The models used to predict these changes are imperfect, and their limitations must be acknowledged. The need for a disruptive shift is further underscored by the study of Herrala and Goel (2016, page 34) regarding the required changes in fertilizer use. The text suggests an overall decline in energy infrastructure, while the fossil electricity investments decline. The text also mentions the need to replace "supplies" by "has to supply" (Sai Ming Lee, China). This change is important to ensure consistency in the language used in the report. The need for a disruptional shift is also mentioned in the Context section, which in turn relies on the available literature. The suggested statement is taken into account - this refers to bioenergy as a whole, including BECCS. This section has been removed from the Chapter 2 ES. It is not fully clear whether the compared fossil fuel energy is in 2050 or today (Deger Saygin, Turkey). This means roughly 10,000 CCS sites are necessary globally. There should be several papers discussing these physical limits (Mitsutsune Yamaguchi, Japan). After the sentence ending with "... by 2050", please consider adding a new sentence: It is worth noting that the models do not fully capture the possibilities associated with "disruptive change" (25.1.2 and 4.2.3.1). Disruptive change in sectors such as transportation and power production, could potentially reduce the need for large-scale deployment of biomass energy. The next sentence should have to be changed accordingly: Greater implementation of biomass energy combined with carbon capture and storage is required when phase out of fossil fuels proceeds more slowly.) (Oyvind Christophersen, Norway) It is not fully clear whether the compared fossil fuel energy is in 2050 or today (Deger Saygin, Turkey). This means roughly 10,000 CCS sites are necessary globally. There should be several papers discussing these physical limits (Mitsutsune Yamaguchi, Japan). It is not fully clear whether the compared fossil fuel energy is in 2050 or today (Deger Saygin, Turkey). This means roughly 10,000 CCS sites are necessary globally. There should be several papers discussing these physical limits (Mitsutsune Yamaguchi, Japan). All of these changes are important to ensure consistency in the language used in the report.
What is the temperature increase in these 1.5°C pathways if in mid-century CDR ends up not being used? Roughly 0.3 to 0.4°C higher based on a central TCRE estimate of 1.65°C/1000PgC.

If there is no CDR then there is no point in having 1.5°C pathways at all. It becomes a nonsensical exercise. This also questions the use of negative emissions in the other pathways which are presented. It questions their feasibility. It would be very useful if the authors could comment on this issue in a more substantial way. Roughly quantifying the scenario assumptions (negative emissions, population growth, per capita energy, food- and natural resources demand) required to achieve the 1.5°C pathways in the summary is essential to understand the scale of the transformation needed. (Bing van Munster, United Kingdom (of Great Britain and Northern Ireland))

Noted. The summary draws from the chapter assessment. Whatever is not assessed in the chapter should not be highlighted in the ES.

Micro-economic costs are not assessed in the chapter and are hence also not highlighted. The ES highlights that "Under conditions of high population growth (and associated low educational attainment for females), low economic development, and limited efforts to reduce energy demand, no 1.5°C pathways have been identified." Given the space constraints of the ES, probably not much more can be said on this topic here.

Clarify "cumulative mitigation" is understood (Michel Schaeffer, Netherlands)

This sentence was removed.

It means there is no low-carbon technology that are compulsory. If some societies decide to exclude some ones (bi, CCS, nuclear...), they must be conscious that it will be more difficult or costly to reach the target. But some lifestyle changes are also powerful. The following reference can be considered for France (Promov, 2011) (Eric Vitalenc, France)

Replaced - this ES only summarizes the Chapter 2 assessment, not the assessment of Chapter 4.

CDR techniques are embedded in the scenarios well before mid-century, but this is not obvious in the Executive Summary - please amend. (Christiane Tietz, Germany)

A sentence has been included.

What is the temperature increase in these 1.5°C pathways if in mid-century CDR ends up not being used? (Levi Golston, United States of America)

This section has been removed from the Chapter 2 ES.

It would be helpful if the relevance of underlying socio-economic pathway could be demonstrated further with specific quantitative examples, and also by comparing how e.g. costs differ for a 1.5 goal and SSP1 and SSP5, and between a 1.5 and 2 degree goal for SSP1, and for SSP5, individually. i.e. when thinking about costs, is the stringency of the climate goal or the underlying development pathway the more critical determinant? Also, it seems that pathways keep on having an iron grip when it comes to hitting the 1.5°C target, and that the main reason is not how well we do on land-use and agriculture, but on carbon removal. There is zero discussion of the economic costs of large-scale CDR. (Claude Delaporte, Belgium)

This section has been removed from the Chapter 2 ES.

If there is no CDR then there is no point in having 1.5°C pathways at all. It becomes a nonsensical exercise. This also questions the use of negative emissions in the other pathways which are presented. It questions their feasibility. It would be very useful if the authors could comment on this issue in a more substantial way. Roughly quantifying the scenario assumptions (negative emissions, population growth, per capita energy, food- and natural resources demand) required to achieve the 1.5°C pathways in the summary is essential to understand the scale of the transformation needed. (Bing van Munster, United Kingdom (of Great Britain and Northern Ireland))

This section has been removed from the Chapter 2 ES.

It is one of the most important issues that this report needs to address! Chapter 2 does not even say what the capital and other costs of the various CDR technologies used in the IAMs after 2030 are. These cost assumptions must be provided for all CDR and renewable energy technologies for every IAM relied on so that their costs and benefits can be compared and understood by all policymakers.

This section has been removed from the Chapter 2 ES.

It is really strange to have this attention to CDR (which is welcome) and have zero commentary on the huge literature about the infeasability of bold CDR (BECCS, notably) scenarios. It is as if that whole literature does not exist. Indeed, the whole Executive Summary is oddly silent on the writing of a key literature. Because of the attention to BECCS, in particular, it would be helpful to have findings focused on that before the more general attention to BECCS plus the rest of CDR (including afforestation) all together. I know the team's assessment of the literature about the realism of these scenarios. It is as if that whole literature does not exist. (Michael MacCracken, United States of America)

This section has been removed from the Chapter 2 ES.
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**Comment**

*This heavy dependence on BECCS emphasizes the problems of IAMs in accounting the real ecosystem changes.*

*Tuomo Kalliokoski, Finland*

*Noted. Chapter 2 in this context relies on the assessment carried out by Chapter 4.*

*Accepted - this has been edited*

*Comment Response*

*Editorial - accepted and implemented*

---

*Delete commas and 'respectively'*

*Roger Bodman, Australia*

*Accepted - this has been edited*

*Editorial - accepted and implemented*

---

*A key feature of mitigation pathways for 1.5 degrees that should be highlighted is that CDR is introduced by 2030 and that already at 2050 substantial amounts of CO2 are removed annually.*

*Tuomo Kalliokoski, Finland*

*Noted. Chapter 2 in this context relies on the assessment carried out by Chapter 4.*

*Accepted - this has been explained in the previous sentence*

---

*It may be good to mention that while temperature is relatively easily reversible, other components of the climate system, such as sea level rise, continue to change despite negative emissions. (Please see comment #2 below for references, which partly applies here as well).*

*Katarzyna B Tokarska, United Kingdom (of Great Britain and Northern Ireland)*

*Taken into account - these aspects should come out of the Chapter 3 assessment*

*Accepted - the ES includes both the compatible carbon budgets and the amounts of CDR*

---

*The potential of afforestation is underestimated because recent results of sustainable agroforestry have been published only recently. In fact, large scale, sustainable afforestation is possible and economically interesting given the demographic trends, which show a 50% increase of population between 2020 and 2050. This means workforce will be there to meet the demand of afforestation in (and less recently) deserted areas, which is the best available solution for carbon capture and storage for environmental and economic sustainability. Reference: “Moving carbon between spheres, the potential osmotic-carbonate pathway of Bromus autumnalis Sc- Moraceae, M. C. Rowley & H. Estrada-Medina & M. Tsoi-Gambos A & Rozin G & Callejas E.P. V. Verrecchia & I. Green, Plant Soil (2017) 412:465–479”, https://doi.org/10.1007/s11104-016-3135-3 [Stephan Savarese, France]*

*Taken into account - A more detailed account of BECCS as a strategy has been included in the IPCC, highlighting that there are also all instances in which BECCS is used much less. However, this assessment is focussed on issues related to a warming of 1.5°C. The scope for further discussions and issues is thus not available.*

*Accepted - the ES includes both the compatible carbon budgets and the amounts of CDR*

---

*A key feature of mitigation pathways for 1.5 degrees that should be highlighted is that CDR is introduced by 2030 and that already at 2050 substantial amounts of CO2 are removed annually. Presenting only the century-level data gives very vague idea of the role of CDR. [Kenneth Mikkelsen, Sweden]*

*Taken into account - these sustainability aspects will further be discussed by Chapters 4 and 5.*

*Accepted - the full assessment of further mitigation options is carried out by Chapter 4.*

---

*A sentence “The total amount of CDR projected … with a third to half” … would benefit from a clarification : readers of the ES may wonder what the other third (or half) is : I assume that it is CDR before carbon neutrality, but I think that it would be better to write it explicitly.*

*[Philippe Maubais, Belgium]*

*Taken into account - this sentence has been updated*

---

*This heavy dependence on BECCS emphasizes the problems of IAMs in accounting the real ecosystem changes.*

*Tuomo Kalliokoski, Finland*

*Noted. Chapter 2 in this context relies on the assessment carried out by Chapter 4.*

*Accepted - the ES includes both the compatible carbon budgets and the amounts of CDR*

---

*The scenario “Efficiency-N” starts BECCS in 2050 in order to reach a total stored of 280 GtCO2 in 2100. Note that this dose not help climate means that we are betting on the implementation of quite controversial strategies, and implementing them needs careful consideration if they are ever to come to fruition.*

*Tuomo Kalliokoski, Finland*

*Noted. this degree of realism should come from the integration of the assessments of chapters 2 and 4.*

*Accepted - this has been edited*

---

*It may be good to mention that while temperature is relatively easily reversible, other components of the climate system, such as sea level rise, continue to change despite negative emissions. (Please see comment #2 below for references, which partly applies here as well).*

*Katarzyna B Tokarska, United Kingdom (of Great Britain and Northern Ireland)*

*Taken into account - these aspects should come out of the Chapter 3 assessment*

*Accepted - a sentence has been added*

---

*The potential of afforestation is underestimated because recent results of sustainable agroforestry have been published only recently. In fact, large scale, sustainable afforestation is possible and economically interesting given the demographic trends, which show a 50% increase of population between 2020 and 2050. This means workforce will be there to meet the demand of afforestation in (and less recently) deserted areas, which is the best available solution for carbon capture and storage for environmental and economic sustainability. Reference: “Moving carbon between spheres, the potential osmotic-carbonate pathway of Bromus autumnalis Sc- Moraceae, M. C. Rowley & H. Estrada-Medina & M. Tsoi-Gambos A & Rozin G & Callejas E.P. V. Verrecchia & I. Green, Plant Soil (2017) 412:465–479”, https://doi.org/10.1007/s11104-016-3135-3 [Stephan Savarese, France]*

*Taken into account - the full assessment of further mitigation options is carried out by Chapter 4.*

*Accepted - this has been explained in the previous sentence*

---

*The scenario "Efficiency-N" starts BECCS in 2050 in order to reach a total stored of 280 GtCO2 in 2100. Note that the CO2 emissions vanish in 2060. DO NOT Quote, Cite, or Distribute Page 24 of 107*
**IPCC WGI SR15 First Order Draft Review Comments And Responses - Chapter 2**

**Comment**

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**Response**

- *The Executive Summary should explicitly refer to the sustainable development challenges of BECCS that are raised in Chapters 4 and 5.*
  - Taken into account - in as far as possible these challenges are highlighted, yet without attempting to duplicate the effort of Chapter 4. The SPM brings these assessments together.

- *Since role of land, forest and soil became key, the problem now is that knowledge on their carbon stocks and emission and degradation mechanism in the spot is still not enough.*
  - Taken into account - these sustainability aspects will further be discussed by Chapters 4 and 5.

- *The Executive Summary should explicitly refer to the sustainable development challenges of BECCS that are raised in Chapters 4 and 5.*
  - Taken into account - in as far as possible these challenges are highlighted, yet without attempting to duplicate the effort of Chapter 4. The SPM brings these assessments together.

- *The unit Mha is not usual. Add conversion to km² as footnote or use only km² (see ch. 3, p. 8, line 28).*
  - [Radim Tolasz, Czech Republic]
  - This statement has been removed

- *Uncertainties in key input data (absorption and geoengineering?) are also briefly to be mentioned.*
  - [Shuzo Nishioka, Japan]
  - Accepted - these uncertainties are now also mentioned

- *This para (and indeed the chapter) tends to ignore analysis at the national scale. Significant progress has been made, and much more national modeling is needed, especially with the key role of nationally determined contributions post Paris (Harald Winkler, Hungary).*
  - [Tibor Farago, Hungary]
  - Given the large uncertainty in land developments, this message has been made more general to communicate a more robust insight

- *In order to put the land use numbers in context, it would help to mention total pasture land in the year 2050/2100.*
  - [Deger Saygin, Turkey]
  - Taken into account - additional CDR measures would be discussed in Chapter 4

- *Given this high demand for land (and some indication of percentage should be given for context), it needs to be indicated that there is potential for shifting at least some of the requirement for CO2 withdrawal to ocean areas, preferably using approaches that provide all required nutrients so they can be done in open ocean areas where there is currently little biological activities instead of trying to just add iron in areas where nutrients are apparently being used, at least in that location.*
  - [Michael MacCracken, United States of America]
  - Accepted - this has been clarified

- *Greatly improved public health and other specific objectives included in the 2030 Agenda and its various SDGs, which are comprehensively discussed in Chapter 5.*
  - [Tobias Farooq, Hungary]
  - This statement has been removed

- *Given the large uncertainty in land developments, this message has been made more general to communicate a more robust insight.*
  - [Michael MacCracken, United States of America]
  - Taken into account - this has been clarified

- *The Executive Summary should explicitly refer to the sustainable development challenges of BECCS that are raised in Chapters 4 and 5.*
  - Taken into account - in as far as possible these challenges are highlighted, yet without attempting to duplicate the effort of Chapter 4. The SPM brings these assessments together.

- *The source of biomass energy and its land-use implications was not in the focus of the assessment by this chapter because these aspects fall within the scopes of Chapters 4 and 5 as well as the Special Report on Land.*
  - [David Waskow, United States of America]
  - Taken into account - additional CDR measures would be discussed in Chapter 4

- *The unit Mha is not usual. Add conversion to km² as footnote or use only km² (see ch. 3, p. 8, line 28).*
  - [Radim Tolasz, Czech Republic]
  - Taken into account - these sustainability aspects will further be discussed by Chapters 4 and 5.

- *Uncertainties in key input data (absorption and geoengineering?) are also briefly to be mentioned.*
  - [Shuzo Nishioka, Japan]
  - Accepted - these uncertainties are now also mentioned

- *The land requirement for afforestation is irrelevant, when the appropriate techniques are used: namely, when using techniques that enable afforestation of land which is no longer used because too arid/sterile. The foreseeable increase of population in vast rural and suburban areas makes it possible to consider afforestation on a massive scale, as shown in references [1] and [2]. This is a paradigm shift, since there is no longer any competition between crop agriculture and agroforestry (which enables feeding humans from forest products, rather than crops, thereby regenerating soils instead of exposing soil to erosion). The relative reduction in crop and livestock requirements (compared with other 1.5°C scenarios) enables a complete replacement of BECCS with Agroforestry CCS. The rest of the GHG budget reduction is achieved thanks to low-GHG energy sources [3]. References: [1] https://exitcoalnow.org/WECAN/7mu2CO2_agroforestancid: [2] http://climateanalytics.org/files/feasibility_1o5c_2c.pdf.*
  - [Michiel Schaeffer, Netherlands]
  - The source of biomass energy and its land-use implications was not in the focus of the assessment by this chapter because these aspects fall within the scopes of Chapters 4 and 5 as well as the Special Report on Land.

- *The Executive Summary should explicitly refer to the sustainable development challenges of BECCS that are raised in Chapters 4 and 5.*
  - [Michael MacCracken, United States of America]
  - Accepted - this has been clarified
the status of IAMs is still not good enough, see also the general comment in the very beginning. A very good example is the well-known Ecom et al. article (http://dx.doi.org/10.1016/j.sitco.2013.09.017) which documents how low the potential of renewables as the entire IAM community. (the key conclusion is that a mitigation strategy cannot work without nuclear of fossil-FCE; however the 60 year-very-conservatively reviewed RE articles prove that this bold statement is not correct). Even Schaefferhuber et al. (2016; nature climate change, 6. 9:49) critiqued the very conservative assumptions of IAMs in the field of renewables. Creutzig et al. (DOI: 10.1038/nenergy.2017.140) showed recently in a very clear and drastic way how wrong the IAMs are. Breyer et al. (DOI: 10.1022/pis.2885) also recently criticized the fully outdated cost assumptions on renewables, in particular solar PV in the IAMs. None of this critique is mentioned in the chapter 2, which is form the scientific point, not acceptable at all. It needs to be clearly pointed out, where are all the deficits and these deficits have to be eliminated in the near future. Clearly, such words are missing. [Christian Breyer, Finland]

Comment

Response

16183 7 3 7 4 This sentence is misleading—at least most of the scenarios evaluated are for getting back below 1.5 C in 2100, and this is not “limiting” warming to 1.5 C as impacts associated with the overshoot temperature reached will be occurring. In the first and then later sentences it needs to be made very clear that the scenarios are aimed at getting back below 1.5 C. [Michael MacCracken, United States of America]

Comment

Response

16184 7 6 7 6 Rather than “embell” say “require”. Indicate what the scenarios/simulations indicate must happens required rather than suggesting that this is what they will happen or will occur. And indicate that, in reality, even more is needed to really stay below 1.5 C to avoid overshoot. [Michael MacCracken, United States of America]

13966 7 9 9 Definite climate protection [Elvira Poloczanska, Germany]

Comment

Response

2782 7 13 The text could be expanded to include Box 2.2 or text relating to cost-effectiveness as the relevant optimization criterion. It should be noted that cost-effectiveness in this context covers only mitigation costs, adaptation costs and residual damages are not considered. Box 2.2 does not make that point. [Erik Hate, Canada]

Comment

Response

3152 7 12 7 13 This sentence says that mitigation scenarios are typically developed by optimizing costs (and benefits). I assume this means that, in fact, all the scenarios used in chapter 2 WERE, IN FACT, developed by IAMs which rely on some form of cost/benefit analysis or optimization. But the Executive summary of chapter 2 says that cost benefit methodologies are important so as the basis for scenario development - which I totally agree with, especially when the IAMs used for the IAS database leave out many major costs and benefits of mitigation scenarios. (Again, see my paper in Climate Change Economics, vol 7, no 1 for a critique of these IAMs.) THIS IS A HUGE AND VERY IMPORTANT CONTRADICTION - THEREFORE THIS WHOLE ISSUE HAS TO BE RESOLVED BY ALL THE AUTHORS AND STEERING COMMITTEE MEMBERS RESPONSIBLE FOR THIS REPORT!! Either way, if the IAMs relied on are accepted or rejected, Chapter 2 must be thoroughly restructured to discuss the issues and results that arise from the approach taken. If it is decided that cost-benefit methodologies can be used that both methodologies can be used (cost/benefit analysis and scenarios designed using other approaches including expert judgement), then all issues need to be addressed from both perspectives. [Richard Rosen, Germany]

Comment

Response

3153 7 14 Achieving the sustainable development goals is mentioned here very casually. Yet, as far as I know, none of the IAMs relied on for the pathways developed earlier in this chapter 2 or model and examine the costs and benefits of any of the non-energy related SDGs. Thus, this subject needs to be discussed more honestly. Which IAMs can model which SDGs, if any can? The policy makers need to know much more about the strengths and weaknesses of each IAM if they are going to continue to be trend in this report. This perhaps represents a significant conflict of interest for the lead authors who are on IAM research teams. Probably non-IAM research team authors should update the sections of chapter 2, and other chapters, that deal with the IAMs. [Richard Rosen, Germany]

Comment

Response

20265 7 16 Define acronym IAM at final usage in this Chapter body [although it was defined on page 32 of Chapter 1] [Aaron Glenn, Canada]

Comment

Response

12897 7 16 Define IAMs [Jorge Carasso, Chile]

Corrected.

14170 7 16 Please define IAM acronym (Integrated Assessment Model) when firstly cited. [Alexandre Strapasson, Brazil]

Corrected.

13957 7 16 spell out IAM before using acronym [Elvira Poloczanska, Germany]

Corrected.

9035 7 16 The meaning of the Integrated Model Assessment acronym (IAM) is it is not explained the first time it appears in the chapter. [Ogde Acazar, Spain]

Corrected.

9548 7 21 In Section 2.5, nothing mentioned on SDGs. If this “sustainable development objectives “ includes SDGs, it should be mentioned in 2.5. [Shuzo Nishioka, Japan]

Taken into account - text revised in line with sustainable development (e.g. introduction, section 2.5.9). Please note that SDGs are treated explicitly in Chapter 5.

9573 7 21 In Section 2.5, nothing mentioned on SDGs. If this “sustainable development objectives “ includes SDGs, it should be mentioned in 2.5. [Shuzo Nishioka, Japan]

Taken into account - text revised in line with sustainable development (e.g. introduction, section 2.5.9). Please note that SDGs are treated explicitly in Chapter 5.

1503 7 26 Pathway is the better word that “path” in the whole chapter [Ken’ichi Matsumoto, Japan]

Noted.
This comment discusses the types of pathways in terms of the shape of their temperature evolution. As it does not cover the mitigation methods employed, we do not believe it would be an appropriate place to add discussion of types of mitigation.

The mandate of the report is to examine 1.5°C mitigation pathways, but the Paris Agreement does not specify stabilization explicitly (though refers to balance for GHGs). We therefore maintain that 1.5°C and a lower target, is the target that this report should look at, but we have revised the text to elaborate that there are multiple options for the trend with a reference to the discussion in section 1.2.3. Note that the scenarios include overshoot-cooling, as suggested in this comment.

The overview of the climate change implications for mountain regions is based on the current contributions/pledges and both the SR15 and the AR6 will hopefully motivate the Parties to raise their ambitions. The issues that need to be considered are very climate-dependent and there are still the INDCs submitted before the adoption of the PM and which will be updated 5 years later, moreover, each Party shall submit new INDC every five years which will represent a progression beyond the Party’s then current NDC – that is why important to mention that the above statement is based on the current contributions/pledges and both the SR15 and the AR6 will hopefully motivate the Parties to raise their ambitions.

The text seems to suggest that it is desirable to get to a warming of 1.5°C and then stay there, here referring to 1.5°C as "a normative end point." While the UNFCCC does talk about stabilizing and so perhaps that 1.5°C is seen as an end point, but consideration of the impacts of such warming (including impacts on sea level) make clear that real stabilization of all aspects of the climate (including sea level) and broadly considering the impacts from 1.5°C average surface warming) will not occur if the global average temperature is the only variable considered (the ocean will keep warming, ice sheets will keep losing mass, sea level will keep rising affecting all sorts of marine species, forests and ecosystems will keep changing, etc.). Scientifically, getting back to what might call stabilization of all the various components of the climate system likely requires going back to warming well less than 1.5°C. As a second, but related point, seeking to stay at 1.5°C will likely require some effort to sustain that warmer level given that getting down to that level will mean essentially giving up fossil fuels and it would likely be then expensive to continue to sustain CO2 and other GHG levels to keep global warming at 1.5°C. So, again, I simply don’t understand this notion of considering 1.5°C don’t say anything about the imperative. Instead, we need to consider 1.5°C as, if at all possible, a peak warming, and otherwise a point along the way to stabilization of the grander climate system (so, ice, oceans, and ecosystems also stabilized) at a much lower increase in global average temperature above preindustrial. (Michael MacCracken, United States of America)

This comment is based on the current contributions/pledges and both the SR15 and the AR6 will hopefully motivate the Parties to raise their ambitions. This paragraph could be included to indicate that climate engineering, both CO2 removal and albedo enhancement, are also possible elements of various pathways. (Michael MacCracken, United States of America)
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<td>Agreed, merged now into section 2.1.1</td>
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<td>how are these obtained and how is this linked to the SSSPV? [Esha Shaw, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>As described at the end of the following paragraph, discussion of these assumptions within recently developed 1.5°C scenarios is given in Section 2.1.4</td>
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<td>It is a bit surprising here that there is no mention here of the possible influence of natural events or variations, so major volcanic eruptions, slight decreases in solar radiation, very large El Ninó or occurrence of extreme events, overreaks of the global agricultural system, collapse of key ice streams from Antarctic or Greenland ice sheets, etc. A true risk-based analysis would be looking at the risks of such natural or extreme influences, at least giving them some discussion on the role of such risks bearing to guide approaches for governments and businesses could be carried out. [Michael MacCracken, United States of America]</td>
<td>Added sentence on this to previous section on scenario impacts being probabilistic.</td>
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<td>I strongly suggest adding technical learning to the list of reasons why scenarios should not be seen as a realistic future pathway. Substantial work in the grey literature (see DIPECHO in particular) and recent Cressig et al. Nature energy paper show the key role that the rate of tech learning can play in the outcomes of scenario analyses. I would like to see a new section somewhere in 2.3.4 on how up to date the key IAMs used in SR1.5 are with respect to the current price and learning rates of renewable energy technology and competitors (fossil energy, BECCS). [Christopher Weber, United States of America]</td>
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<td>First and second sentences merged so as to have one making the relevant point.</td>
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<td>The models are aimed at temperature but use forcing to guide them. We address limitations and SLCPs later in the chapter, but we maintain the description of the scenarios here as using forcing targets since that's how they were created.</td>
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<td>8</td>
<td>38</td>
<td>The implicit notion here that the target can be based on a forcing in 2100 takes me back to the major Energy Modeling Forum study of several years ago that set a target of something like 2.9 W/m² in 2100 and looked at the least expensive ways to get to that. A problem not early on recognized in formulating the problem this way is that what matters for climate is not the forcing in 2100, but the accumulated forcing over time—and this led to some investigators allowing, for example, black carbon to be emitted without controls to 2050 and methane to 2050 or so, for the shorter lifetimes of these species meant that some magic control device could quickly and inexpensive (given the discount rate) bring their concentrations back to necessary levels by 2100—so overshoot was allowed. This was all done not keeping the focus on what the temperature and climate changes would be—just what the forcing would be. Well, the study ended up being quite problematic and having to be modified. So, I'd just note that, as far as the climate is concerned, having the IAMs to be used to project to 2100 can give quite misleading results—indeed much less than optimal results—for how best to keep climate change in check. It seems to me that what are needed are IAMs that optimize scenarios based on keeping overall impacts to a minimum and not choosing some single year when radiative forcing must be at a certain value. I am suspicious already—and the text of lines 42-53 does not reassure this at all. [Michael MacCracken, United States of America]</td>
<td>The models are aimed at temperature but use forcing to guide them. We address limitations and SLCPs later in the chapter, but we maintain the description of the scenarios here as using forcing targets since that's how they were created, but we note that the temperature responses are what's assessed in this chapter so there are no alternative scenario responses.</td>
</tr>
<tr>
<td>4761</td>
<td>8</td>
<td>38</td>
<td>8</td>
<td>38</td>
<td>What does &quot;otherwise similar scenarios&quot; mean? An explanation or example should be given. [Elaina Georgopoulou, Greece]</td>
<td>Changed to &quot;scenarios with similar socio-economic assumptions&quot;</td>
</tr>
<tr>
<td>5161</td>
<td>8</td>
<td>39</td>
<td>8</td>
<td>40</td>
<td>Add a fourth category: d) technology lead scenarios (= 100% RE/SE scenarios) [Svein Teise, Australia]</td>
<td>The type of technology used is part of the 'various socio-economic assumptions' already included in the variations described for class a.</td>
</tr>
<tr>
<td>4762</td>
<td>8</td>
<td>39</td>
<td>8</td>
<td>40</td>
<td>It would be better to say 'years of scenarios with a path that follows the NOC until 2030, and much more stringent mitigation actions afterwards, as some NOC's imply stringent actions early on and up to 2050, while others do not share this effort.' [Elaina Georgopoulou, Greece]</td>
<td>Revised similar to suggested.</td>
</tr>
<tr>
<td>12732</td>
<td>8</td>
<td>39</td>
<td>8</td>
<td>40</td>
<td>Since there is no single NDC, sentence should be rephrased to &quot;...path that follows the country/regional NDC until 2030.&quot; [Vassiliki Dangou, Netherlands]</td>
<td>Revised to plural, and INDICaNDCs (as in reply to comment 1844).</td>
</tr>
<tr>
<td>3297</td>
<td>8</td>
<td>46</td>
<td></td>
<td></td>
<td>Quantity Fine - would it be better to say that if there is at least one 1.5 degree path? ... [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Seemed unnecessary to say we could assess these if they existed, as of course they couldn't be assessed if there weren't any, so deleted this phrase.</td>
</tr>
<tr>
<td>5162</td>
<td>8</td>
<td>51</td>
<td>8</td>
<td>51</td>
<td>Add technology list and market performance over the past decade to bring technology choice in the context of current markets. Suggested to use REN21 - Global Status Report Renewables 2004 till 2017 as a reference for the RE side. [Svein Teise, Australia]</td>
<td>This sentence gives some examples from AR5, but is not meant to be an exhaustive description. We believe that the phrase 'which technologies are important' is enough to describe that various technologies and how they are assessed to change over time were looked at in AR5 and believe it would be distracting to add a list here and go into market performance.</td>
</tr>
<tr>
<td>6631</td>
<td>8</td>
<td>55</td>
<td>8</td>
<td>55</td>
<td>The word 'pathways' should be changed to 'pathway' [Victor Ongorna, Kenya]</td>
<td>Done.</td>
</tr>
<tr>
<td>17954</td>
<td>8</td>
<td>55</td>
<td>8</td>
<td>6</td>
<td>The FOD text remarks that &quot;it is unrealistic that any pathways developed today will be exactly followed.&quot; It would be appropriate here to make clear that pathways are specifically crafted not to be maps to be &quot;exactly followed&quot;, but rather to help clarify the choices facing policymakers and their political implications. In this context, it is important to reflect on the argument by Beck, S. &amp; M. Mahony, Nature Clim Change (2017). <a href="https://www.nature.com/articles/nclimate3264">https://www.nature.com/articles/nclimate3264</a> - that pathways and scenarios do not represent possible futures, but also help to bring certain futures into being - that the way pathways are produced and presented have implications for what kind of futures are seen as possible by policymakers, and what kinds of questions they can ask. It would be good if the report more explicitly recognize this aspect of its role. [Bard Lahn, Norway]</td>
<td>Thank you, text on this added to last paragraph in section 2.1.2</td>
</tr>
<tr>
<td>7028</td>
<td>8</td>
<td>56</td>
<td></td>
<td></td>
<td>References seem unnecessary for the statement &quot;society will adjust its response as new information becomes available&quot; [Erika Mata, Sweden]</td>
<td>Agreed.</td>
</tr>
</tbody>
</table>
2038). These adjustments - - 2038. More concretely, this Special Report was requested by the Parties to the UNFCCC with a view that the assessments of the Chapter will be taken into account in 2018 for the evaluation of the collective efforts of the Parties in relation to progress towards the long-term goal of the Agreement and also for preparation of their subsequent NDCs. Obviously, it is also valid for the AR5 when a global stocktake will be undertaken by the Parties in 2023. These adjustments - - [Explanation: these revisions are based on recent developments that are not yet fully taken into account in the AR5, such as the progress of the climate change negotiations and the adoption of the Paris Agreement].

Cited literature is based on scenarios developed - - technology availability => future technology availability [Olivier Boucher, France] Added.

9216 9 8 10 4 The IAM community has a great tradition of putting the scenarios in a public database, though, past experience has shown it is only a subset of the database (particularly in the SSP database). Will this database be made public? Will it be the entire database or subset(s)? And when will it be made available? [Glen Peters, Norway]

9210 9 8 10 4 There is no real mention on how the scenarios were generated? Presumably they come from IAMs, and presumably the authors of the report would assess literature on the ability of IAMs to appropriately generate outcomes that are useful for the SR. If you don’t explain and assess the models used, don’t complain when the scenarios and models are later called “black boxes.” [Glen Peters, Norway]

9212 9 8 10 4 Will the scenario database approach, there is a real threat that this Chapter is just putting the scenarios in different ways to show different characteristics. The chapter becomes a description of the scenario database, and not an assessment of the literature or scenarios. It would be nice to see the authors really provide an assessment, which yes, may mean criticizing some scenario results. [Glen Peters, Norway]

9217 9 8 10 4 As of writing not one of the papers in Table 2.1 is published. The literature deadline is in about a month. How can there be any discussion in the literature of the scenarios? The authors will have no literature on which to assess the literature, they will only have the studies? How will the lack of literature be dealt with? [Glen Peters, Norway]

9211 9 8 10 4 A scenario database is not assessing the literature. It is assessing the scenario database. I think there needs to be some reflection by the authors on how to assess the literature, they will only have the studies? How will the lack of literature be dealt with? [Glen Peters, Norway]

9213 9 8 10 4 A box in Chapter 1 discusses how feasibility will be an organising principle of all chapters. It would be good for the authors to explain how they follow up on that in this chapter. [Glen Peters, Norway]

9214 9 8 10 4 How do the authors deal with single studies. Hansen et al. and how are they informed by the climate literature? How do the authors deal with single studies. Hansen et al. and how are they informed by the climate literature? [Glen Peters, Norway]

9215 9 8 10 4 There are really critical independent studies that may be missed in this approach. For example, the debate on Jacobson et al. at 2015 PNAS and Crack et al. 2016 PNAS has considerable important implications for the credibility of the Chapter. In addition to important implications for designing a future energy system and mitigation. How would the methodology of this chapter allow an assessment of those issues (and there are many), drawing out the implications that would be useful for policy makers? [Glen Peters, Norway]

15029 9 22 9 22 If there any discussion of the IAMs reliance on BECCS as a means of reaching 1.5°C by 2100? What is the balance between BECCS, CCS/CCUS, and/or nuclear? Some balance of BECCS, CCS, and/or nuclear is needed for deep decarbonization, but it doesn’t necessarily have to fall on only one of these technologies (e.g., it could fall mostly on CCS or nuclear if BECCS doesn’t materialize) [Farhan Aftab, United States of America]

3156 9 23 23 Access to this data base must be given to any official report reviewer who requests access. Otherwise, MATERIAL FROM THIS DATABASE SHOULD NOT BE ALLOWED TO BE USED IN THIS SPECIAL REPORT. It is just as important to review that technical material as the text of the report, in part to check that the database material has been described and interpreted correctly in the report. The basis for all statements in SR1.5 must be transparent to the world. This report is not an exercise of some secret society of IAM modellers. [Richard Rosen, Germany]

5164 9 23 23 Make database publicly accessible [Simon Tekie, Australia]

20391 9 23 9 30 Are all these scenarios compatible with say actual 2015 or 2016 GHG emissions? [Olivier Boucher, France]

The point here is not the scenarios themselves, just that work using those scenarios has shown that earlier mitigation hedges against unfavorable later developments. We re not aware of work with newer scenarios that supports this point, so retain the citations.

Example added for adaptive to clarify.

The bases for all statements in SR1.5 SHOULD NOT BE ALLOWED TO BE USED IN THIS SPECIAL REPORT. It is just as important to review that technical material as the text of the report, in part to check that the database material has been described and interpreted correctly in the report. The basis for all statements in SR1.5 must be transparent to the world. This report is not an exercise of some secret society of IAM modellers. [Richard Rosen, Germany]

The SOD makes the underlying scenario literature have not changed fundamentally since AR5. A technical assessment of these models would be valuable, but rather something the AR6 should take on, as the SR1.5 has been given the explicit guidance to build on AR5 and consider aspects of direct relevance to the question of 1.5°C. [Olivier Boucher, France]

There is no real mention on how the scenarios were generated? Presumably they come from IAMs, and presumably the authors of the report would assess literature on the ability of IAMs to appropriately generate outcomes that are useful for the SR. If you don’t explain and assess the models used, don’t complain when the scenarios and models are later called “black boxes.” [Glen Peters, Norway]

The report assesses the literature, so of course must rely on published studies but it’s designed to evaluate and critique those studies to the extent possible and so does not depend on the existence of other published studies assessing the primary literature. Critiques on scenarios have also already been published in the literature, and these are also taken into account. [Glen Peters, Norway]

The report addresses the literature, so of course must rely on published studies but it’s designed to evaluate and critique those studies to the extent possible and so does not depend on the existence of other published studies assessing the primary literature. Critiques on scenarios have also already been published in the literature, and these are also taken into account. [Glen Peters, Norway]

There are really critical independent studies that may be missed in this approach. For example, the debate on Jacobson et al. at 2015 PNAS and Crack et al. 2016 PNAS has considerable important implications for the credibility of the Chapter. In addition to important implications for designing a future energy system and mitigation. How would the methodology of this chapter allow an assessment of those issues (and there are many), drawing out the implications that would be useful for policy makers? [Glen Peters, Norway]

A scenario database is not assessing the literature. It is assessing the scenario database. I think there needs to be some reflection by the authors on how to assess the literature, they will only have the studies? How will the lack of literature be dealt with? [Glen Peters, Norway]

A box in Chapter 1 discusses how feasibility will be an organising principle of all chapters. It would be good for the authors to explain how they follow up on that in this chapter. [Glen Peters, Norway]

How do the authors deal with single studies. Hansen et al. and how are they informed by the climate literature? How do the authors deal with single studies. Hansen et al. and how are they informed by the climate literature? [Glen Peters, Norway]

There are really critical independent studies that may be missed in this approach. For example, the debate on Jacobson et al. at 2015 PNAS and Crack et al. 2016 PNAS has considerable important implications for the credibility of the Chapter. In addition to important implications for designing a future energy system and mitigation. How would the methodology of this chapter allow an assessment of those issues (and there are many), drawing out the implications that would be useful for policy makers? [Glen Peters, Norway]
When you say “putting 1.5°C scenarios into context”, do you mean that the temperature increase in these 130 scenarios is 1.5°C? If not, it is useful to address the range of temperature increase in these 130 scenarios. [Stefano Gueganol, Greece]

SSPs are described in chapter 1, and we have added a pointer here to Box 1.1 where that description is given. It is impractical to list numerical quantities for each driver (as there are many, and these vary over time) from each scenario, but relevant references are given in Ch 1 and supplemented by those provided here regarding the scenarios assessed in this chapter.

The SOD includes additional discussion of scenarios beyond those generated by the IAMs and deposited into the scenario database, including ones such as those identified here.

The reference is wrong, the IEA 66% Well Below 2 Degrees Scenario is different from the IEA report ‘Energy Technology Perspectives’ (simulation model) http://www.iea.org//menu/index.aspx?r=SubCat&PMenuID=36&CatID=141&SubCatID=3828 Moreover, since here only the IEA scenario is to be cited, according to the report (Notes on Page 1), it should be cited as: Chapter 2 of Perspectives for the energy transition – investment needs for a low-carbon energy system 506/2015/IEA 2017 For reference, the Energy Technology Perspectives is a different publication (http://www.iea.org/etp/) and uses ETP-TIMES model (optimization model) for their scenarios, and their scenario is called ‘Beyond 2 Degrees’. [Biakna SHOYU-TEHRANI, Japan] The statement seems to be of the indicated page and lines. However, the SOD nevertheless ensures that all abbreviations are correctly introduced and that sentences are readable formats, despite the authors of the study being well-aware of both the IPCC Special Report on 1.5°C and the existence of the database supporting this assessment. Wherever appropriate

The 66% Well Below 2 Degrees Scenario is part of the report produced by IEA and REN21 and was elaborated with the World Energy Model (simulation model) http://www.rena.org//menu/index.aspx?r=SubCat&PMenuID=36&CatID=141&SubCatID=3828 Moreover, since here only the IEA scenario is to be cited, according to the report (Notes on Page 1), it should be cited as: Chapter 2 of Perspectives for the energy transition – investment needs for a low-carbon energy system 506/2015/IEA 2017 For reference, the Energy Technology Perspectives is a different publication (http://www.iea.org/etp/) and uses ETP-TIMES model (optimization model) for their scenarios, and their scenario is called ‘Beyond 2 Degrees’. [Biakna SHOYU-TEHRANI, Japan]

The SOD includes additional discussion of scenarios beyond those generated by the IAMs and deposited into the scenario database, including ones such as those identified here.

The statement seems to be of the indicated page and lines. However, the SOD nevertheless ensures that all abbreviations are correctly introduced and that sentences are readable formats, despite the authors of the study being well-aware of both the IPCC Special Report on 1.5°C and the existence of the database supporting this assessment. Wherever appropriate

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The statement seems to be of the indicated page and lines. However, the SOD nevertheless ensures that all abbreviations are correctly introduced and that sentences are readable formats, despite the authors of the study being well-aware of both the IPCC Special Report on 1.5°C and the existence of the database supporting this assessment. Wherever appropriate

For quantitative assessment of scenario results, the authors rely on data from studies being made available in the dedicated scenario database that has been set up for the Special Report. Data that is only available elsewhere, for example, in tabular format in a report, which is not machine-readable, can generally not, and at most in very exceptional circumstances be included, due to time and capacity limits. For both studies cited by the expert reviewer, no scenarios have been submitted to the database, nor has data been provided in other machine-readable formats, despite the authors of the study being well-aware of both the IPCC Special Report, and the existence of the database supporting this assessment. Whenever appropriate, the authors can refer to those studies that have been included in the discussion of results.
The choice of reference period and measurements used for the report are crucial for the calculations of the remaining carbon budget. However, this is not discussed in Chapter 1 (1.2.1). Nor are the implications of uncertainties in the reference period, or in the measurement time itself, discussed in any of the sections. (Comment repeated for Chapter 1) I wrote this before the publication of Miller et al. at 2017. NGe. After that, it has become clear that the interpretation of differences between realized and modeled temperature change also needs to be discussed in one of the sections. (Elni Samuel, Norway)

1842 10 19
10 10
Table 2.1. Table 2.1. The reference period measurement discussion is also be incorporated into the review.

1703 10 19
The text referring to scenarios above 2°C should be shortened. (Elni Kadiati, Austria)

1704 10 19
The text referring to scenarios above 2°C should be shortened. (Elni Kadiati, Austria)

1417 10 1 0 1
Table 2.1. The reference period measurement discussion is also be incorporated into the review.

1703 10 19
The text referring to scenarios above 2°C should be shortened. (Elni Kadiati, Austria)

5708 10 1 0 10
As the table is not completed, it is difficult to see the information it wants to present. Also IAM needs to be spelled out. (Hong Yang, Switzerland)

3298 10 3
Consider adding the number of scenarios within each study name to the table so readers can appreciate how scenarios are dominated by certain key forc. (Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)

707 10 1 0 10
We suggest to take into account the uncertainties proposed by the GBCOC (Global Initiative to Save Our Climate) collaboration. These scenarios are variants of the MESSAGE Supply and Use scenarios with accelerated development of Nuclear energy, especially in its sustainable version: "How much can nuclear energy do about global warming?" (André Berger, Tom Blees, Francois-Marie Bréon, Barry W. Brok, Philippe Hansen, Ralf B. Grove, Claude Goet, Wujung Li, Frederik Livent, Herve Nifenecker, Michel Peti, Gérard Pierre, Henri Prévot, Sebastien Richel, Henri Safe, Massimo Salvatore, Michael Schneeweberger, Suyun Zhou. https://doi.org/10.1504/EGU.2017.068786.

4903 10 10 11
Carbon budget is a secondary metric estimated by use of pseudo-linear relationship between temperature and cumulative amounts of CO2 emissions which has great uncertainties. Thus, it feels strange that carbon budget is treated in the same line as other three physical parameters, radiative forcing, atmospheric concentrations and temperature. (Naeza Takagi, Japan)

4334 10 12 10 12
It is necessary to include more references regarding "atmospheric concentrations" (Gastón de Oliveira, Brazil)

1506 10 12 10

905 10 14 10
It would perhaps be useful to list the short-lived climate forcings at this point (David Infield, United Kingdom (of Great Britain and Northern Ireland)

20791 10 15 10 16
One of the more important references is Shindell et al at 2012, which highlighted the importance of limited SLCFs and contributing to a pathway compatible with 1.5°C and 2°C (Johan Carl Ivar Kuylenstierna, United Kingdom (of Great Britain and Northern Ireland)

20844 10 15 10 16
One of the more important references is Shindell et al at 2012, which highlighted the importance of limited SLCFs and contributing to a pathway compatible with 1.5°C and 2°C (Johan Carl Ivar Kuylenstierna, United Kingdom (of Great Britain and Northern Ireland)

12822 10 18
The only model for quantitative calculations in this chapter is MAGICC. While this is understandable (this SR preceeds the comprehensive comparison in section 2.6) it also represents a significant liability. The authors provide a discussion in section 2.6 but this is not covered in this chapter. (Thomas Stocker, Switzerland)

19361 10 16 24
The use of a single model (MAGICC) for most of this chapter is rather worrying. I appreciate that in theory MAGICC can be made to represent any climate model, however this chapter should shine to cover a range of literatures to include many different modelmaking frameworks as possible according to its assessment. (William Collins, United Kingdom (of Great Britain and Northern Ireland)

1761 10 18 24
Consider mentioning here that the calibration of MAGICC was done using CMIP5 and there will be new results coming out with CMIP6 that will be used in the result section. (Gabriel de Oliveira, Brazil)

8218 10 20 10 22
MAGICC has not been updated to AR6.3 (out of control, but not clear what is the implications of using one SCM with an ageing parameterisation. In terms of comparability, that point is not really relevant as you can always run the AR5 scenarios through an updated MAGICC or an alternative SCM. It would be great for all authors to assess the implications of these decisions. (Oliver Peters, Germany)

6887 10 27 15 12
What is missing in this section is a reasoned conclusion about the best definition of the carbon budget for the purposes of using in policy setting. The focus on 1.5°C carbon budget and the different numbers lead to a very complex discussion from which it is not possible for policy users to draw conclusions. The fact that in the Exuc Summary of the chapter one set of numbers is given without identifying the definitions used is stark. (Bert Melz, Netherlands)
The various definitions of carbon budgets are confusing; the addition of a figure (with for example the representation of a typical pathway of global CO2 emissions and of the associated global temperature) to illustrate these various carbon budgets (TEB, TAB, TPB, TRB) through their respective periods of time, might help the readers. [Serge PLANTON, France]

Can you please be more specific with the reference IPCC, 2013, indicating at least the chapter [Caserini Stefano, Italy] taken in to account— this reference has been corrected accordingly.

I cannot find the term of “Threshold Exceedance Budgets (TEB)” in AR5WGI report and “Threshold Avoidance Budgets (TAB)” in AR5WG report.

The period 1880-1861 would be better written as 1861-1880 [JACEK PISKOZUB, Poland] accepted— the reference period has been corrected accordingly

20861 11 5 11 9 These lines suggest that a TEB of 2000GtCO2 with 68% likelihood means that the temperature threshold of 2°C is exceeded with a probability of 68% when cumulative emissions are 2000GtCO2. This seems different from “With a 68% likelihood, the TEB is 2000 GtCO2”, which seems to suggest that it is 68% sure that the TEB is 2000 GtCO2. As this is the first time “68% likelihood” is used, it would be helpful to include a sentence such as: “68% likelihood means that...” for clarification. [Heleen de Coninck, Netherlands]

9152 11 7 11 8 1880-1881 period shall be corrected to “1881-1880 period” [Makino Ricardo Jicentho Espírito, Brazil] accepted— the reference period has been corrected accordingly

14378 11 8 The period 1880-1881 would be written better as 1881-1880 [JACEK PISKOZUB, Poland] accepted— the reference period has been corrected accordingly

3299 11 8 Switch to 1880-1881 to 1881-1880. [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)] accepted— the reference period has been corrected accordingly

5982 11 8 11 8 Typo error: “1880-1881” [Shi Ming Lee, China] accepted— the reference period has been corrected accordingly

10430 11 8 11 8 1990-1991 fixed - wrong, probability just reversed [Jonathan Lynn, Switzerland] accepted— the reference period has been corrected accordingly

9658 11 8 11 8 Because of chronological coherence, the 1880-1881 period should be the other way around, 1880-1881. [Díaz Arcasen, Spain] accepted— the reference period has been corrected accordingly

6358 11 8 11 8 1881-1880 = 1880-1881 [Andy Reijninger, New Zealand] accepted— the reference period has been corrected accordingly

507 11 8 11 8 Accepted— the reference period has been corrected accordingly

If the way in which the effects of non-CO2 GHGs were accounted for involved using a GWP, then the time period used for GWP needs to be stated and that this approach tends to focus only on the Kyoto Basket of Gases needs to be made very clear. This sentence and the rest of the paragraph appear to depend on same way of combining the effects across multiple warming/cooling factors (GHGs and aerosols) and how this is done is really important and controversial—so it should be explained elsewhere. [Michael MacCracken, United States of America] accepted— a box is dedicated to this topics. The revised text now clearly refers to this box.

When warming exceeds 2°C with a 66% likelihood, the TEB... [Junich Tsutsui, Japan] accepted— the reference period has been revised accordingly.

It seems TAB is defined over a period, eg to 2100, and TPB is a TAB to peak warming? Though, the way you have worded it here is rather ambiguous with TPB and TRB. This is a new terminology to Rogelj et al 2016? If so, can you state this. Again, a table of definitions would do wonders [Glen Peters, Norway] accepted— a box is dedicated to this topics. The revised text now clearly refers to this box.

If the way in which the effects of non-CO2 GHGs were accounted for involved using a GWP, then the time period used for GWP needs to be stated and that this approach tends to focus only on the Kyoto Basket of Gases needs to be made very clear. This sentence and the rest of the paragraph appear to depend on same way of combining the effects across multiple warming/cooling factors (GHGs and aerosols) and how this is done is really important and controversial—so it should be explained elsewhere. [Michael MacCracken, United States of America] accepted— a box is dedicated to this topics. The revised text now clearly refers to this box.

The calculation of the time period 1861-1880 for climate sensitivity is a bit arbitrary, but I agree that it is a useful exercise. The calculation is made by assuming that the warming would have continued linearly when cumulative emissions are 2900 GtCO2. This seems different from “With a 66% likelihood, the TEB is 2900 GtCO2”, which seems to suggest that it is 66% sure that the TEB is 2900 GtCO2. As this is the first time “66% likelihood” is used, it would be helpful to include a sentence such as: “66% likelihood means that...” for clarification. [Heleen de Coninck, Netherlands] accepted— a box is dedicated to this topics. The revised text now clearly refers to this box.
This is a great chapter with profound implications for policy makers. Some sections of this chapter could be written more simply to have full effect. For example, I am sure there are simpler ways of saying “Both CO2-only and multi-forcer estimates of carbon budgets are informative to understand the amounts of total net cumulative anthropogenic carbon emissions compatible with a given temperature limit over a given time period.” The section on remaining carbon budget in particular could be simplified. (Anton Cartwright, South Africa)

This sentence has been reworded into “Note that the 25-75% percentile range for TABs for 2°C is narrower when based on the scenario database to this report than previous estimates using the AR5 scenario database, i.e., 590—1240 GtCO2 (Rogelj et al. 2016b), because an ensemble of uncertainties that might impacts the carbon budget; that is (1) the methodological differences and (2) the physical uncertainties that includes climate sensitivity.

It is unclear why TEB estimate for 2°C (1300 GtCO2) is so much higher than TAB (810 GtCO2), and also in Table 2.2. It may be good to briefly explain that could lead to such differences in those budget estimates (as some may argue that TABs could be higher than TEBs, emissions are aimed right after the TEB is reached). (Katarzyna B Tokarska, United Kingdom (of Great Britain and Northern Ireland))

It is necessary to clarify from where these values were obtained. (Gabriel de Oliveira, Brazil)

It is unclear why “the ensemble of opportunity” does not intend to capture the total uncertainty of emissions pathways. (BenElMest, Netherlands)

This sentence has been reworded into “Note that the 25-75% percentile range for TABs for 2°C is narrower when based on the scenario database to this report than previous estimates using the ARS scenario database, i.e., 590—1240 GtCO2 (Rogelj et al. 2016b), because an ensemble of opportunity does not intend to capture the total uncertainty of emissions pathways.”

What is “the ensemble of opportunity”? Please explain why the ranges are different. (BenElMest, Netherlands)

This sentence has been reworded into “Note that the 25-75% percentile range for TABs for 2°C is narrower when based on the scenario database to this report than previous estimates using the ARS scenario database, i.e., 590—1240 GtCO2 (Rogelj et al. 2016b), because an ensemble of opportunity does not intend to capture the total uncertainty of emissions pathways.”

Give a reason why these estimates are larger than in AR5. This would be an important aspect in the assessment. Or else reference forward to the appropriate location in the text. (Thomas Stocker, Switzerland)

This sentence has been reworded into “Note that the 25-75% percentile range for TABs for 2°C is narrower when based on the scenario database to this report than previous estimates using the ARS scenario database, i.e., 590—1240 GtCO2 (Rogelj et al. 2016b), because an ensemble of opportunity does not intend to capture the total uncertainty of emissions pathways.”

Sentence should indicate how much larger and why—there is just not enough information presented here. (Michael MacCracken, United States of America)

This sentence has been reworded into “Note that the 25-75% percentile range for TABs for 2°C is narrower when based on the scenario database to this report than previous estimates using the ARS scenario database, i.e., 590—1240 GtCO2 (Rogelj et al. 2016b), because an ensemble of opportunity does not intend to capture the total uncertainty of emissions pathways.”

Capitalize the first letters of “threshold peak budget” and “threshold return budget.” (Kentaroh Matsumoto, Japan)

The word “TRB” definition is unclear; a precision on the overshoot type might help the understanding (“temperature overshoot”?). (Serge PLANTON, France)

This sentence has been reworded into “Note that the 25-75% percentile range for TABs for 2°C is narrower when based on the scenario database to this report than previous estimates using the ARS scenario database, i.e., 590—1240 GtCO2 (Rogelj et al. 2016b), because an ensemble of opportunity does not intend to capture the total uncertainty of emissions pathways.”

It is necessary to clarify from where these values were obtained. (Gabriel de Oliveira, Brazil)
<table>
<thead>
<tr>
<th>Comment No</th>
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<tbody>
<tr>
<td>6964</td>
<td>11</td>
<td>41</td>
<td>11</td>
<td>41</td>
<td>Suggest to add ‘assumed’ before ‘presence’. [Sae Ming Lew, China]</td>
</tr>
<tr>
<td>9021</td>
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<td></td>
<td></td>
<td>Table 2 should also include a column with very likely (90%) below 2°C pathways. Throughout this report it seems that well below 2°C is solely interpreted as likely (66%) below 2°C. This is, however, not stated explicitly apart from references on what is ‘often used’ (e.g. in Box 1.1). Providing a single interpretation for the PA language would be too policy prescriptive, in particular as an interpretation that links well below 2°C to pathways holding warming below 2°C with a probability well above 66% is very plausible given the history and context of the PA language. The expression ‘holding… well below 2°C’ is a strengthening of previous language and signals an increase in both the margin and likelihood by which warming is to be kept below 2°C compared to holding below 2°C (e.g. Schlesser et al. [2016]). (Michael Schaeffer, Netherlands)</td>
</tr>
<tr>
<td>11124</td>
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<td></td>
<td></td>
<td>Table 2 shows the 25%-75% ranges of carbon budgets, so it only shows 50% of the total probability range. I would add the 10%-90% interval to get an idea of the full range of carbon budget (min-max)</td>
</tr>
<tr>
<td>1552</td>
<td>12</td>
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<td>7</td>
<td>Do these budgets start January 1st 2016 or January 1st 2017?</td>
</tr>
<tr>
<td>16193</td>
<td>12</td>
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<td>12</td>
<td>7</td>
<td>Table 2.2 shows the 25-75% ranges of carbon budgets, so it only shows 50% of the total probability range. I would add the 10%-90% interval to get a feeling of the real uncertainties here. [Andries Hof, Netherlands]</td>
</tr>
<tr>
<td>9840</td>
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<td>7</td>
<td>Table 2.2 or other places: The equilibrium climate sensitivity (ECS) of MAGICC will be assumed to be between 2.5 and 4.5°C, likely, and 3.0°C most likely for the assessment. But this is not necessarily consist of the IPCC WGI AR5 (ECS is likely to be 1.5-4.5°C and the most likely value did not provided.) This fact should be clearly described, while this is stated in Sector 2.6.4. [Margo Akimoto, Japan]</td>
</tr>
<tr>
<td>7571</td>
<td>12</td>
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<td></td>
<td>When Paris asks: never exceed 2°C, why do you use such low probabilities to comply with target? (for 1.5 target you can use smaller probabilities to be consistent with Paris). Should you not use at least 95% probability of never exceeding when looking at 2°C scenario (and you may come to conclusion that never exceed 2C and possibly not 1.5°C is nearly identical in carbon budget left...?) And how does this square with the ppm view: c) if 450 ppm CO2 is 2°C limit with 66% probability (or if not what it is ) - because this is what I found in last IPCC report, how does this square with reality that we are already at 407 ppm just CO2 and annually increasing 2-3 ppm. In essence: it seems the numbers show too large carbon budgets - at least make the case that the budgets could be SUBSTANTIVELY smaller [Mathis Wackernagel, United States of America]</td>
</tr>
<tr>
<td>6825</td>
<td>12</td>
<td>1</td>
<td>12</td>
<td>7</td>
<td>Table 2.2 or other places: The equilibrium climate sensitivity (ECS) of MAGICC will be assumed to be between 2.5 and 4.5°C, likely, and 3.0°C most likely for the assessment. But this is not necessarily consist of the IPCC WGI AR5 (ECS is likely to be 1.5-4.5°C and the most likely value did not provided.) This fact should be clearly described, while this is stated in Sector 2.6.4. [Margo Akimoto, Japan]</td>
</tr>
<tr>
<td>3159</td>
<td>12</td>
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<td>12</td>
<td>Again, this material is far too complex and poorly organized. It could probably be summarized in one page. For policy makers it should provide an answer to the simple question: if the world follows a non-overshoot 1.5 degree scenario, by which year would net emissions on a CO2 equivalent basis have to go to zero based on the median climate sensitivity? All this other information muddies the picture for policy makers. Obviously, non-overshoot scenarios would have to reach zero emissions before the earliest scenarios indicated in Figure 2.4 on page 2-19. I would suggest translating most numbers for budgets into a carbon equivalent basis, so that policy makers get a direct sense of the bottom-line when all greenhouse gas emissions are combined. What much of this discussion of these three pages could be expressed in budgets for all emissions together, with the explanation that some components might be higher or lower. [Richard Rosen, Germany]</td>
</tr>
<tr>
<td>9222</td>
<td>12</td>
<td>18</td>
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<td>I just read a nice section on carbon budgets and come to a... section on carbon budgets? How is 2.2.2.1 and 2.2.2.2 related? Why are there two sections? I think there needs to be a much better discussion of why they differ, etc. [Olen Peters, Norway]</td>
</tr>
<tr>
<td>11125</td>
<td>12</td>
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<td>While the Special Report does not have to remain consistent with previous IPCC reports, especially the AR5, I would be good to elaborate on the differences between the data sets used there (IEA/EDGAR). This would enable readers to better compare results (budgets) of SR15 and AR5. [Michael Schaeffer, Netherlands]</td>
</tr>
<tr>
<td>20792</td>
<td>12</td>
<td>13</td>
<td>48</td>
<td></td>
<td>The use of acronyms in these pages make this extremely heavy reading. Spelling them out more often would facilitate understanding [Johan Carl Ivar Kuylenstierna, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
<tr>
<td>7030</td>
<td>12</td>
<td>18</td>
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<td>Could the uncertainties be related to existing classifications, e.g. in Walter W. E., P. Harnisch, J. Rötter, F. van der Sluijs, M. van Asselt, P. Janssen, M.P. Kreyer von Krauss. Defining uncertainty: A conceptual basis for uncertainty management in model-based decision support, Integrated Assessment 4 (2003) 5-17. It would be easier for those measuring different types of uncertainties if these were defined, including sectorial details, e.g. for Buildings: Booth A. T., R. Choudhary, and D. J. Speijerghaer, handling uncertainty in housing stock models, Building and Environment (2012) 48: 166–173, L. Heil, S. Schloßmann F. From the Building Level Energy Performance Assessment to the National Level: How are Uncertainties Handled in Building Stock Models, Procedia Engineering (2017) 180: 1443-1452. My point is that, those exploring the detailed sectorial solutions in line the 1.5C pathways need an agreed methodological framework - for measuring uncertainty in this case - to relate to. [Érika Mata, Sweden]</td>
</tr>
<tr>
<td>20845</td>
<td>12</td>
<td>18</td>
<td>13</td>
<td>48</td>
<td>The use of acronyms in these pages make this extremely heavy reading. Spelling them out more often would facilitate understanding [Johan Carl Ivar Kuylenstierna, United Kingdom (of Great Britain and Northern Ireland)]</td>
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<td>2608</td>
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<td>12</td>
<td>20</td>
<td>The chapter is a bit inconsistent with respect to whether cumulative carbon emissions are quoted with respect to 1865 or 2015. [Robert Koppe, United States of America]</td>
</tr>
<tr>
<td>17956</td>
<td>12</td>
<td>19</td>
<td>12</td>
<td>27</td>
<td>It would appear that the recent publication of Millar et al. Nature Geoscience (2017), <a href="https://doi.org/10.1038/ngeo3031">https://doi.org/10.1038/ngeo3031</a> introduces another uncertainty into the process of comparing carbon budgets, relating to the base year for temperature increase. As Millar et al. use temperature increase from 2015 as its starting point, this raises the question of how their budgets can be made compatible with the report's definition of 1.5°C (from p.11 to Ch. 1 of the FOD). &quot;A 1.5°C world is defined as one in which temperatures averaged over a multi-decade timescale are expected to be 1.5°C above the pre-industrial reference period.&quot; It is not possible to know, of course, how the single base year of 2015 compares to the industrial reference period on a &quot;multi-decade timescale,&quot; i.e. whether it is &quot;too high&quot; or &quot;too low&quot; compared to averaged warming since pre-industrial time. Depending on how interannual variability has been handled by Millar et al. this could make it difficult to say if the carbon budgets derived based on a 2015 base year is too high or too low compared to budgets derived from a pre-industrial reference period. This might be important to highlight in the section discussing uncertainties. [Bård Lahn, Norway]</td>
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<tr>
<td>9025</td>
<td>12</td>
<td>19</td>
<td>12</td>
<td>20</td>
<td>Unclear which figure the +-2 refers to. [David Infield, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
<tr>
<td>3902</td>
<td>12</td>
<td>19</td>
<td>12</td>
<td>50</td>
<td>This choice should be justified, given it follows from the previous sentence which used other approaches. [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
<tr>
<td>12975</td>
<td>12</td>
<td>23</td>
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<td>24</td>
<td>Please report the value of total net cumulative anthropogenic emissions for 2016 considered in this chapter, i.e. 2015 ± 205 in Le Quere et al. 2018. Note that Le Quere et al. 2018 is a first assessment that should be updated. This value should be written before the value of the annual emissions. [Casneri Stefano, Italy]</td>
</tr>
<tr>
<td>6630</td>
<td>12</td>
<td>24</td>
<td>12</td>
<td>24</td>
<td>What about emissions from e.g. coastal flooded habitats that can increase as a consequence of warming and sea-level rise? [Cazet Motoioib, Spain]</td>
</tr>
<tr>
<td>19846</td>
<td>12</td>
<td>25</td>
<td>12</td>
<td>27</td>
<td>It is not clear what these budgets of 36 and 5 GtCO2 are referring to. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
<tr>
<td>14213</td>
<td>12</td>
<td>26</td>
<td>12</td>
<td>27</td>
<td>The contributions of fossil fuel emissions plus cement production and land-use/land cover change are estimated as 36 and 5 GtCO2, respectively, with a 66% uncertainty range of ±2 GtCO2. I believe these numbers are supposed to be per annum. In contrast to the numbers in the next paragraph. [Jason Darven, Canada]</td>
</tr>
<tr>
<td>910</td>
<td>12</td>
<td>26</td>
<td>12</td>
<td>27</td>
<td>Unclear which figure the + -2 refers to. [David Infield, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
<tr>
<td>12976</td>
<td>12</td>
<td>26</td>
<td>12</td>
<td>27</td>
<td>Please indicate the year relative to these data. [Casneri Stefano, Italy]</td>
</tr>
<tr>
<td>12977</td>
<td>12</td>
<td>26</td>
<td>12</td>
<td>27</td>
<td>Take suggestion using the cm. GtCO2/year, since previously all the figures were related to CO2 budget and not to CO2 emissions in a single year, and this could generate confusion. [Casneri Stefano, Italy]</td>
</tr>
<tr>
<td>14320</td>
<td>12</td>
<td>26</td>
<td>12</td>
<td>27</td>
<td>It is unclear what the uncertainty range of 2 GtCO2 applies to 36 GtCO2 and/or to 5 GtCO2. [Serge PLANTON, France]</td>
</tr>
<tr>
<td>4764</td>
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<td>30</td>
<td>12</td>
<td>30</td>
<td>Add here the full name of TOC so that one does not have to go to Chapter 1 to find out what this is. [Elena Georgopoulou, Greece]</td>
</tr>
<tr>
<td>11907</td>
<td>12</td>
<td>30</td>
<td>12</td>
<td>31</td>
<td>The indicative range should be replaced with ‘assessed likely range’. In this context ‘assuming a Gaussian distribution’ should be deleted. In fact, the assumption of a Gaussian distribution is used to derive the remaining carbon budget based on TCRE, not the likely range of TCRE itself. [Junichi Tsutsui, Japan]</td>
</tr>
<tr>
<td>3003</td>
<td>12</td>
<td>34</td>
<td>12</td>
<td>34</td>
<td>Consider providing the standard deviation since you are using a Gaussian. That will give some more information about the nature of the distribution. [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
<tr>
<td>9224</td>
<td>12</td>
<td>34</td>
<td>12</td>
<td>34</td>
<td>As in Miller et al. 2017, it is possible to use a log-normal distribution. See Peters 2018 <a href="http://dx.doi.org/10.1038/nclimate3000">http://dx.doi.org/10.1038/nclimate3000</a> for a discussion of that in relation to the TCRE, mainly the St. [Olaf Peters, Norway]</td>
</tr>
<tr>
<td>951</td>
<td>13</td>
<td>5</td>
<td>13</td>
<td>6</td>
<td>The author (Tachiuri et al. 2015) with RCP4.5, although they use a kind of pattern scaling using 1% pa scenario to run a terrestrial ecosystem part. Also know that their estimate in TCRE range (1.1–1.7 K/TC) is at 2055 with the historical run. [Koaru Tachiuri, Japan]</td>
</tr>
<tr>
<td>3304</td>
<td>13</td>
<td>11</td>
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<td>The first part of this sentence is unnecessary—inhomogeneously implies values differ across space. However, we know warming is not even across the globe, so does this ‘inhomogeneous’ distribution matter? [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
<tr>
<td>2922</td>
<td>13</td>
<td>15</td>
<td>13</td>
<td>20</td>
<td>Page 2-13 line 15: The sentence here implicitly assumes that Zero Emissions Commitment (ZEC) for CO2 is zero or negative. However at least one model shows a positive ZEC – Frölicher &amp; Paynter, 2015. I recommend following the definition of TCRE defined in Frölicher &amp; Paynter, (2015), where TCRE is defined as TIE (T temperature, Ecumulative emissions) until emissions of CO2 are zero, and TCRE is the time ocean heat uptake reaches zero. [MacDougall Andrew, Canada]</td>
</tr>
<tr>
<td>2192</td>
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<td>18</td>
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<td>TCRE is slightly weaker ... This is not the case when decreasing comes before increasing, since the asymmetry of TCRE is due to response time lag. It should be explicitly stated that the weaker TCRE for decreasing occurs only when decreasing comes after increasing, and is not an inherent nature of the Earth system. [Michio Kawamiya, Japan]</td>
</tr>
<tr>
<td>11908</td>
<td>13</td>
<td>18</td>
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<td>23</td>
<td>This paragraph is confusing. While TCRE is slightly weaker with decreasing CO2 than with rising CO2, Zickfeld and MacDougall (2016) imply a slightly higher temperature outcome for a given carbon budget when it is achieved by net CDR after a carbon budget overshoot. It appears that these are not consistent. [Junichi Tsutsui, Japan]</td>
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<tr>
<td>2925</td>
<td>13</td>
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<td></td>
<td>I think Zickfeld and MacDougall (2016) is trying to refer to Zickfeld et al. 2016. [MacDougall Andrew, Canada]</td>
</tr>
</tbody>
</table>

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### Comment and Response - Chapter 2

<table>
<thead>
<tr>
<th>Comment No</th>
<th>From Page</th>
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<td>11909</td>
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<td>27</td>
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<td>27</td>
<td>Technical terms regarding Figure 2.1 are not consistently used. While threshold return budget is used in the text, threshold peak carbon budget is used in the figure legend. [Junichi Tsutsumi, Japan]</td>
</tr>
<tr>
<td>6632</td>
<td>13</td>
<td>34</td>
<td>13</td>
<td>44</td>
<td>...what about the balance between generation/emissions/sequestration of carbon in form of methane and others which may change in e.g. coastal ecosystems (without permafrost) as a consequence of the warming and the sea-level rise? Surely it may be considered as another source of uncertainty. [Casimiro Mutio Solerino, Spain]</td>
</tr>
<tr>
<td>7433</td>
<td>13</td>
<td>34</td>
<td>13</td>
<td>48</td>
<td>...consider the important findings from this para into the ES. Furthermore please consider making the topics of this para into a stand-alone section, and elaborate further on these issues, as they seem to be of high relevance to policymakers. [Bryndis Christophersen, Norway]</td>
</tr>
<tr>
<td>10324</td>
<td>13</td>
<td>34</td>
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<td>47</td>
<td>Despite of the importance of the permafrost feedback, there are other feedbacks that may be of same relevance such as the ones related to disturbances of certain ecosystems including large fires due to increase in drought (including, but not only in boreal regions and South Asia, Pakistan), [not see for example beetle episodes in North America that resulted in several hundred million tonnes of emissions during recent years] and this is only related to terrestrial systems. [Maria Jose Sanchez Sanchez, Spain]</td>
</tr>
<tr>
<td>10490</td>
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<td>36</td>
<td>13</td>
<td>36</td>
<td>Might be more correct to write CO2 and methane instead of carbon and methane [Harold Leffertstra, Norway]</td>
</tr>
<tr>
<td>13890</td>
<td>13</td>
<td>37</td>
<td>13</td>
<td>38</td>
<td>Define EMIC [Jorge Carrasco, Chile]</td>
</tr>
<tr>
<td>20206</td>
<td>13</td>
<td>38</td>
<td>13</td>
<td>38</td>
<td>To RCPS-5 [Aaron Gurney, Canada]</td>
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<tr>
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<td>38</td>
<td>RCPS-5≠RCPS 5 [MacDougall Andrew, Canada]</td>
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<td>4523</td>
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<td>13</td>
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<td>tpc 11 to RCPS5 [Rachel Toalz, Czech Republic]</td>
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<td>13</td>
<td>38</td>
<td>Change to RCPS 5 [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]</td>
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<tr>
<td>9758</td>
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<td>13</td>
<td>38</td>
<td>Typo: Not RCPS5 but RCPS 5 [Manfred Treiber, Germany]</td>
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<td>Typo: Not RCPS5 but RCPS 5 [Manfred Treiber, Germany]</td>
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<td>10666</td>
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<td>13</td>
<td>38</td>
<td>Typo: RCP 45 should be RCP 4.5 [Kristin Campbell, United States of America]</td>
</tr>
<tr>
<td>7434</td>
<td>13</td>
<td>38</td>
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<td>39</td>
<td>Consider linking this to chapter 3.7.4.3 which suggest that a considerable amount of permafrost will still be lost if the temperature is stabilized at 1.5C. The amount of overshoot will probably also affect potential permafrost loss and this feedback, please consider elaboration about. [Bryndis Christophersen, Norway]</td>
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<tr>
<td>3306</td>
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<td>13</td>
<td>40</td>
<td>Quantity 'highly' [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
<tr>
<td>2196</td>
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<td>13</td>
<td>45</td>
<td>It is trivial that the lowest from thresholds based on multiple targets is likely to be lower than a threshold based on a single one. Isn't this simply the reason for the lower threshold for multiple targets? [Michiko Kawamura, Japan]</td>
</tr>
<tr>
<td>12978</td>
<td>13</td>
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<td>45</td>
<td>I believe that 'like global mean temperature rise'... should be 'like global mean sea level rise'... [Giovanni Stefani, Italy]</td>
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<tr>
<td>6142</td>
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<td>45</td>
<td>13</td>
<td>45</td>
<td>repetition of 'global mean temperature rise'. Also don't use 'like', use 'such as'. [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
<tr>
<td>10437</td>
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<td>14</td>
<td>14</td>
<td>Figs 2.1 the classifications of the pathways (dots and lines) in this and 2.2 on p2-15 is only explained in 2.3.3.1 on p2-15 and table 2.3 on p2-16. My failing but could not begin to understand the figures until I had seen the table. Fig 2.3 on p2-17 easier as it follows [Jonathan Lynn, Switzerland]</td>
</tr>
<tr>
<td>2783</td>
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<td>17</td>
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<td>17</td>
<td>Figures 2.1, 2.2 and 2.3 show results for warming well over 2°C, which are not relevant for the rest of the chapter and severely compress the scale of the results relating to cases with warming of 2°C or less [Eric Hallak, Canada]</td>
</tr>
<tr>
<td>3308</td>
<td>14</td>
<td>17</td>
<td>14</td>
<td>17</td>
<td>Replot graph with larger font for axis labels [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]</td>
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<td>17</td>
<td>Figure 2.1. re-order legend items to match order of data in figure (e. g. 3.5 top, 1.5 bottom) [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
<tr>
<td>13526</td>
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<td>17</td>
<td>Figure 2.1. make the 'non-co2 warming contribution' label horizontal so easier to read. [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)]</td>
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<td>17406</td>
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<td>A [Tom Gabriel Johansen, Norway]</td>
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<td>Add index format to &quot;CO2&quot;. [Radim Tolasz, Czech Republic]</td>
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<td>20392</td>
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<td>Chapter 1 had adopted 1850-1879 for the reference period. Shouldn't this be followed here? [OK JUST SEE THE THE NOTE TO REVIEWERS ON PAGE 15. - IGNORE THIS ONE] [Olivier Boucher, France]</td>
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<td>20393</td>
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<td>3</td>
<td>Please explain the meaning of the vertical arrow. According to chapter 1, the vertical is the y-axis of the triangles should be 1°C, but that doesn't seem to be quite the case here and this needs to be explained. Overall the plot is a bit confusing because the circles refer to hypothetical CO2-only scenarios (not only for the future but also during the historical period in order to compute the 1°C increase relative to 1850-1900, if we understand correctly), so there is a mix of a hypothetical scenario but some reference to a real historical scenario for the quantities plotted on the x and y axis. It would help if you could show what is consistent or not with observations [Olivier Boucher, France]</td>
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<td>6143</td>
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<td>What message or conclusions should be drawn from Figure 2.1? I have no idea of the relevance of this. It needs to be explained why it is here. [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)]</td>
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<td>Add index format to &quot;CO2&quot;. [Radim Tolasz, Czech Republic]</td>
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<td>18784</td>
<td>14</td>
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<td>3</td>
<td>Section 2.2.3 should address the role of SLCP/SCLP in causing temperature rise to overshoot the 1.5°C threshold in the near-term period. The more rapid crossing of the threshold due to the role of SLCP/SCLP is an important dimension that should be addressed; Figure 2.2 illustrates the temporal evolution of the temperature contribution, but the narrative does not highlight this dimension. [David Waakos, United States of America]</td>
</tr>
</tbody>
</table>
Section 2.2.3 should address the role of SLCFs/SLCP in causing temperature rise to overshoot the 1.5°C threshold in the near-term period. The model of the impact of short-lived climate forcers (SLCFs) on the temperature threshold, but the narrative does not highlight this dimension. (David Waaksoo, United States of America)

Add Shindell et al 2012 and maybe UNEP/WMO 2011. These were the reports that really got people interested in the temperature impacts of SLCFs by about 2000GtCO2 per ... non-CO2 forcers -> This sentence is extremely difficult to understand. Some example about how to interpret this

What are examples of some of these targeted mitigation measures? [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]

Add Shindell et al 2012 and maybe UNEP/WMO 2011. These were the reports that really got people interested in the temperature impacts of SLCFs (Shindell et al. 2011). This is a really cool report. There are really cool uncertainties in the CO2 is a cool report. This is a really cool uncertainty in the future. I’d suggest more emphasis on this point is needed. [Michio Kawamiya, Japan]

This is a very cool report. There are really cool uncertainties in the CO2 is a cool report. There are really cool uncertainties in the future. I’d suggest more emphasis on this point is needed. [Michio Kawamiya, Japan]

AR5 AR5 (Myhre et al. 2013) used the terminology of Near-Term Climate Forcers, partly to avoid the debate over whether methane was long-lived or short-lived. If this chapter is going to use the Short-lived Climate Forcer terminology it should be defined, and clarified as to whether this is equivalent to the AR5 NTCF definition or not. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]

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TCRE, it would be valuable to expand on this. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]

This is a very cool report. There are really cool uncertainties in the CO2 is a cool report. There are really cool uncertainties in the future. I’d suggest more emphasis on this point is needed. [Michio Kawamiya, Japan]
I'm puzzled by the way this key relationship, namely 2000 Gt CO2 per degree of warming from non-CO2 forcings, has been derived. It seems overly complex and mixes scenario-specific assumptions about how non-CO2 emissions change within a scenario family and co-vary with CO2 mitigation (and basic physical science). What's wrong with the following reasoning: TCRE (from AR5) is 0.8-2.5 degrees per 1000 PgC. Assuming gaussian uncertainty (as in AR5), this means one degree warming for 2,200 Gt CO2. So it follows logically that every day degree warming caused by non-CO2 forcings, the allowable CO2 budget reduces by 2,200 Gt CO2 for total warming to remain within a given limit, does it not? Which is close to the 2,000 Gt CO2 derived by the authors but not the same, but there has been a much simpler rationale and allows an uncertainty assessment. If my reasoning is wrong, it would be helpful if the authors could explain in their acknowledgment of why this is not a legitimate approach, and provide more statistical information on how they arrive at 2,000 Gt CO2 including uncertainty. Note that whenever the correct answer and approach, clarifying this relationship is a potential key finding for many policymakers who struggle to make sense of the contribution of non-CO2 gases, especially short-lived ones like CH4, to the overall objective of limiting warming. Express this as "every tenth of a degree warming from non-CO2 forcings reduces the carbon budget compatible with 1.5 or 2 degree temperature goal by 220 Gt CO2", and note that the carbon budget compatible with 1.5 is in the order of X-Y Gt CO2, and it becomes very transparent that this and how much non-CO2 mitigation matters, in the sense that it cuts X-Y% of the remaining carbon budget. [Andy Resinger, New Zealand] 

6359 14 38 15 3 Of Fig 2.2— Add index format to “CO2” (v) [Radim Tomal, Czech Republic] 

4625 15 2 Fig 2.2—Add index format to “CO2” (v) [Radim Tomal, Czech Republic] 

9760 15 1 15 3 is it possible to better explain “This relationship is robust in most of the mitigation pathways limiting warming below 2°C. Above this temperature threshold, this relationship between carbon budget and temperature contribution from non-CO2 forcing does not hold.” Why does it not hold? [Mark Teder, Germany] 

4977 15 1 15 3 is it possible to better explain “This relationship is robust in most of the mitigation pathways limiting warming below 2°C. Above this temperature threshold, this relationship between carbon budget and temperature contribution from non-CO2 forcing does not hold.” Why does it not hold? [Mark Teder, Germany] 

6144 15 5 15 12 Replot the y-axis on (a) the same as the x-axis on (b). Rotate (b) so that both diagrams have the ‘non-CO2 warming contribution’ on the same axis. Incredibly hard to interpret what this figure is trying to tell me. [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)] taken into account — Figure 2.2 has been modified in order to improve its message. Besides, the text in relation with this figure has been revised accordingly. 

13297 15 5 15 12 Figure 2.2. Suggest moving colour legend to panel a as readers likely to start to comprehend panel a before panel b. [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)] taken into account — Figure 2.2 has been improved accordingly. 

13298 15 5 15 12 Figure 2.2: re-order legend items to match order of data in useful way for policy makers. It basically just communicates the message that any result within the range of 0.2-1.2 degrees is possible. One problem is that many input assumptions for different scenarios are changing at the same time. The authors need to ask themselves what message for policy makers needs to be communicated, and then they need to design a simple figure to communicate that message. Whatever figure or table must be focused on only the 1.5 and 2.0 degree pathways. This is true also for all the material presented on the following pages - why does the reader really need to have details about scenarios having a temperature increase of more than 2.07. What message is essential for policy makers? The Paris Agreement says the temperature increase should be limited to somewhere between 1.5 and 2.0 degrees C, so higher limits do not need to be addressed in this report. [Richard Rosen, Germany] taken into account — the figures and text have been improved accordingly. Besides, the revised section now focus on low warming scenarios. 

3157 15 5 15 12 Figure 2.2.a is a perfect illustration a set of results that is not presented in a useful way for policy makers. It typically just communicates the message that any result within the range of 0.2-1.2 degrees is possible. One problem is that many input assumptions for different scenarios are changing at the same time. The authors need to ask themselves what message for policy makers needs to be communicated, and then they need to design a simple figure to communicate that message. Whatever figure or table must be focused on only the 1.5 and 2.0 degree pathways. This is true also for all the material presented on the following pages - why does the reader really need to have details about scenarios having a temperature increase of more than 2.07. What message is essential for policy makers? The Paris Agreement says the temperature increase should be limited to somewhere between 1.5 and 2.0 degrees C, so higher limits do not need to be addressed in this report. [Richard Rosen, Germany] taken into account — the text and figures have been improved accordingly. Besides, the revised section now focus on low warming scenarios. 

17461 15 7 8 [Tom Gabriel Johansen, Norway] taken into account — Figures of section 2.2 has been revised accordingly. 

17501 15 7 8 [Angela Morell, Norway] taken into account — Figures of section 2.2 has been revised accordingly. 

20395 15 7 15 12 Figure: explain the color code in the caption or refer back to Table 2.3 to make it clear that eg <2°C scenarios only include >1.5°C and <2°C scenarios. [Céline Boucher, France] taken into account — Figure 2.2 has been revised in agreement with the new temperature classification used in the chapter. 

2194 15 10 15 12 as function of temperature contribution ... per GtCO2 of non-CO2 warming. -> This sentence is extremely difficult to understand. Some examples about how to interpret Figure 2.2b) should be provided. [Michio Kawamiya, Japan] taken into account — the wording of the paragraph has been improved accordingly. 

3160 15 17 19 1 Again, as I have said before, this is where a couple of interesting 1.5 DEGREE NON-OVERSHOOT SCENARIOS have to be included here, even if they cannot be developed using IAMs. Then, the carbon equivalent remaining budget numbers for all scenarios must be made consistent with, and hopefully identical to, the ones cited in draft chapter 1. If this is not done, this entire report will be out of compliance with the request stemming from the Paris Agreement. [Richard Rosen, Germany] taken into account — the revised scenario database used in the SOD now included several non-overlapping scenarios; they have been assessed accordingly. 

19306 15 18 15 20 Very important and very well written paragraph [Marco Mazetti, Switzerland] 

9300 15 19 15 19 The first word in “These differences can be categorised by three key features” may be “These”. [Sır Hülüs, Turkey] taken into account — this paragraph has been merged with section 2.1. 

16195 15 20 15 21 It really is not helpful scientifically or with respect to long-term impacts to be thinking of 1.5 C as a long-term goal—that is a climate situation that would be quite untenable for, for example, the sea level sensitivity is 15-30 meters per degree C, which is what one would derive from consensations during glacial-interglacial cycling, or 15-15 meters per degree C that one might infer from considering Earth’s climatic history and warm-period amounts of ice on land. If the goal is to stabilise the climate using the broad definition of climate instead of temperature, global warming in excess of 0.5 C is likely unacceptable—this report should thus be considering various long-term pathways of stabilization (all the way down to zero above preindustrial) and using 1.5 C as a marker or maximum acceptable on a pathway to below that level. [Michael MacCracken, United States of America] rejected. The suggestion is not in line with the mandate of this Special Report. 

906 15 28 15 20 Would it not have been possible to convert non-CO2 emissions into CO2 equivalents to make comparisons easier? [David Infield, United Kingdom (of Great Britain and Northern Ireland)] rejected — we chose to assess non-CO2 forces either in terms of radiative forcings or in terms of radiative forcing equivalents. 

3310 15 32 Is there any merit in a separate group for pathways which do not include a 1.5 deg or 2 deg overshoot? The distinction between overshoot and non-overshoot pathways was discussed in Ch1 and may it may be useful to see the differences in stringency for the same temperature outcome in 2100. [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)] taken in to account — the scenarios classifications has been revised in SOD.
Comment No | From Page | From Line | To Page | To Line | Comment | Response
--- | --- | --- | --- | --- | --- | ---
14934 | 16 | 1 | 16 | 1 | Labeling of scenario groups: I’m not sure it is accurate to call 66% probability 2°C scenarios “well below 2°C” and similar for “well below 1.5°C”. If this labeling is kept, further justification is needed for why these labels are used, and how this occurs with the legal literature on the detailed meaning of PA Article 2.1(a). Consistently with Chapter 1, I would like to see more focus on labeling stabilization vs. overshoot scenarios along with these ambition level groupings. Table 2.4 is helpful for this but a visual representation (again, simple if possible) of each median scenario type, showing the median year of overshoot, degree of overshoot (dcyr), etc. in emissions and temperature terms [Christopher Wheeler, United States of America] | taken into account—The labelling of scenario groups has been revised in the SOD
16196 | 16 | 6 | 16 | 6 | These pathways lead to refer to the maximum values—not the long-term values of warming. Is this notion of stabilizing at 1.5°C really the goal in any of these pathways? The long-term goal should really to get back to close to zero—and once one starts to come down from an ascendance, stopping at 1.5°C would require undoing much of the change that has been invested, and this might well involve considerable expense. So, why this focus on stabilizing at 1.5°C? [Michael MacCracken, United States of America] | taken in to account— the classification of scenarios has been updated for the SOD. At the same time, it is the chapter's and this report's mandate to assess the impacts of 1.5°C and associated pathways. The chapter content cannot go beyond the scope indicated by the approved mandate outline to a degree indicated by the reviewer comment.
10976 | 16 | 3 | 16 | 3 | Need to bold/overshoot into the classification? [Ilkka Jum, United Kingdom (of Great Britain and Northern Ireland)] | taken into account: Two new scenarios classes have been introduced in the SOD pathways classification
6873 | 16 | 6 | 16 | 6 | On table 2.3 see my general remark on the definition of the term "well below" [Bart Metz, Netherlands] | taken in to account — the scenarios classification has been totally reviewed
7031 | 16 | 5 | 16 | 5 | Not clear database the rightmost column of table 2.3 refers to. [Erik Maas, Sweden] | Taking into account. Scenario database is described in the section 2.1.4. of Chapter 2 FOD, however, the reference will be also provided in section 2.3.1 in the SOD
1509 | 16 | 5 | 16 | 5 | In the Table 2.3, it would be better to show the probabilities that can achieve 1.5C for each pathway as in Figure 2.3 [Ken'ichi Matsumoto, Japan] | Taking into account. This section now includes a table to exhibit probabilities that can achieve 1.5°C or ≤2°C
10657 | 16 | 9 | 16 | 22 | Additional citation possible to Xu and Ramamonjisoa 2017. (Well below 2°C. Mitigation strategies for avoiding dangerous to catastrophic climate changes, PNAS, doi:10.1073/pnas.1618481114) to show the consequence of delaying mitigation and the ability to achieve net-zero at 2050; delaying even ten years (from 2020 to 2030) requires far more negative emissions in the future to compensate. [Kristin Campbell, United States of America] | taken into account— Because uncertainties related to Earth system feedbacks and deployment of CDR are assessed in other section or subsection, the revised text has been improved to better liaise with those section.
17414 | 16 | 14 | 16 | 16 | I would like to see the statement where this overshooting is put to the context i.e. there is high uncertainty of feedbacks and deployment of CDRs which result in high risks in overshoot scenarios. [Tuomo Kallokoski, Finland] | taken in to account— the revised scenario database used in the SOD now included several non-overshooting scenarios; they have been assessed accordingly
9759 | 16 | 14 | 16 | 16 | It is a serious deficit not to have non-overshoot scenarios. There is some evidence that the possible budget for 1.5°C could be higher (see e.g. Miller et al. (2017) Emission budgets and pathways consistent with limiting warming to 1.5°C, nature geoscience, 18 SEPTEMBER 2017) which could allow non overshoot scenarios. Or new results in literature will come. [Marko Treuil, Germany] | taken in to account— the revised scenario database used in the SOD now included several non-overshooting scenarios; they have been assessed accordingly
4976 | 16 | 14 | 16 | 16 | It is a serious deficit not to have non-overshoot scenarios. There is some evidence that the possible budget for 1.5°C could be higher (see e.g. Miller et al. (2017) Emission budgets and pathways consistent with limiting warming to 1.5°C, nature geoscience, 18 SEPTEMBER 2017) which could allow non overshoot scenarios. Or new results in literature will come. [Marko Treuil, Germany] | taken in to account— the revised scenario database used in the SOD now included several non-overshooting scenarios; they have been assessed accordingly
12733 | 16 | 15 | 16 | 15 | Why not use the acronyms presented in table 2.3, instead of writing "<1.5degC" or "~1.5degC"? Also true for the rest of the chapter. [Vassilis Daioglou, Netherlands] | taken into account— the scenario classifications has been revised in SOD
20403 | 16 | 18 | 18 | 16 | Please better define “carbon enutrality”. I gather you mean net-zero ANTHROPOGENIC CO2 emissions (i.e not accounting for C feedbacks). [Oliver Boucher, France] | taken into account— the scenarios classifications has been revised in SOD
6145 | 16 | 21 | 16 | 21 | missing word ‘in’; should read ‘declines’ in virtually [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)] | Editorial
7994 | 16 | 21 | 16 | 21 | ‘Declines virtually’ should be ‘declines in virtually’ [Robert Shapiro, United States of America] | Editorial
2303 | 16 | 26 | 16 | 29 | Delete the sentence “In many ways...” This represents the authors’ qualitative judgement and gives the false impression that less the less ambitious mitigation pathways would not require fast and forceful action. [Kenneth Miller, Sweden] | taken into account—The revised text has been improved to better liaise with those section.
7032 | 17 | 18 | 17 | 18 | Could references be given for the data shown in Fig 2.3 and Table 2.4? [Erik Maas, Sweden] | taken into account—these table are derived from SR15 scenario database, as explained in the introduction of the chapter.
13299 | 17 | 7 | 17 | 7 | Figure 2.3: rotate “50%-50%” and “66%-66%” labels so text is horizontal, as easier to read. [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)] | Editorial
13301 | 17 | 7 | 17 | 7 | Figure 2.3: for panel b which shows the 50th percentile - is this simply the median? Median may be more readily understood. [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)] | Editorial
523 | 17 | 17 | 17 | 1 | It does not seem that any of the scenarios follow the proposed trajectory of 80% elimination of emissions by 2030 and 100% by 2050 as proposed in Figure 2 of Jacobson, M.Z., M.A. Delucchi, Z.A.F. Bauer, S.C. Goodman, 2017, Nature, 552, 275-282. | Editorial
13302 | 17 | 17 | 17 | 1 | Figure 2.3: re-order legend items to match order of data in figure (i.e. a. 3.5 tsp, 1.5 bottom) [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)] | Editorial
17462 | 2 | 2 | 2 | 2 | [Tristan Isherwood, Norway] | Editorial
17502 | 2 | 2 | 2 | 2 | [Alpaga Momin, Norway] | Editorial
4526 | 3 | 7 | 3 | 7 | Change “1850-1900” to “1855-1879” to be consistent with Chapter 1. [Radim Tolzis, Czech Republic] | rejected—this reference period is now consistent with the working definition used in Chap 1
6146 | 4 | 4 | 17 | 7 | Replace ‘by’ with ‘in’, which is more precise and requires less thought to understand. [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)] | Editorial
3161

While it is alright to describe the fact that there are many different pathways to any given temperature target in any given future year, there are many non-overshoot pathways is much more highly constrained. Yet, such a scenario could lead to beneficial growth in global employment (green growth) because of the higher investment requirements in the next few decades. What pages 21 and 22 need to do much better is to make it clear that input assumptions for scenarios such as those cited for three scenarios in figure 2.5 are only loosely related to the output results for emissions depicted in the graphs at the top of figure 2.5. The reader needs to understand that the emissions results depend on the entire validity of the integrated assessment models used to calculate those emissions, which means that the results depend on hundreds if not thousands of equations, constraints, and input cost and operating assumptions for various energy technologies, among other things. The reader also needs to be clear that each scenario was often run by a different model, so the difference in emissions results is not just due to the differences in basic scenario assumptions as listed in figure 2.5, but also hundreds of other differences that differ between IAMs. Therefore, the reader needs to be presented with some tables that give some of the numerical values for a considerable number of key input assumptions that are most important for determining differences in emissions results such as technology costs, constraints on how fast global energy technologies can penetrate the global mix, etc. This is crucial for TRANSPARENCY sake!! [Richard Rosen, Germany]

17415

This should be stated at the general conclusions of this report in order to indicate how difficult the aim is. [Tuomo Kalliokoski, Finland]

Taking into account. This section has been revised accordingly. An detailed assessment of IAM has been introduced

926

Net zero CO2, what about net zero GHG, more relevant for Paris. Also, what about the “balance”, more relevant for Paris. [Glen Peters, Norway]

Taking into account. Table 2.4 provides carbon budgets by scenarios categories whereas table 2.2 provides TPB across all scenarios

4765

In page 16 (lines 18-19), it says that “9th 1.5°C pathway class (-1.5°C and 1.5°C) reach carbon neutrality (or net-zero CO2 emissions) before 2050 in most of those scenarios’’. Thus, how many scenarios do reach carbon neutrality between 2040-2007? [Elena Georgoupolou, Greece]

Taking into account. The number and probability of scenarios staying below or returning below 1.5°C has been clarified. Besides the text of this section has been revised in agreement with the new scenario classification

12972

Fig 2.4 - Add index format to “CO2” (4x) [Radim Tolasz, Czech Republic]

Taking into account. This section has been revised accordingly. An detailed assessment of IAM has been introduced

14321

With a concentration of 400 ppm in 2015, 430 ppm corresponds to about 8% of increase rather than about 5%. [Serge PLANTON, France]

Taking into account. This statement (but in different words) is included in the Executive summary

16197

I don’t understand this sentence. Based on the figure, the non-linearity is due to scenarios where the temperature changes more than 1.5°C. And moreover, how 1.5°C could be reached if net carbon balance is zero all at 2100? It is possible to be increasing trend at 2100 if 2°C limit is not to be crossed? In fig 2.3b one curve may be close to this statement but even it seems to cross the 2°C limit before 2100. [Tuomo Kalliokoski, Finland]

Taking into account. In section 2.2, all numbers are computed relative to the first jet pat 2010. By providing both the absolute values and the values expressed relative to today’s levels we are able to apply a consistent approach throughout the entire chapter.

3311

I don’t understand the sentence. Based on the figure, the non-linearity is due to scenarios where the temperature changes more than 1.5°C. And moreover, how 1.5°C could be reached if net carbon balance is zero all at 2100? Is it possible to be increasing trend at 2100 if 2°C limit is not to be crossed? In fig 2.3b one curve may be close to this statement but even it seems to cross the 2°C limit before 2100. [Tuomo Kalliokoski, Finland]

Taking into account— we have revised the current section accordingly

17417

...change ‘contract’ to ‘contrast’ [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]

Taking into account. This section has been revised accordingly. An detailed assessment of IAM has been introduced

2004

It is claimed that a part of negative emissions is used for compensating carbon emissions. Explain how it is determined that that share of negative emissions are dedicated towards that purpose. Do the models explicitly deploy the quantity of negative emissions that are necessary to neutralise the residual warming? Furthermore, inform the reader also of the use of the remaining part of negative emissions. [Kenneth Möllersten, Sweden]

Taking into account— it has been mentionned in Section 2.3.1.1 of this Chapter

16198

I would urge that there also be information given (in text and/or plots) in what would be required to do even more—so to get back to 0 C. 0.5 C, and 1.0 C warming by 2100. So, how much removal of CO2 would be needed to do this, or how much reduction in radiative forcing would be needed to get back to these levels—that is, basically lay out what would be required to get some particular level, which is indeed what we want to be doing.

Taking into account — This lies outside the scope of this chapter and probably this entire Special Report on 1.5°C of Global Warming

14713

Please define AFOLU in the figure description. See also Strapasson et al. (2017, DoI: 10.1111/gcb.12498) for the AFOLU simulation. See full citation above. [Alexandre Strapasson, Brazil]

Taking into account— we have revised the current section.
### IPCC WGI SR15 First Order Draft Review Comments And Responses - Chapter 2

<table>
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**Comment:** Section 2.3 barely touches on non-CO2 mitigation. Given that the AIM scenario manages particularly deep reductions in methane and ozone, it must evolve different pathways than the other models and this should be explored somewhere in section 2.3. Many methane sources do not decrease automatically with a reduction in fossil fuels (e.g. landfill and waste management, agriculture). Literature is available on methane mitigation and should be covered in this section. ([William Collins, United Kingdom (of Great Britain and Northern Ireland)](https://example.com))

**Response:** Accepted - this caveat has been included and further elaborated in Section 2.6 on knowledge gaps and assessment tools

**Comment:** The IAM models used in SR 1.5 (and AR5) are sophisticated, detailed, and target exactly the right questions. Indispensable tools, these. But I believe they share a systemic kind of limitation causing them to overstate the energy use reductions arising from energy efficiency programs and so underestimate likely future energy demand. At minimum, I would offer, the IAMs underestimate the up-side uncertainty of future energy demand in response to efficiency gains. While the problem I see is systemic, it manifests in the models along four different lines, depending on the methodological approach taken: ([HARRY SAUNDERS, United States of America](https://example.com))

**Response:** Accepted - this caveat has been included and further elaborated in Section 2.6 on knowledge gaps and assessment tools

**Comment:** The IEA acknowledges the "rebound" effect, but reports it out at only around 10%. To illustrate the significance of this, if one were to instead assume rebound will be 50%, a figure that can be easily supported by the growing literature on rebound effects [3,4,5,6,7,8,9,10,11,12,13,23,26,27], meeting the carbon emissions target in the IEA "New Policies Scenario" would require global clean energy deployment about one-third higher than the agency's already ambitious targets, about 4.7 Terawatts of additional clean energy by 2035, or slightly more than total US electric power production in 2016. ([HARRY SAUNDERS, United States of America](https://example.com))

**Response:** Accepted - this caveat has been included and further elaborated in Section 2.6 on knowledge gaps and assessment tools

**Comment:** The IEA/IRENA model suffers, in my considered opinion, from being too rigid in its depiction of production-side processes. This follows in large part from its development legacy, stretching back some four decades, of employing/assuming what is technically known as Leontief-like behavior (or "fixed-factors behavior"). ([Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)](https://example.com))

**Response:** Accepted - this caveat has been included and further elaborated in Section 2.6 on knowledge gaps and assessment tools
Some researchers identify a further possible problem with the energy intensity projection method [24]. In their review of AR4, these researchers say the scenarios used there employ a kind of double counting of energy efficiency gains, with declining energy intensity in the base case already incorporating future ongoing technology improvements in energy efficiency; yet the scenarios add more on top of that. When viewed this way, these authors show that the assumed magnitudes of energy reductions due to energy efficiency gains are more than double the gains attributed in the scenarios to new-efficiency policy initiatives. Whether this remarka a problem in AR5 or remains one in SR 1.5 I do not know, but if so, it could exaggerate the energy efficiency demand reductions being reported by energy intensity projection-based models, meaning the corresponding reported scenario results underestimate future energy demand. [HARRY SAUNDERS, United States of America]

In general, the larger the CES elasticity of substitution between energy and other inputs, the larger will be energy efficiency rebound [1,2,16]. If this elasticity value is too low, the model will overstate energy use reductions from energy efficiency gains. ADVANCE documentation for AIM currently does not show the elasticity magnitudes (broken link), but the REMIND-MagPIE model uses a value of 0.5 in the highest nest, though it is unclear from the documentation how the reading for this three-factor structure works. This value is likely low, based on elasticities measured empirically for the US economy [8,10] and for Sweden [25].

More importantly, AIM, REMIND and WITCH apparently select single, fixed values for the substitution elasticity. But theory says that this elasticity is the primary driver of energy rebound [16,1,2], and so assuming a fixed value for this elasticity is tantamount to assuming the answer as to how efficiency gains translate to projected energy use [1].

Empirical evidence is wanting of the appropriate substitution elasticity/elasticities to use in a CES formulation [2], though some work has been done showing very large elasticity for Sweden [25] measured over a 200 year period. Empirical evidence for the more general and flexible Translog function shows multi-factor energy elasticities to be large [8,10] and thus conducive to large rebound magnitudes. [HARRY SAUNDERS, United States of America]

This approach of fixing assumed parameter values also underestimates the risk. The uncertainty attendant to future energy use depends heavily on uncertainty about the elasticity value. At minimum it is easy to argue that energy use currently projected in the scenarios is highly uncertain, and so contributes to the risk of 1.5°C overshoot.

One way around this particular issue might be to ask the relevant IAM modeling teams to provide sensitivity analyses with respect to their assumed levels of substitution elasticity.

The way efficiency gains are assumed to enter the CES function also has a large effect on projected energy use (not showing in the ADVANCE documentation for AIM or REMIND). Here out-of-date documentation for WITCH I have a possible problem arises if these use the so-called AEEI method going back to Manne and Richels as this introduces distortions that act to overestimate demand reductions due to energy efficiency gains [2,16], and so project energy use in a downward-biased way.

[PLEASE SEE COMMENT 3.1 appended at the end of Chapter 2 re use of intensity projections. [HARRY SAUNDERS, United States of America]
<table>
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<td>1685</td>
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<td>There is one further issue related to the scope comprehended in past and recent studies on efficiency rebound effects. It involves a limitation that plays out differently in industrialized vs. developing economies:</td>
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<td>Relying on Household Behavior to the Exclusion of the Productive Economy</td>
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<td>Globally, only about one-third of energy is used directly by households (household operation and personal transportation); the remaining two-thirds is used in the productive economy to produce goods and services (energy used in industry, commerce, commercial transportation) [17]. Unfortunately, the vast majority of energy efficiency rebound studies have historically evaluated rebound effects in the household sector, and largely in advanced economies. But on the productive side, empirical evidence shows rebound effects to be much larger [9,10,11,12,13]. Studies like Gillingham et al. [18,19], referenced in the SR 1.5 report, do not consider the productive economy, where most energy is used, and so are limited by this fact.</td>
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<td>The problem is compounded by the fact that historically, most rebound studies focused on advanced economies (this is changing), where saturation effects in households are shown to limit rebound. In developing countries, this constraint is not binding and rebound will tend to be higher [4,5,11,23,26,27].</td>
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<td>[HARRY SAUNDERS, United States of America]</td>
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<td>The Good News</td>
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<td>The good news in all this is that energy efficiency – and energy rebound itself – increases economic welfare [16,18,19,20]. In developing countries, more efficient lighting, heating, cooking and refrigeration allow poor populations living in energy poverty to consume much more energy. Beyond the household, energy-intensive production sectors such as steel, cement and chemical manufacturing are expected to grow enormously across the globe over much of this century as emerging economies build the basic infrastructure of modernity. Energy efficiency rebound will enhance this economic welfare creation.</td>
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<td>This means that even though energy use projections may be understated owing to rebound being understated, the capacity of the economy to meet key poverty eradication and equity SDGs is augmented by this rebound dynamic and the rebound calculations become less constrained. Nordhaus [21] even argues that the “tradeoff” is not a tradeoff at all but its opposite, since the faster third world consumption of energy grows in the near term the sooner it will peak and be sustained thereafter at a lower level than otherwise. This, owing to the salutary effects of adequate energy use on population growth/birth rates due to broad income gains, and enhanced capacity of a wealthier global population to deliver energy system decarbonization. [HARRY SAUNDERS, United States of America]</td>
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<td>Mitigating Rebound</td>
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<td>Two statements in the report suggest that policy must be applied to prevent or reduce rebound effects [Sections 4.4.6.2, 4.4.7.2]. But policies designed to thwart cost-effective energy efficiency gains risk reducing the above SDG-enhancing economic welfare gains unless the policies are of a particular nature. Specifically, to offset rebound effects using a carbon tax (or GHG taxes more generally) would substantially reduce economic output, employment, and producer profits/cash flows [22], taken on its own. I estimate the required carbon tax to offset rebound effects would be around $95/tonne for the US productive economy, with substantial corresponding economic welfare losses. Significantly, developing countries may be harmed disproportionately by rebound suppression policies [3,4,23].</td>
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<td>HOWEVER, if the tax is “revenue neutral” with tax proceeds completely recycled to the non-governmental economy, these negative effects appear to be offset [22]. But this would require a substantial global commitment to such a scheme, and would require governments to resist the temptation to use these tax revenues for other purposes; some governments so far have a spotty record honoring such commitments (cf. the UK Climate Change Levy (CCL)).</td>
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<td>Bottom line is: I offer the thought that SR1.5 guidance to suppress rebound should be qualified by the caution that such policies could reduce the capacity to meet other SDG goals, especially for developing countries where energy demand is well below saturation levels [3,4,5]. It may even be better to forgo advising such rebound mitigation policies in the context of the SR1.5 comprehensive framework, at least for developing countries. [HARRY SAUNDERS, United States of America]</td>
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<td>References Cited</td>
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| 4. Chacko, J.; Daigup, T.; Roy, J. (2013). "Rebound effect: how much to worry?" Current Opinion in Environmental Sustainability 5(2), 216-228. [large but varying rebound measured; rebound effects in developing countries likely to be higher than industrialized countries; rebound mitigation policy may not be appropriate for developing countries]

| Accepted - this caveat has been included and further elaborated in Section 2.6 on knowledge gaps and assessment tools |
| 1689       | 20        | 66        |         |         |
| 11. Barker, T. (2013) "Macroeconomic impacts of energy efficiency policies’ Presentation to the IEA Roundtable on Energy Efficiency, 25-26 January, 2013, Paris (total global rebound is about 50% by 2030; industrialized world (OECD) rebound effect is less than the developing world (non-OECD)]

| Accepted - this caveat has been included and further elaborated in Section 2.6 on knowledge gaps and assessment tools |
| 1690       | 20        | 66        |         |         |

| Accepted - this caveat has been included and further elaborated in Section 2.6 on knowledge gaps and assessment tools |
resulting characteristics/properties were better described and more thoroughly discussed. Thus, I suggest you start with the causes, restrictions and future commitments (Davis and Socolow 2014, Environ.Res.Lett. 9 (2014) 084018) affect the feasibility of these mitigation pathways? [Levi Golston, SAUNDERS, United States of America]


Other References


Comment No | From Page | From Line | To Page | To Line | Comment | Response
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20329 | 20 | 1 | 66 | 26 | See also my other comment to same lines. Readers should have more information about to what extent the characteristics/properties rely on exogenous assumptions and to what extent they are results of some optimization – and when it comes to the latter – what is optimized and under what restrictions/barriers. This would make the lines of reasoning more transparent and convincing. One natural starting point would be to derive possible cost-effective solutions (from the benchmarks (SSPs)). From there, more complicated worlds can be introduced – to clarify how outcomes depend on barriers, conflicting interests, technological uncertainty, resources, etc. The narratives underlying the assumptions, restrictions and optimization objective(s) should be given. The material in Fig. 2.5 is helpful ingredients that could be better integrated. Also, the introduction of 2.4.3.1. seems to be a good way of starting the whole chapter with SSPs. [Taran Fach, Norway] | Taken into account - yet, given explicit guidance by the co-chairs the SSPs should not be used exclusively as a framing concept for the chapter. This thus indeed complicates a structured discussion on the topic.
6360 | 20 | 19 | | | I would expect a clearer up-front discussion in this section that under some socio-economic development patterns in the baseline, 1.5 pathways are infeasible (with reference to the relevant definition of infeasibility). Plus, I would like to see a clearer discussion of how 1.5 pathways differ from 2 degree pathways, rather than a discussion of what a 1.5 degree pathway looks like. E.g. the statement on page 23 lines 3-8 is useful, because it helps clarify that 1.5 is not primarily achieved by throwing more BECCS at the problem but it does rely on early action at least to as much. [Andy Reisinger, New Zealand] | Noted
7033 | 20 | 19 | 21 | | I find it contradictory that the text says clearly that there are a variety of pathways, but then Fig 2.5 presents only 3 Pathways that are not introduced in the text. [Erika Måå, Sweden] | Taken into account - The three scenarios shown in this FOD figure are an illustrative sample. They are not exhaustive but aimed at illustrating the diversity amongst potential stringent mitigation scenarios. However, this figure has been removed in the SOD.
4841 | 20 | 19 | 22 | 6 | Scenario 3 has substantial fossil and requires substantial BECCS (90% of all bio-co) to offset. Is a scenario with more application of CCS directly on Fossil not more plausible with the potential limitations on biomass and also as the BECCS power needs to land in the energy system [Wilfred Maass, Germany] | Taken into account - The three scenarios shown in the FOD were an illustrative sample. Many other options are possible, which are shown and assessed in the remainder of the chapter. Scenario 3, however, already shows very little residual emissions from fossil fuel and industry, indicating that the potential for further application of CCS on fossil is limited in these very stringent scenarios.
6486 | 20 | 20 | 20 | 20 | Earlier assessments have [Roger Bodman, Australia] | Editorial
2611 | 20 | 20 | 20 | 34 | Is there sort of feasibility assessment made of the variety of scenarios that are compatible with 1.5 deg? Eg. if they all have different impacts on economic development, societal inequalities etc., are some automatically written off for being incompatible with the SDGs? [Zoha Shawoo, United Kingdom (of Great Britain and Northern Ireland)] | Taken into account - The three scenarios shown here are an illustrative sample. The SOD does not use them anymore
12981 | 20 | 20 | 20 | 34 | I suggest to place in this chapter a broad introduction to the three scenarios, instead of giving details in the caption of figure 2.5. A connection with what written in Chapter 1 on human-caused radiative forcing (i.e. 1.9 W m-2) could be useful [Casini Stefano, Italy] | Taken into account - The three scenarios shown here are an illustrative sample. The SOD has been removed in the SOD.
12982 | 20 | 20 | 20 | 34 | I suggest to decide and use the same name for each scenario, writing it also in the first line of Figure 2.5. I suggest not using for SSP-SSPS “energy intensive fossil fuelled” but instead “fossil-intensive-technology-focused” since this is also a mitigation scenario and the high technological level should be indicated in his name [Casini Stefano, Italy] | Taken into account - The three scenarios shown here are an illustrative sample. The SOD has been removed in the SOD.
16109 | 20 | 21 | 20 | 22 | While there is no single pathway to 1.5 C. It is worth repeating here that all such pathways involve phasing out net CO2 emissions, and all such pathways that want to minimize overshoot have this happening by near the middle of the century. So, I'd urge reiterating the commonalities—not just basically say anything is possible, as this sentence does. [Michael MacCracken, United States of America] | Accepted - we make clear that while there is a variety in scenarios, they have distinct characteristics for the phase-out of CO2. We also include a separate section on overshoot vs non-overshoot.
911 | 20 | 25 | 20 | 25 | It’s not clear how/inequalities themselves affect emissions. [David Infeld, United Kingdom (of Great Britain and Northern Ireland)] | Taken into account - The three scenarios shown here are an illustrative sample. The SOD has been removed in the SOD.
5165 | 20 | 28 | 20 | 29 | Globally coordinated solutions - provide example or delete. As a matter of fact, all successful solutions currently in the actual market are regionally driven. Request to reformulate the sentence “regionally driven” instead of “regionally fragmented” [Sven Tasko, Australia] | Taken into account - The three scenarios shown here are an illustrative sample. The SOD has been removed in the SOD.
2469 | 20 | 33 | 20 | 34 | While you state that policy decisions and societal choices are essential in shaping pathways, you only focus on policy--i.e., only on top-down approaches. [Lisa Lucero, United States of America] | Taken into account - The three scenarios shown here are an illustrative sample. The SOD has been removed in the SOD.
4528 | 21 | | | | Figure 2.5 - Add index format to "Wm-2" (2x) [Radim Tolasz, Czech Republic] | Noted
9939 | 21 | | | | Consider adding the SSP scenario in the figure (e.g., Scenario 1(SSP1), Scenario 2 (SSP2), Scenario 3 (SSP 5)) [Iulain Florin VLADU, Germany] | Taken into account - The three scenarios shown in this FOD figure are an illustrative sample. They are not exhaustive but aimed at illustrating the diversity amongst potential stringent mitigation scenarios. However, this figure has been removed in the SOD.
7162 | 21 | | | | The material in Fig. 2.5 is helpful ingredients that could be better integrated. Also, the introduction of 2.4.3.1. seems to be a good way of starting the whole chapter with SSPs. [Taran Fach, Norway] | Taken into account - The three scenarios shown in the FOD were an illustrative sample. Many other options are possible, which are shown and assessed in the remainder of the chapter. Scenario 3, however, already shows very little residual emissions from fossil fuel and industry, indicating that the potential for further application of CCS on fossil is limited in these very stringent scenarios.
9652 | 21 | | | | Nuclear should not be indicated with a radiation danger sign, as those signs are reserved to indicate a warning. E.g. atom (see for instance IAEA) | Accepted - yet, given explicit guidance by the co-chairs the SSPs should not be used exclusively as a framing concept for the chapter. This thus indeed complicates a structured discussion on the topic.
10328 | 21 | | | | Figure 2.5 presents 3 mitigation pathways for 1.5, for [i.e.1.5 or ?1.5] Can be clarified how this pathways relate or correspond to the Table 2.4 ones?. Why this ones are choosen for illistration?. Are the green, purple and violet colours in the figures corresponding to the same scenarios after in all figures where the colours appear? (it seems no...) [María Jose Sans Sanchiz, Spain] | Taken into account - The three scenarios shown here are an illustrative sample. The SOD has been removed in the SOD.
14937 | 21 | | | | Figure 2.5 needs some serious work. The visualization of SSPs is incredibly challenging but this graphic doesn’t quite cut it yet. First, the black vs. grey vs. white at bottom of graphics are confusing. Second, the CO2 pathway graphics are probably the least interesting part of the graphic; I would suggest deletion. Finally, I would suggest a better visualization of the societal outcomes currently in text. Perhaps a stoplight graphic would work wellshowing the SSPs on one axis and a single indicator for each major parameter (population, GDP/cap, equity, tech shares of key technologies (bio/TPE, nuc/TPE), etc.). Such graphics are widely used in grey literature and I find convey multiple dimension data effectively [Christopher Weber, New Zealand] | Taken into account - The three scenarios shown here are an illustrative sample. The SOD has been removed in the SOD.
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<td>321</td>
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<td>Figure 2.5: Add scenario 4 category - Energy supply portfolios excluding CCS and nuclear, current categories are biased and do not reflect latest state of scientific knowledge. Energy models excluded CCS and nuclear and moved to 100% BECAUSE of the profound market failure of those technologies. It is a matter of responsibility and precautionary principle to develop climate mitigation scenarios without technologies which are proven unsuccessful in the energy market over the past decade. ([Sven Teske, Australia])</td>
<td>Accepted - the caveat has been included and further elaborated in Section 2.6 on knowledge gaps and assessment tools</td>
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<td>Figure 2.5: Add scenario 4 category - Energy supply portfolios excluding CCS and nuclear, current categories are biased and do not reflect latest state of scientific knowledge. Energy models excluded CCS and nuclear and moved to 100% BECAUSE of the profound market failure of those technologies. It is a matter of responsibility and precautionary principle to develop climate mitigation scenarios without technologies which are proven unsuccessful in the energy market over the past decade. ([Sven Teske, Australia])</td>
<td>Accepted - the caveat has been included and further elaborated in Section 2.6 on knowledge gaps and assessment tools</td>
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<td>Figure 2.5: Add scenario 4 category - Energy supply portfolios excluding CCS and nuclear, current categories are biased and do not reflect latest state of scientific knowledge. Energy models excluded CCS and nuclear and moved to 100% BECAUSE of the profound market failure of those technologies. It is a matter of responsibility and precautionary principle to develop climate mitigation scenarios without technologies which are proven unsuccessful in the energy market over the past decade. ([Sven Teske, Australia])</td>
<td>Accepted - the caveat has been included and further elaborated in Section 2.6 on knowledge gaps and assessment tools</td>
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<td>Figure 2.5 shows a dramatic increase in nuclear power. This need for nuclear power to work alongside wind, solar biofuels and CCS isn’t reflected in the text. While there are strategies for maintaining warming at 1.5°C that don’t involve nuclear, many of those strategies do. An exploration of how much nuclear has been contributing to carbon-free electricity (or at least very little carbon) and could continue to do so should be included in the text as it is in this figure. The first scenario includes an even higher contribution of nuclear power, and the second and third both show nuclear power quintupling over the projected period. Additionally, there’s the grey (baseline case) and black (scenario case), and the red-outlined cases all explained, the black outlines around white bars in the scenarios with no explanation, it is uncertainty? ([Marco Mazzotti, Switzerland])</td>
<td>Accepted - the white bars with black contour were depicting &quot;empty placeholders&quot;. They were indeed not explained in the caption. However, due to restructuring of the chapter, the figure was now removed.</td>
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<td>() ([Tom Gabriel Johansen, Norway])</td>
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<td>([Angela Morelli, Norway])</td>
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<td>([Jacobson, M.Z., and M.A. Delucchi, A path to sustainable energy by 2050, Scientific American, November 2009]) ([Mark Jacobson, United States of America])</td>
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- The scenarios 1-3 proposed are unrealistic, in that they include CCS and growths in nuclear (at least in scenarios 2 and 3), when it is shockingly clear that CCS does not and is unlikely to exist at any useful scale in the future and nuclear costs are so high and nuclear takes so long to implement that current projects have been abandoned (e.g., two South Carolina plants have stopped construction and the Georgia Vogtle plant may soon follow suit). The only nuclear growth at this time is in non-liberalized markets, and those don’t make up for the ones being shut down. Most experts agree there is virtually no chance for nuclear to be helpful for solving the climate problem, particularly limiting to 1.5 warming. Further, scenarios do exist that should be cited in this report that do not require either CCS or nuclear to go to zero emissions in the energy sector, namely the following 8 papers involving dozens of authors. [Mark Jacobson, United States of America]

- It’s vital to discuss population management. [Lisa Lucero, United States of America] 

- Is it correct to start a sentence with a number? And other places. [Jorge Carrasco, Chile]

- The only nuclear growth at this time is in non-liberalized markets, and those don’t make up for the ones being shut down. Most experts agree there is virtually no chance for nuclear to be helpful for solving the climate problem, particularly limiting to 1.5 warming. Further, scenarios do exist that should be cited in this report that do not require either CCS or nuclear to go to zero emissions in the energy sector, namely the following 8 papers involving dozens of authors. [Mark Jacobson, United States of America]

- Taken into account - the scenario shown here are illustrative and combined with the assessments of real-world policies in Chapter 4 their realism can be assessed. Including an exhaustive discussion of this topic is outside the scope of Chapter 2, as it would strongly overlap with other sections of the report. The additional references are appreciated and will be considered in the assessment of the energy system in the appropriate section in this chapter.

- The scenarios 1-3 proposed are unrealistic, in that they include CCS and growths in nuclear (at least in scenarios 2 and 3), when it is shockingly clear that CCS does not and is unlikely to exist at any useful scale in the future and nuclear costs are so high and nuclear takes so long to implement that current projects have been abandoned (e.g., two South Carolina plants have stopped construction and the Georgia Vogtle plant may soon follow suit). The only nuclear growth at this time is in non-liberalized markets, and those don’t make up for the ones being shut down. Most experts agree there is virtually no chance for nuclear to be helpful for solving the climate problem, particularly limiting to 1.5 warming. Further, scenarios do exist that should be cited in this report that do not require either CCS or nuclear to go to zero emissions in the energy sector, namely the following 8 papers involving dozens of authors. [Mark Jacobson, United States of America]

- Accepted - the context of population projections has been provided in a bit more detail - although a detailed discussion of population for climate change mitigation falls outside the scope of a Special Report on 1.5°C

- Accepted - this was a typo and has been clarified, also with an additional discussion on population projections

- Accepted - this was a typo and has been clarified, also with an additional discussion on population projections

- Taken into account - future female educational attainment has shown to strongly influence fertility rates

- Taken into account - future female educational attainment has shown to strongly influence fertility rates

- Accepted - this has been highlighted in the introduction of scenarios

- Accepted - some points of reference have been included

- Accepted - this was a typo and has been clarified, also with an additional discussion on population projections

- Noted - the SOD has been edited to make this clearer. questions of equity are not within the scope of chapter 2, but rather fit in chapter 4.

- Taken into account - most scenarios currently included in the FOD do not stabilize, they overshoot 1.5°C and then slowly embark on a downward trajectory facilitated these aspects are

- Taken into account - the SOG has been edited to make this clearer: questions of equity are not within the scope of chapter 2, but rather fit in chapter 4.

- Accepted - this was a typo and has been clarified, also with an additional discussion on population projections

- Accepted - this was a typo and has been clarified, also with an additional discussion on population projections

- Taken into account - most scenarios currently included in the FOD do not stabilize, they overshoot 1.5°C and then slowly embark on a downward trajectory facilitated these aspects are

- Accepted - this was a typo and has been clarified, also with an additional discussion on population projections

- Taken into account - most scenarios currently included in the FOD do not stabilize, they overshoot 1.5°C and then slowly embark on a downward trajectory facilitated these aspects are

- Taken into account - the SOG has been edited to make this clearer: questions of equity are not within the scope of chapter 2, but rather fit in chapter 4.

- Taken into account - the SOG has been edited to make this clearer: questions of equity are not within the scope of chapter 2, but rather fit in chapter 4.
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<th>Comment No</th>
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<tbody>
<tr>
<td>3313</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>6</td>
<td>Quantity faster in both instances [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Taken into account - the quantifications requested here are provided in the following paragraphs</td>
</tr>
<tr>
<td>16203</td>
<td>23</td>
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<td>6</td>
<td>The phrase regarding electrification is not complete. [Michael MacCracken, United States of America]</td>
<td>Editorial - corrected</td>
</tr>
<tr>
<td>913</td>
<td>23</td>
<td>23</td>
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<td>6</td>
<td>Although energy per capita is an important measure, surely total energy demand (which factors in population assumptions) is more directly linked to impact? [David Infield, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Accepted - final energy demand is shown instead</td>
</tr>
<tr>
<td>10438</td>
<td>23</td>
<td>23</td>
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<td>6</td>
<td>* a faster electrification of energy and use* not faster in electrification [Jonathan Lynn, Switzerland]</td>
<td>Accepted - final energy demand is shown instead</td>
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<tr>
<td>6526</td>
<td>23</td>
<td>10</td>
<td>23</td>
<td>10</td>
<td>Figure 2.6: not only for this figure, need legends to understand exactly what are the bars of different colors without reading captions. [Shiyou Kobayashi, Japan]</td>
<td>Editorial - labels have been included in the top left panel</td>
</tr>
<tr>
<td>1510</td>
<td>23</td>
<td>10</td>
<td>23</td>
<td>10</td>
<td>What are the bars showing in Figure 2.6? [Kanichi Matsumoto, Japan]</td>
<td>Editorial - labels have been included in the top left panel</td>
</tr>
<tr>
<td>10943</td>
<td>23</td>
<td>10</td>
<td>23</td>
<td>11</td>
<td>Fig. 2.6: colours of the bars remain unclear - legend to be added [Christian Breyer, Finland]</td>
<td>Editorial - labels have been included in the top left panel</td>
</tr>
<tr>
<td>4766</td>
<td>23</td>
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<td>11</td>
<td>Figure 2.6 - a legend should be added explaining to which category of scenarios correspond the yellow, blue and grey shaded bars. Alternatively, this could be explained in the title as (in Figure 2.7). [Eleena Georgopoulos, Greece]</td>
<td>Editorial - labels have been included in the top left panel</td>
</tr>
<tr>
<td>6148</td>
<td>23</td>
<td>10</td>
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<td>16</td>
<td>Figure 2.6 does not explain what grey, yellow and blue mean. This is the first time the SSP colouring is used: has this figure been moved from later in the document? [Philp Sargent, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Editorial - labels have been included in the top left panel</td>
</tr>
<tr>
<td>9545</td>
<td>23</td>
<td>10</td>
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<td>16</td>
<td>Please illustrate color code of pillars in each graph, and pillars themselves [Shiyou Kobayashi, Japan]</td>
<td>Editorial - labels have been included in the top left panel</td>
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<tr>
<td>9675</td>
<td>23</td>
<td>10</td>
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<td>16</td>
<td>Please illustrate color code of pillars in each graph, and pillars themselves [Shiyou Kobayashi, Japan]</td>
<td>Editorial - labels have been included in the top left panel</td>
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<tr>
<td>7035</td>
<td>23</td>
<td>10</td>
<td>23</td>
<td>16</td>
<td>What do the colors (grey, yellow, blue) represent in Fig 2.6? [Eniko Mate, Sweden]</td>
<td>Editorial - labels have been included in the top left panel</td>
</tr>
<tr>
<td>12983</td>
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<td>10</td>
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<td>16</td>
<td>Fig 2.6 is a legend for the three scenarios is missing, what written in the first line of the caption of fig 2.7 could be ok (baseline - black, Etc) [Cassimer Stefano, Italy]</td>
<td>Editorial - labels have been included in the top left panel</td>
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<tr>
<td>13306</td>
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<td>10</td>
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<td>16</td>
<td>Figure 2.6. The meaning of the colours (grey, yellow, blue) do not appear to be explained: (1 baseline; 1.5; and 2); label sub-plots a-d for consistency with other figures in chapter [Jonathan Hanris, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Editorial - labels have been included in the top left panel</td>
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<tr>
<td>9495</td>
<td>23</td>
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<td>17</td>
<td>Figure 2.6: there is no legend which shows 1.5C: 2OC, and baseline. [Masao Takagi, Japan]</td>
<td>Editorial - labels have been included in the top left panel</td>
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<tr>
<td>5167</td>
<td>23</td>
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<td>17</td>
<td>Figure 2.6: Add information how many difference scenarios have been included for each model - database unclear [Even Teake, Australia]</td>
<td>Taken into account - a report annex is being proposed which documents the scenarios available in the database and to the assessment</td>
</tr>
<tr>
<td>5168</td>
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<td>17</td>
<td>Figure 2.6: Add figure with energy intensity in (MJ/$GDP) in order to make different assumptions transparent [Sven Teske, Australia]</td>
<td>Taken into account - a report annex is being proposed which documents the scenarios available in the database and to the assessment</td>
</tr>
<tr>
<td>10978</td>
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<td>16</td>
<td>Would like to discuss the presentation of this type of information. A recommendation of the Expert Meeting was to make more use of deep dives into marker/energy scenarios and I am missing that here. I am not sure what the value policymakers get out of this diagram with huge ranges for every variable. [Shiyou Kobayashi, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Taken into account - such deep dives will also be available. Not every figure is a deep dive. Section 2.4 will provide deep dives. Policymakers should get the general trends from these large ranges</td>
</tr>
<tr>
<td>12023</td>
<td>23</td>
<td>12</td>
<td>23</td>
<td>12</td>
<td>Colors of bars, and definition of whiskers not explained [Thomas Stocker, Switzerland]</td>
<td>Editorial - labels have been included in the top left panel</td>
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<td>11769</td>
<td>23</td>
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<td>23</td>
<td>12</td>
<td>A (trim dẫn bài - Noriskyh, Norway)</td>
<td>Noted</td>
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<td>12874</td>
<td>23</td>
<td>12</td>
<td>23</td>
<td>12</td>
<td>Figure 2.6: Indicate meaning of the colours, cross bars and dot lines. [Jorge Camasco, Chile]</td>
<td>Editorial - labels have been included in the top left panel</td>
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<tr>
<td>17655</td>
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<td>A (Andrea Noto, Norway)</td>
<td>Noted</td>
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<tr>
<td>3314</td>
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<td>What do the colours mean in Fig 2.6? [Iustin Bishop, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Editorial - labels have been included in the top left panel</td>
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<tr>
<td>12735</td>
<td>23</td>
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<td>12</td>
<td>A legend should be added describing the colours of the bars (1: grey baseline; yellow=2degree, blue=1.5 degrees). Also mention in the caption (1) (Vaasal Deogbuh, Netherlands)</td>
<td>Editorial - labels have been included in the top left panel</td>
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<tr>
<td>11912</td>
<td>23</td>
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<td>16</td>
<td>The legend doesn't include an explanation of the colours used in the graphs. [Amandine Denis-Ryam, Australia]</td>
<td>Editorial - labels have been included in the top left panel</td>
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<tr>
<td>14322</td>
<td>23</td>
<td>12</td>
<td>23</td>
<td>16</td>
<td>The color code is missing. [Serje PLANTON, France]</td>
<td>Editorial - labels have been included in the top left panel</td>
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<tr>
<td>3315</td>
<td>23</td>
<td>18</td>
<td>23</td>
<td>16</td>
<td>Change 'in' to 'in' Iustin Bishop, United Kingdom (of Great Britain and Northern Ireland)</td>
<td>Editorial - corrected</td>
</tr>
<tr>
<td>7435</td>
<td>23</td>
<td>18</td>
<td>23</td>
<td>19</td>
<td>Consider more elaboration on the nature of the energy demand reductions. The nature of energy demand reductions is of great policy relevance. Primary energy demand will fall from BAU levels simply because of electrification of society. Jacobsen et al (Jacobsen et al, 2018, 1–14 September, 2017. Almex Eliever: <a href="http://dx.doi.org/10.1016/j.joule.2017.07.005">http://dx.doi.org/10.1016/j.joule.2017.07.005</a> estimate that this effect is in the order of a 42.5% reduction in primary energy demand by 2050 (although within their own scenario modelling). Demand reductions in the models that come about as a consequence of climate mitigation rather than as a mitigation measure activity pursued should be described. This will help policymakers to make efficient policy. [Byrned Christophersen, Norway]</td>
<td>Taken into account - here the overall picture is provided, while the sectoral subsections in Section 2.4 provide deeper dives for the energy, transport, buildings, industry and AFOLU sectors. Demand reductions are covered there.</td>
</tr>
<tr>
<td>10439</td>
<td>23</td>
<td>18</td>
<td>23</td>
<td>28</td>
<td>'Energy demand reduction is' to 'energy demand reductions are' [Jonathan Lynn, Switzerland]</td>
<td>Editorial - has been corrected</td>
</tr>
<tr>
<td>3162</td>
<td>23</td>
<td>18</td>
<td>23</td>
<td>30</td>
<td>This discussion of energy demand reductions (efficiency improvements and fuel switching?) does not make it clear whether all these ranges of numbers are for different models, different scenarios, or different sets of input assumptions. For example, it does not state whether or not these numbers are results from models, or input assumptions. Either way this section should explain how they are computed, and key assumptions input to their calculation. Also, are any of the incremental costs for these higher efficiency technologies included in the models? (My understanding is that they are input assumptions for different scenarios, which may differ between different IAMs relied on for this report.) Thus, in general, the report needs to describe and justify the basis for these numbers. [Richard Rosen, Germany]</td>
<td>Taken into account - First, the FOD figure 2.8 has now been updated to also report the 6 of scenarios and contributing modelling frameworks per class.</td>
</tr>
</tbody>
</table>
How much smaller? [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]

The size reductions are discussed in the body of this paragraph where various levels of final energy demand are provided.

How much "smaller" is precisely what is meant here.

How much CO2 is attributed to food and feed production? [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]

Rejected - we have not been able to extract these exact numbers from the available data.

How could an example be given? Energy demand reductions are particularly important because end-use efficiency improvements are able to leverage upstream energy reductions which can be several times to an order of magnitude larger than the initial end-use demand reduction. Sentences before and after may need to be re-written as well. [Jason Doran, Canada]

Accepted - the sentence has been edited and the next sentence already provides an example.

An example would be useful here. [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]

Taken into account - the example of lighting is provided.

Figure 2.7: for Panel b - data marks at top of plot may not be noticed against border of plot - could remove top and right hand borders of the plot or extend the y-axis range upwards. [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)]

Rejected - this figure has been removed.

Figure 2.7: explain colour of dots in legend in the plot (rather than in caption text, where it may not easily be found). [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)]

Rejected - this figure has been removed.

The role of transformation of many coastal ecosystems (human transformation but also the changes promoted by the relative sea-level oscillations).

Delete the last 's' in 'assessments' to make it 'assessment'. [Himangana Gupta, India]

Editorial

Do Not Quote, Cite, or Distribute Page 50 of 107

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Comment Response

3316 23 19 How much smaller? [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]

The size reductions are discussed in the body of this paragraph where various levels of final energy demand are provided.

3476 23 19 19 Perhaps 'less challenging' instead of 'smaller'. [Elena Georgiadou, Greece]

Rejected - "smaller" is precisely what is meant here.

14215 23 20 23 22 This sentence is awkward and should be broken into 2 or more sentences. Additionally, the idea behind it is quite strange. Is this in absolute numbers or relative numbers? Could an example be given? [Mendas Zrinka, United Kingdom (of Great Britain and Northern Ireland)]

Accepted - the sentence has been edited and the next sentence already provides an example.

13183 23 29 30 Here and in other sections of this chapter, authors can consider comparing the projections with data from 2015 instead of 2010 or earlier since this is a rather outdated base year. [Değer Sevinç, Turkey]

Taken into account - here a 2010 reference year is provided as this is available from the submitted scenario data.

13184 23 29 30 Please clarify whether non-energy uses are also included. [Değer Sevinç, Turkey]

Rejected - it is unclear what is meant with non-energy uses of energy.

12738 23 30 23 30 Make it clear that the absolute energy demand numbers quoted here are for a 1.5 Scenario. [Vasipso Huang, Netherlands]

Accepted - this figure has been clarified.

5762 23 30 24 4 In figure 2.8 there should be an indication of which one of the S3P scenarios represent each colour. [Ogna Alcaniz, Spain]

Rejected - this figure has been removed.

11216 24 24 Fig 2.7 - Add index format to "Fig 2.7" (2x) [Radim Tolasz, Czech Republic]

Rejected - this figure has been removed.

4528 24 24 Figure 2.8: Suggest to include a legend to the graph (colors associated to bar) in addition to caption. [Michael Schaefler, Netherlands]

Accepted - a legend has been added.

13307 24 24 1 24 11 Figure 2.7: explain meaning of colour (black, green, blue) in plots, e.g. in a legend. Colour for baseline, 1.5 and 2 should be consistent throughout the report's plots. [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)]

Rejected - this figure has been removed.

13308 24 24 1 24 11 Figure 2.7: In Panel b - data marks at top of plot may not be noticed against border of plot - could remove top and right hand borders of the plot or extend the y-axis range upwards. [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)]

Rejected - this figure has been removed.

13309 24 24 1 24 11 Figure 2.7: Explain which part of the box plot relates to min and max. [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)]

Rejected - this figure has been removed.

13310 24 24 11 24 11 Figure 2.7: Explain colour of dots in legend in the plot (rather than in caption text, where it may not easily be found). [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)]

Rejected - this figure has been removed.

17466 24 3 A [Tom Gabriel Johansen, Norway]

Editorial

17508 24 3 A [Angela Monell, Norway]

3318 24 3 Colours should be consistent across Fig 2.6 and Fig 2.7 if the boxes represent similar warming limits. [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]

Accepted - this figure has been removed.

534 24 3 24 3 There is no information in this figure caption about what the demand reductions are due to. Do the demand reductions account for the factors in the comment above (efficiency of electricity, eliminating energy in fossil fuel extraction/transformation, which were first identified in Jacobson, M.Z., and M.A. Delucchi, Providing a path to sustainable energy by 2030, Scientific American, November 2006 and 2009, Jacobson, M.Z., and M.A. Delucchi, Providing all Global Energy with Wind, Water, and Solar Power, Part I: Technologies, Energy Resources, Quantities and Areas of Infrastructure, and Materials, Energy Policy, 39, 1154-1169, doi:10.1016/j.enpol.2010.11.040, 2011. [Mark Jacobson, United States of America]

Accepted - this figure indeed shows macro indicators of overall energy demand. The sector sections on building, transport, energy, and industry further in this chapter look into more detail in the demand issues.

12876 24 10 24 34 UNIRE model, REMEMBRANCE2 model need to be described some how [Lorenzo Carasco, Chile]

Accepted - this figure has been removed.

6391 24 13 24 28 It would be helpful if this para could provide a clearer link back to the finding about how much non-CO2 warming reduces the carbon budget - use this to demonstrate why and to what extent reduction of non-CO2 emissions from agriculture (which is the biggest source after taking out fossil methane) is a critical element of achieving 1.5 degrees. Talk about how these reductions could be achieved (supply and demand side). [Andy Reisinger, New Zealand]

Taken into account - a reference has been made to the influence of non-CO2 emissions on the remaining carbon budget.

10239 24 13 24 28 re with respect to mitigation challenges it is worth mentioning the impact of land/landscape practices on the seas basins, coasts and global oceans in reducing the level of emissions. [Mendes Zrinka, United Kingdom (of Great Britain and Northern Ireland)]

Rejected - the impact of mitigation pathways on the environment is part of the Chapter 3 assessment. As no reference is provided here by the reviewer it is unclear what can be included in Chapter 2.

6634 24 13 24 31 The role of transformation of many coastal ecosystems (human transformation but also the changes promoted by the relative sea-level oscillations) may be another important further aspect to be considered. [Cagnot Mullot Sobrino, Spain]

Rejected - the discussion of coastal ecosystems and their transformation for reasons other than climate change mitigation would be outside the scope of this chapter.

3163 24 13 24 28 Similarly, this section on the agricultural and land-use aspects of 1.5 degree scenarios must include how non-overshoot scenarios are affected by these issues. Furthermore, the different ways that different IAMs model land-use and agriculture must be discussed to the extent that these different modeling approaches affect major greenhouse gas emissions. The authors might want to focus on the model results that they believe are most credible in order to give policy makers guidance regarding the importance of policies dealing with these issues. In general, Chapter 2 does not provide much in detail in the demand issues.

Accepted - the SOD now includes a dedicated section on overshoot and non-overshoot. A further dedicated sector section speaks to the land-use and agricultural aspects of the transformation.

3319 24 16 How much CO2 is attributed to food and feed production? [Justin Bishop, United Kingdom (of Great Britain and Northern Ireland)]

Rejected - we have not been able to extract these exact numbers from the available data.

12738 24 18 24 28 As shown in fig 2.8 (left panel), there are few scenarios that show forest area reduction AND attainment of the 1.5 target. These should at least be mentioned in the text, highlighting that these scenarios probably assume greater (extreme) reductions in agricultural emissions and/or significant use of BECCS/CCDR (7) [Vasipso Huang, Netherlands]

Accepted - these details, however, are highlighted in section 2.4.6
This sentence is confusing - current text says you can expand forest cover and reduce ag emissions, or you can not expand forest cover and decrease ag emissions by a little - all compatible with 1.5 degrees. Which is true, but presumably in the latter case, the CO2 budget compatible with 1.5 degrees would be a lot smaller (otherwise, why does it make no difference if forest cover increases or not, or if ag emissions are reduced strongly or only a little?). The key point is that there are a lot of alternative pathways for the AFOLU sector, but choices in the AFOLU sector have a strong interplay with consequences for CO2 emissions budget from other sectors to help bring it out. The question of "how much is it worth if we could reduce agricultural GHG emissions by X%", or "how much do agricultural GHG emissions have to be reduced to be compatible (not incompatible) with a 1.5 degrees goal" is very important for folks dealing with climate change and food security (and that's a lot of people and policies!). This chapter could provide a key service to those discussions by clarifying the interplay between sectors (i.e. there are no absolute answers, but here is the change in carbon budget, and here is the additional mitigation cost, if agriculture does or doesn't reduce its emissions by a given amount relative to baselines). [Andy Reisinger, New Zealand]
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<td>1722</td>
<td>26</td>
<td>27</td>
<td>27</td>
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<td>Table 2.5, Column 2, Land use demand options: It is possible to also add protection of pristine forests and sustainable management of forests as it protects long sequenced carbon, both above-ground and below-ground. [Yirmigania Gupta, India]</td>
<td>Accepted - these options have been added</td>
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<tr>
<td>14217</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>1</td>
<td>Table 2.5 The lateral placement of topics like high-temperature geothermal heat is next to 'restoration of peat- and wetlands' both are good things to look at, but as far as I can tell, they have nothing to do with each other. Can this table be organized in a different way so that topics that are next to each other (similarly) don't look like they're supposed to be linked? [Jason Donec, Canada]</td>
<td>Editorial - the table has been improved for clarity with topics listed vertically so that no connections are suggested where there are none</td>
</tr>
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<td>2471</td>
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<td>26</td>
<td>1</td>
<td>Table 2.5, as well as most other tables, should also have a column on impacts on people [Lisa Lucero, United States of America]</td>
<td>Rejected - this table details mitigation options available for 1.5°C pathways and their inclusion in the scenarios assessed here. Impacts on people would hence not be in this scope.</td>
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<td>20406</td>
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<td>26</td>
<td>26</td>
<td>3</td>
<td>I am not sure how to read this table. [Olivier Boucher, France]</td>
<td>Taken into account - the table has been entirely restructured and a better description has been provided in the caption</td>
</tr>
<tr>
<td>1555</td>
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<td></td>
<td>Table should make more visible and be more precise on demand reduction measure. For example in the mobility sector, should be mentioned (each in one cell) avoided trips, modal shift from car to bicycle and public transportation, car-sharing scheme, bike-sharing scheme, ... For energy (each in one cell) reducing non essential night-time lighting, reducing non essential heating and air-conditioning in buildings, switching off of appliances instead of standby, ... Reduction of meat consumption should be explicitly mentioned, amongst other dietary changes. [Noël Lecours, Belgium]</td>
<td>Accepted - the aim of this table is to provide an overview of how measures are treated and included in integrated models, not to give an exhaustive overview of each single measure. The suggested measures have thus been included as example, yet not all in separate cells.</td>
</tr>
<tr>
<td>6149</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>4</td>
<td>The table is not easy to see and understand. Technologies in the same row are related each other? [Yuki Ishimoto, Norway]</td>
<td>Taken into account - the table layout has been improved for clarity</td>
</tr>
<tr>
<td>6150</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>4</td>
<td>The entry for &quot;Tidal energy&quot; in column 1 does not differentiate between barrages (height) and turbines (flow) which are very different in almost every important respect. [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Taken into account - we have now improved the granularity of mitigation measure representation in the table</td>
</tr>
<tr>
<td>16204</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>4</td>
<td>Regarding Table 2.5. What is the rationale for the ordering of items in column ? How can solar and wind be so low on the list compared to the first four that are all likely to play lesser roles. Also, &quot;Tidal energy&quot; should be changed to &quot;Tidal and current energy&quot; or something similar - there is a technology coming that gets around the problems that led Rolls Royce and GE to give up trying to get energy from the currents. There is nothing here on batteries and other storage - will be vital, particularly the ultra-capacitor batteries that will easily facilitate electrification of the transport sector because they can be rapidly recharged and will not deteriorate through a thousand more times of cycling than a chemical battery. [Michael MacCracken, United States of America]</td>
<td>Taken into account - The ordering of options was arbitrary at this point. The table has been improved to avoid suggesting links where there are none. The order of measures still remains rather arbitrary.</td>
</tr>
<tr>
<td>5710</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>4</td>
<td>Table 2.5 seems not complete [Hong Yang, Switzerland]</td>
<td>Noted</td>
</tr>
<tr>
<td>6949</td>
<td>26</td>
<td>27</td>
<td>27</td>
<td>1</td>
<td>The table is not easy to see and understand: Technologies in the same row are related each other? [Yuik Ishimoto, Norway]</td>
<td>Accepted - the table has been improved for clarity. The table still remains one single table even though</td>
</tr>
<tr>
<td>12104</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>1</td>
<td>It is stated that SDG includes Climate Action and, at Chapter 5, talk off between &quot;mitigation and adaptation&quot; and &quot;sustainable development. SDG is not equal to sustainable development but confusion may be occurred. One idea avoid confusion is to change sustainable development at some section to economic development. [Takashi Hongo, Japan]</td>
<td>Taken into account - this table has been improved for clarity</td>
</tr>
<tr>
<td>9163</td>
<td>26</td>
<td>27</td>
<td></td>
<td>1</td>
<td>If raw material substitution (for example, fossil CO2 by bio-CO2 in the beverage industry) include in the demand side measures? Is it part or reduced material demand? What about agriculture expansion only in degraded lands? [Adelmo Ricardo Jacintho Esparta, Brazil]</td>
<td>Taken into account - these measures have now been included</td>
</tr>
<tr>
<td>12964</td>
<td>26</td>
<td>27</td>
<td>27</td>
<td>2</td>
<td>Table 2.5 is confusing: at first sight one might expect that there is some horizontal link between columns, especially because there are white cells, but I do not see any horizontal link. In line 2 of column 2, &quot;Higher share of useful energy&quot; seems to be a subset of energy efficiency, if not simply identical to energy efficiency. There might be possibilities to clarify the difference between line 1 and 2 of this column [Philippe Marbaix, Belgium]</td>
<td>Taken into account - the table has been improved for clarity</td>
</tr>
<tr>
<td>21093</td>
<td>26</td>
<td>4</td>
<td></td>
<td></td>
<td>Table 2.5 is confusing: at first sight one might expect that there is some horizontal link between columns, especially because there are white cells, but I do not see any horizontal link. In line 2 of column 2, &quot;Higher share of useful energy&quot; seems to be a subset of energy efficiency, if not simply identical to energy efficiency. There might be possibilities to clarify the difference between line 1 and 2 of this column [Philippe Marbaix, Belgium]</td>
<td>Taken into account - the table has been improved for clarity</td>
</tr>
<tr>
<td>21094</td>
<td>26</td>
<td>4</td>
<td></td>
<td></td>
<td>Table 2.5, column 2, line 3: aren't behavioral changes considered in baselines and even in mitigation alternatives, as an external parameter (the cell is white)? This might be clarified, otherwise one may either conclude that nothing related to behavioral change is in the models, or that this is unclear. Column 2, line 2: I am surprised that measures such as insulation of buildings are &quot;typically not in IAM&quot;. If this is true, it might be a serious limitation? [Philippe Marbaix, Belgium]</td>
<td>Taken into account - we have now improved the granularity of mitigation measure representation classes in the table</td>
</tr>
<tr>
<td>11913</td>
<td>26</td>
<td>4</td>
<td></td>
<td></td>
<td>In the second column, section on &quot;other demand reductions&quot;, it would be good to mention here that new business models (eg autonomous vehicles allowing for a decrease in the size of the car fleet through the shared ownership) and new production processes (eg 3D printing) could also lead to reductions in material demand [Amandine Deris-Ryan, Australia]</td>
<td>Accepted - these measures have been added as examples to the table.</td>
</tr>
<tr>
<td>5226</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>4</td>
<td>Table 2.5 is not clear. At first glance, it looks like the boxes on one same line are connected in some way, but actually they are not. There are thus many empty boxes in strange places. Also, the legend explains the colour code, but it is not clear what the bold letters or italic letters mean. [Blanka SHGAC-TEHERRN, Japan]</td>
<td>Editorial - the table has been improved for clarity</td>
</tr>
<tr>
<td>14218</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>4</td>
<td>Table 2.5 Once again nuclear power is mentioned in the table, but not sufficiently explored in the text. Further, this table doesn't make sense with nuclear being put where it is with no context. [Jason Donec, Canada]</td>
<td>Taken into account - a discussion of nuclear power is included in the energy supply section (2.4.2)</td>
</tr>
<tr>
<td>2206</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>4</td>
<td>Column 3, row 1 identifies combustion and fermentation but neglects gasification (which is neither combustion or fermentation, yet a potential option for CO2 capture). [Kenneth Möllersten, Sweden]</td>
<td>Taken into account - gasification has been added to the cell</td>
</tr>
<tr>
<td>4769</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>4</td>
<td>Table 2.5: Given that a large part of the existing building stock in several countries has poor/no insulation, it is very strange that insulation of buildings for CO2 capture). [Kenneth Möllersten, Sweden]</td>
<td>Taken into account - a discussion of nuclear power is included in the energy supply section (2.4.2)</td>
</tr>
<tr>
<td>14324</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>4</td>
<td>In this table there is in general no direct link between the options in the 3 columns that are on the same line, it is perhaps better to suppress the horizontal lines separating the options. [Serge PLANTON, France]</td>
<td>Editorial - the table layout has been improved for clarity</td>
</tr>
</tbody>
</table>
IPCC WGI SR15 First Order Draft Review Comments And Responses - Chapter 2

Comment No | From Page | From Line | To Page | To Line | Comment | Response
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4293 | 26 | 4 | 27 | The continuation of Table 2.5 needs to have the headings repeated on the new page. And also needs to be 3 separate tables as the information items Direct Air Capture has been proposed "using chemical solvents and solid sorbents", and not only solvents (see works from your own reference for For steel and cement industries, please see van Ruijven et al. (2016) (http://dx.doi.org/10.1016/j.resconrec.2016.04.016= [Deger Saygin, Turkey] Noted

9549 | 27 | Column 2 Line 3: Decarbonising the energy intensive basic materials industry through electrification-Implications for future EU electricity demand, Stefan Lechtenboecker, Lar J. Nielsen, et al., Energy http://dx.doi.org/10.1016/j.energy.2016.07.110 will be a good reference [Shuzo Nishioka, Japan] Noted

9576 | 27 | Column 2 Line 3: Decarbonising the energy intensive basic materials industry through electrification-Implications for future EU electricity demand, Stefan Lechtenboecker, Lar J. Nielsen, et al., Energy http://dx.doi.org/10.1016/j.energy.2016.07.110 will be a good reference [Shuzo Nishioka, Japan] Noted

13157 | 27 | For steel and cement industries, please see van Ruijven et al. [2016] (http://dx.doi.org/10.1016/j.resconrec.2016.04.016= [Deger Saygin, Turkey] Noted

11914 | 27 | In the second column, section on "Electification of demand", subsection on "industry", I think it is important to list here alternative technologies which have a broader application that just one specific sector. In particular, there are many technologies available to provide heat through electricity, for example heat pumps and electric boilers. The report "Electric Power Research Institute (EPRI) 2009, The Potential to Reduce CO2 Emissions by Expanding End-Use Applications of Electricity, Final Report, Palo Alto" provides a good overview, and I'm sure there would be many peer reviewed articles which discuss this as well. It would also be worth mentioning technologies which can allow electrification of mining, for example conveyor belts which are already used in some mines worldwide, or trolley-assisted mining trucks (as discussed in Wolinetz, M & Bataille, C 2012, BC Hydro Electrolysis Potential Review Final Report, in BC Hydro, Integrated Resource Plan, Appendix 6C: Electrification Potential Review, viewed 30 May 2014. https://www.bcydro.com/energy-infrastructure/meeting-demand_growth_invp/documents_centers/reports/november-2013-irp.html). While these reports are not published in peer-reviewed publications, I would expect that these technologies would be mentioned in a few. [Amarnil Demir-Ryan, Australia]

20902 | 27 | Table 2.5: "Power-to-gas, methanisation, synthetic hydrocarbons". Perhaps use "synthetic fuels" instead of "synthetic hydrocarbons" to include non-carbon fuels such as ammonia [Marine Connor, France]

20303 | 27 | Table 2.5: "CCS in industrial process applications..." and "Replacing fossil fuels by electricity...": Aren't these demand side measures? [Marine Connor, France]

6151 | 27 | The continuation of Table 2.5 needs to have the headings repeated on the new page. And also needs to be 3 separate tables as the information items in the same row has no relation to one another. [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)]

14219 | 27 | The continuation of Table 2.5 needs to have the headings repeated on the new page. And also needs to be 3 separate tables as the information items in the same row has no relation to one another. [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)]

4170 | 28 | Table 2.5: Rapid decarbonisation will also require significant investments in hydro and nuclear and for renewable energy to develop effective storage or move away from partnering with natural gas as a back up and move towards lower carbon intensive options such as hydro or nuclear. This pathway also requires successful CCS. [Michelle Leslie, Canada]

4294 | 26 | 4 | 27 | Direct Air Capture has been proposed "using chemical solvents and solid sorbents", and not only solvents (see works from your own reference for For steel and cement industries, please see van Ruijven et al. (2016) (http://dx.doi.org/10.1016/j.resconrec.2016.04.016= [Deger Saygin, Turkey] Noted

20795 | 28 | 71 | It seems there is a lot of emphasis on limiting carbon emissions and what would need to be done there. Since the executive summary mentions that the mitigation of SLCFs has a large impact, reducing the amount of CO2 that needs to be removed, for example, I miss the discussion of the measures and policies that would need to be implemented to mitigate methane, implement the Kigali agreement, and also a description of the BC measures tat are relevant. The innovation in the UNEP/WMO assessment (and in Shindell et al 2012) was to identify those BC mitigation measures, where there was a net reduction in temperature - i.e. focussing on the BC rich sources, and not on those mitigation measures that reduced relatively large amounts of OC. I do not see this discussion of relevant mitigation measures either. Therefore there seems to not be a balance between the CO2 mitigation required and the role of mitigation measures for these other gases and particles. This leads the reader to think that only CO2 mitigation is needed, despite statements explaining how important they are. Also, there is a large reliance on biomass burning with CCA. To what extent would more ambitious mitigation of methane, HFCs and effective BC measures reduce the reliance on this unproven and potentially controversial technology? In addition, there are some particularly large benefits for sustainable development of the SLCF mitigation measures, and I don't see that discussed much either. It would be good to understand how much mitigation of methane, HFCs and BC is assumed in the in the reductions discussed [Johan Carl Ivar Kuylenstierna, United Kingdom (of Great Britain and Northern Ireland)]

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Table 2.6: none of the 60 peer-reviewed articles on 100% RE is mentioned; this scientific field is fully 'forgotten' here. Why? A fast decarbonisation in the line referring to "Additional reductions, on top of reductions from both CO2 and non-CO2 required for 2°C, are mainly from CO2", this statement is misleading as it emphasis that... 

As suggested in my general comments on the chapter and the entire report, table 2.6 should integrate the top-down information from the IAMs and the bottom-up information now in ch 4.2 and 4.3 by moving the material from ch 4 to ch 2. I suggest to insert a separate column in the table that discuss the difference between top-down and bottom-up estimates. If the sentence meaning in the second column of the third row on demand side would fit into such an additional column. [Bert Metz, Netherlands]

Table 2.6, line 2: do you mean "demand side" in terms of final product demand or "energy demand side"? I would guess that the demand for final products is relevant but section 2.3.4.2 suggests that what it meant by "end use sectors" is "energy end-use". The difference could be important, as "energy demand" is influenced by energy efficiency. If it is "energy demand", then there should probably be a clarification about the difference between this 2nd line and the 3rd line ("energy efficiency"). For example in a building the demand might be related to the size of the room and the desired temperature, in addition to energy efficiency aspects. [Philippe Marbaix, Belgium]

Table 2.6: it seems there is a lot of emphasis on limiting carbon emissions and what would need to be done there. Since the executive summary mentions that the mitigation of SLCF's has a large impact, reducing the amount of CO2 that needs to be removed, for example, I miss the discussion of the measures and policies that would need to be implemented to mitigate methane, implement the Kyoto agreement, and also a description of the BC measures tat are relevant. The innovation in the UNEP/WMO assessment (and in Shindell et al 2012) was to identify those BC mitigation measures, where there was a net reduction in temperature - i.e. focusing on the BC rich sources, and not on those mitigation measures that reduced relatively large amounts of CO. I do not see this discussion of relevant mitigation measures either. Therefore there seems to be a balance between the CO2 mitigation required and the role of mitigation measures for these other gases and particles. This leads the reader to think that only CO2 mitigation is needed, despite statements explaining how important they are. There is also a large reliance on biomass burning with CO2. To what extent would more ambitious mitigation of methane, HFCs and effective BC measures reduce the reliance on this unproven and potentially controversial technology? In addition, there are some particularly large benefits for sustainable development of the SLCF mitigation measures, and I don't see that discussed much either. It would be good to understand how much mitigation of methane, HFCs and BC is assumed in the in the reductions discussed [Johan Carl Ivar Kuyperskena, United Kingdom (of Great Britain and Northern Ireland)]

Row 12: The first column identifies CDR at scale before mid-century. However the second column only mentions snapshot figures for 2050. The... 

A fast decarbonisation is surely necessary for 1.5°C. This table draws on the sector assessments in the underlying sections [Christian Breyer, Finland]

Comment No From Page From Line To Page To Line Comment Response
2048 28 28 71 71 It seems there is a lot of emphasis on limiting carbon emissions and what would need to be done there. Since the executive summary mentions that the mitigation of SLCF’s has a large impact, reducing the amount of CO2 that needs to be removed, for example, I miss the discussion of the measures and policies that would need to be implemented to mitigate methane, implement the Kyoto agreement, and also a description of the BC measures tat are relevant. The innovation in the UNEP/WMO assessment (and in Shindell et al 2012) was to identify those BC mitigation measures, where there was a net reduction in temperature - i.e. focusing on the BC rich sources, and not on those mitigation measures that reduced relatively large amounts of CO. I do not see this discussion of relevant mitigation measures either. Therefore there seems to be a balance between the CO2 mitigation required and the role of mitigation measures for these other gases and particles. This leads the reader to think that only CO2 mitigation is needed, despite statements explaining how important they are. There is also a large reliance on biomass burning with CO2. To what extent would more ambitious mitigation of methane, HFCs and effective BC measures reduce the reliance on this unproven and potentially controversial technology? In addition, there are some particularly large benefits for sustainable development of the SLCF mitigation measures, and I don’t see that discussed much either. It would be good to understand how much mitigation of methane, HFCs and BC is assumed in the in the reductions discussed [Johan Carl Ivar Kuyperskena, United Kingdom (of Great Britain and Northern Ireland)] Taken into account - Chapter 2 discusses mitigation pathways in line with 1.5°C and compares these to 2°C pathways. The discussion of measures and policies is part of the Chapter 4 assessment.

12740 28 28 28 28 This table should be consistent concerning if the "supporting information" is in contrast to a 2degree or baseline scenario. According to the legend it is always with respect to the 2degree scenario; however many of the points are true for that scenario as well. If the 1.5 scenario is simply "more of that", it should be clear how much more. Given that a 2 degree scenario already has a huge effort, this table should make it clear what the EXTRA effort is. [Vassilis Daioglou, Netherlands] Rejected - this table now gives a general overview of characteristics of 1.5°C pathways, sometimes compared to 2°C, sometimes more in general

10844 28 8 28 11 I end this table really helpful in synthesising key messages from the modelling. [Skea Jim, United Kingdom (of Great Britain and Northern Ireland)] Noted

6877 28 8 28 12 A fast decarbonisation is surely necessary for 1.5°C. This table draws on the sector assessments in the underlying sections [Christian Breyer, Finland] Noted

6394 28 8 28 8 Table 2.6: row on "additional reductions, on top of...". This statement is only true for the exogenous technological change hard-wired into IAMs. A lot of research is currently going on to increase the potential abatement for c.g. CH4 from enteric fermentation, which is far bigger single CH4 source in IAMs in 2 or 1.5 deg C scenario, through methane inhibitors or a vaccine. The table and accompanying text has to make clear where its conclusions are contingent on assumptions about technological development, especially where there are active technology programmes that the IAMs largely ignore. Which is fine - but then you need to make clear that these are IAM assumptions, but there is other literature that says it doesn't have to be that way. [Andy Reisinger, New Zealand] Accepted - we have ensure that it is clear that this depends on the mitigation measures included in IAMs

9227 28 11 28 11 Last row in table, good to include land requirements of the CDR at that scale [Glenn Peters, Norway] These can vary strongly and would not be one of the key features

2207 2007 Noted - this table will be further updated after finalisation of the scenario rel in the database

535 28 11 28 11 Table 2.6: missing the 100% clean renewable energy scenarios laid-out in the 8 papers above. [Mark Jacobson, United States of America] This table draws on the assessment of the sectoral sections and the 1.5°C-related literature

2101 2101 With the demand side we refer to the industry, transport, and buildings sectors. Both energy demand and demand for products play a role here. [Johan Carl Ivar Kuylenstierna, United Kingdom (of Great Britain and Northern Ireland)] Rejected - we consider the statement pointing towards a phase-out coal not in any way to imply that there are no 100% RE pathways

5169 28 11 28 12 Table 2.6: add additional raw with scenarios which phase-out fossil fuels (including CCS) rapidly. This statement is misleading as it emphasis that there are no 100% RE pathways (climate mitigation scenarios, which is untrue. [Glenn Peters, Norway] contain no details about the impact of those additional reductions come from? [Elena Georgopoulou, Greece] Rejected - this table now gives a general overview of characteristics of 1.5°C pathways, sometimes compared to 2°C, sometimes more in general

4770 28 11 28 12 Table 2.6: in the line referring to "Additional reductions, on top of reductions from both CO2 and non-CO2 required for 2°C, are mainly from CO2", from which sectors/sub-sectors do these additional reductions come from? [Elena Georgopoulou, Greece] Mainly from the end-use sectors

4771 28 11 28 12 Table 2.6: it would be useful to indicate the differences between 2.0C and 1.5C in all times. [Elena Georgopoulou, Greece] Noted

14220 14220 It may help the reader if the underlying factors that impact the evolution of emissions are explained in more detail, for example to show the contribution of technologies (in addition to BECCS), impact of structural changes, demand changes, carbon reduction etc [Deger Saygin, Turkey] Taken into account - these underlying factors are addressed in the following sections of the chapter

4531 4531 Table 2.6: line 2: do you mean "demand side" in terms of final product demand or "energy demand side"? I would guess that the demand for final products is relevant but section 2.3.4.2 suggests that what it meant by "end use sectors" is "energy end-use". The difference could be important, as "energy demand" is influenced by energy efficiency. If it is "energy demand", then there should probably be a clarification about the difference between this 2nd line and the 3rd line ("energy efficiency"). For example in a building the demand might be related to the size of the room and the desired temperature, in addition to energy efficiency aspects. [Philippe Marbaix, Belgium] Noted

13188 13188 This table draws on the sector assessments in the underlying sections and the 1.5°C-related literature

10330 10330 Figure 2.9 is difficult to interpret. Se comments above (general) and comment 5 [Maria Jose Sanz Sanchez, Spain] Taken into account - the figure has been modified
Comment No | From Page | From Line | To Page | To Line | Comment | Response
--- | --- | --- | --- | --- | --- | ---
20796 | 29 | 32 | 32 | 32 | I find this section could be more informative. What exactly is assumed for the four different sources of SCGs? How much methane abatement is assumed in which sector? What is the maximum 5 reduction in methane, and for remaining emissions, what assumptions have been made about the difficult to abate sources? For example, FAO has proposed that improved management of livestock, through feed and pasture improvement and improved livestock fertility, could reduce methane emissions per unit of product (milk or meat) by up to 40%. Has this been used or is it assumed that this cannot be done? If it is not included, why is this considered to be more difficult than biomass + CCS, which is also unproven on a large scale? It says that reducing methane from paddy fields is sometimes not included, although widely practised, and what about waste emissions? I miss a discussion of the mitigation potential and how much is assumed, over what time period, and what would the advantages be of more rapid implementation? This is true for more rapid implementation of the Kigali agreement to phase out HFCs more quickly. And also the impact of reducing BC rich sources rapidly on temperature progression. [Johan Carl Ivar Kuylenstierna, United Kingdom (of Great Britain and Northern Ireland)] | Taken into account - these aspects are important yet are not specific to 1.5°C. Given constraints in scope and space, these aspects will be better considered in the overall AR6 assessment.

18783 | 29 | 9 | 32 | 32 | Section 2.3.3 should address the role of SLCP/SLCP in causing temperature rise to overshoot the 1.5°C threshold in the near-term period (e.g. by 2050). The more rapid crossing of the threshold due to the role of SLCP/SLCP is an important dimension that should be addressed. [David Waskow, United States of America] | Taken into account - the revised draft includes a dedicated section on overshoot and how various aspects contribute (section 2.3.2)

20849 | 29 | 32 | 32 | 32 | This new development is highlighted in the framing chapter 1. HFCs are discussed in context of the Kigali Agreement in the revised section 2.3 | Taken into account - these aspects are important yet are not specific to 1.5°C. Given constraints in scope and space, these aspects will be better considered in the overall AR6 assessment.

18816 | 29 | 9 | 32 | 32 | 2.3.3 The Kyoto non-CO2 gases include some formerly "non-Montreal" F-gases which future emissions will be controlled in accordance with the 2016 Agreement. There is an important policy-related development, which will change the "interplay" between the ODS and GHG mitigation and will have certain implications on the implementation of the Paris Agreement. The Kigali A. is correctly mentioned on p. 39, but here: at least, a reference to it would be important in relation to the non-CO2 GHGs. [Torbjorn Farago, Hungary] | This new development is highlighted in the framing chapter 1. HFCs are discussed in context of the Kigali Agreement in the revised section 2.3

21095 | 29 | 3 | 29 | 5 | This sentence is quite obvious; is it really useful? [P.Hope Martin, Belgium] | Accepted - the sentence has been removed

12985 | 29 | 4 | 29 | 5 | Use "should" instead of "are" [Cassien Stefano, Italy] | Editorial - has become obsolete as sentence has been deleted

13742 | 29 | 4 | 29 | 5 | They have to be strongly reduced [Ewalski Karolyn, Netherlands] | Accepted - in line with data available to the SOD, this has been changed to "peak and start declining before 2030"

6878 | 29 | 6 | 29 | 5 | peak and start declining by 2030 is contradicting fig 2.3.a that shows all 1.5 trajectories [Bert Metz, Netherlands] | Accepted - in line with data available to the SOD, this has been changed to "peak and start declining before 2030"

51700 | 29 | 7 | 29 | 7 | define "typical" scenario, 100% RE scenarios usually have an emission peak around 2020 (not 2030 as stated) [Geoff Tease, Australia] | Accepted - The introduction was unnecessary. It has been removed so as to more quickly reach the substantive parts of the section

1847 | 29 | 9 | 29 | 12 | Though a combination of various both: delete both [Hiromi Gupta, India] | Noted

17223 | 29 | 12 | 29 | 12 | a combination of various both: delete both [Hiromi Gupta, India] | Editorial

6879 | 29 | 15 | 29 | 15 | mid-century. Similar emission pathways were considered in the past either for concentration stabilisation or global warming limitation criteria, which had some but inadequate effects on policy actions and were leading to increasing climate science-policy gap (Farago 2016). The 1995 SAR included a pathway with the return of CO2 emissions to 1990 levels within forty years and substantial decrease afterwards; the AR4 in 2007 referred to peaking around 2050. The more rapid crossing of the threshold due to the role of SLCP/SLCP is an important dimension that should be addressed. [David Waskow, United States of America] | This new development is highlighted in the framing chapter 1. HFCs are discussed in context of the Kigali Agreement in the revised section 2.3

9438 | 29 | 16 | 29 | 17 | mid-century. Similar emission pathways were considered in the past either for concentration stabilisation or global warming limitation criteria, which had some but inadequate effects on policy actions and were leading to increasing climate science-policy gap (Farago 2016). The 1995 SAR included a pathway with the return of CO2 emissions to 1990 levels within forty years and substantial decrease afterwards; the AR4 in 2007 referred to peaking around 2050. The more rapid crossing of the threshold due to the role of SLCP/SLCP is an important dimension that should be addressed. [David Waskow, United States of America] | Accepted - has been clarified

2208 | 29 | 26 | 29 | 27 | The figure is difficult to interpret. [Kenneth Möllersten, Sweden] | Noted

9439 | 29 | 26 | 29 | 27 | Mid-century. Similar emission pathways were considered in the past either for concentration stabilisation or global warming limitation criteria, which had some but inadequate effects on policy actions and were leading to increasing climate science-policy gap (Farago 2016). The 1995 SAR included a pathway with the return of CO2 emissions to 1990 levels within forty years and substantial decrease afterwards; the AR4 in 2007 referred to peaking around 2050. The more rapid crossing of the threshold due to the role of SLCP/SLCP is an important dimension that should be addressed. [David Waskow, United States of America] | Noted

6880 | 29 | 26 | 29 | 27 | What is the difference between the two panels in the top row of the figure? And why is the net CO2 from land-use and land-use change only going negative by 2050 for 1.5 scenarios? [Shoudhri what happen earlier? Having the bottom-up material on land use emissions here (moved from ch 4, as I suggested in my general comments) would help to put these findings into perspective. [Bert Metz, Netherlands] | Taken into account - the difference between the top two panels is "gross" and "net" CO2 FF & L emissions, the direction of which is provided in the caption. Unfortunately a restructuring of the report was not possible. Land-use CO2 is becoming near zero by 2030 in many of the 1.5°C-concentric scenarios (bottom-left panel).

13312 | 29 | 26 | 30 | 30 | 2.9 Figure 2.9: Give each sub-plot a heading and spell out potentially unfamiliar acronyms, e.g. FF & I, [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)] | Editorial - the figure has been simplified and labelled in a better way

13313 | 29 | 26 | 30 | 30 | 2.9: Explain meaning of colours in a legend in the graph. [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)] | Editorial

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Comment | Response
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9814 29 | 26 29 30 | I would also present all GHG values in CO2 equivalent (i.e. also N2O and15CH4). | Taken into account - values for Kyoto GHG are included in the emissions overview table. Values are given for 2010, 2030, 2050, and 2100.
9842 29 | 26 29 30 | Counterintuitive that a deeper decarbonisation pathway would decrease the amount of Forest CCS, clarify it is linked to the rapid phase out of coal (Wieland Maas, Netherlands). | Taken into account - this clarification is also included in the subsection on the energy system.
9906 29 | 26 29 | 30 12 | Figure 2.9 has a lot of information and is too complicated, especially SSP types represented by dots. More improvements are requested. (Masato TAKAGI, Japan) | Taken into account - this figure has been modified
17324 29 | 27 | Subsection 2.3.1 highlights the diversity in pathways compatible with 1.5%. From Figure 2.9, it’s not difficult to catch the difference among scenarios. However, it’s not easy to find the differences among pathways compatible with 1.5% and features of each pathway. (Young-Hae Ohn, Republic of Korea) | Accepted - the figure design has been changed to better highlight the features of the pathways
17408 29 | 28 | A [Tom Gabriel Johansen, Norway] | Noted
17509 29 | 28 | A [Angela Moll, Norway] | Noted
4532 29 | 29 | Change "grey to black" [Radim Tola, Czech Republic] | Accepted - colours are now fully labelled
9543 29 | 29 | In the figure 2.9 the grey colour doesn’t appear. it only appears in the description of the figure. I think it must be black [Olgica Alcaraz, Spain] | Accepted - colours are now fully labelled
4533 30 | Fig 2.9 - Add index format to "CO2" (s) [Radim Tola, Czech Republic] | Editorial
13189 30 | The definitions used in Table 2.7 are not fully clear. What is the difference between gross and net emissions? There are also two times "net CO2 emissions" which are not fully clear what they refer to. [Deager Saygin, Turkey] | Accepted - less emissions classes are now included in the table, all of which should be clear to the reader
11112 30 | 20 20 20 | In these cases, it’s common practice to refer to the rate of change compared to a fixed base year. E.g. – x% below 1990 by 2050 and annual rate y% of 1990 levels. This would also help policy makers during the NDC revision process, while global GI are incomparable to most. (Michel Schaeffer, Netherlands) | Accepted - reduction rates relative to 2010 included
6881 30 | 22 30 30 | The discussion on the findings for studies using different SSPs raises serious problems for the key messages to policy makers (see my general remarks on the chapter on this issue); more discussion is needed on how to interpret these studies: should policy makers try to influence the conditions through policy in order to have a better chance to stay below 1.5 or is the message that they just should identify in what SSP situation they are and act accordingly? (Bert Metz, Netherlands) | Taken into account - Although the SSPs provide us with a useful set of scenarios, the assessment is not built solely on their insights. The SOD now highlights non-SSP scenarios where appropriate. The emissions section, for instance, now focusses on specific 1.5°C and 2°C scenarios instead.
5171 30 | 23 30 23 | typo: either "in a scenario" or "in scenarios" [Susan Teske, Australia] | Editorial
9301 30 | 25 30 23 | The plural form of "scenario(s)" in "in a scenario(s) that" may be singular as "scenario(s)." (Izabella Danigrosa, Netherlands) | Editorial
12743 30 | 23 30 23 | in a scenario that... [Izabella Danigrosa, Netherlands] | Editorial
12744 30 | 27 30 27 | Bracket never closes (Izabella Danigrosa, Netherlands) | Editorial
12988 30 | 30 30 30 | The cumulative mitigation... in terms of Total GHG emissions? Please specify [Canserini Stefano, Italy] | Taken into account - this particular number was for CO2 only. However, this section has been removed.
6882 30 | 35 30 30 | How come that BECCS use in SSP1 is lower than in SSP2; doesn't look logical to me [Bert Metz, Netherlands] | Taken into account - this section has been removed from the SOD
10680 30 | 40 30 40 | too much info into a single table? [Izabella Danigrosa, United Kingdom] | Taken into account - less emissions categories are shown now. However, limiting it to less scenario categories would not be possible without losing balance.
9185 30 | 40 30 1 | I tried to stick to the 1.5 categories groups; I found that the budgets are presented for at least 55% and 66%, whereas for the 2030 emissions levels this has not been done. I would like to be consistent and also present 2030 emissions levels for at least 50% and 66% [Michel den Elzen, Netherlands] | Accepted - this information is now presented following an updated scenario classification which separates these different classes
9185 30 | 40 31 1 | If you are the 1.5 scenarios group(s) the budgets are presented for at least 55% and 66%, whereas for the 2030 emissions levels this has not been done. I would like to be consistent and also present 2030 emissions levels for at least 50% and 66% [Michel den Elzen, Netherlands] | Accepted - this section has been modified as to not to suggest an unambiguous benefit or scenario.
17325 30 | 40 30 31 | Table 2.7 shows almost same information which is represented by Figure 2.9. [Young-Hae Ohn, Republic of Korea] | Taken into account - this table in additional reports reduction rates
12987 30 | 40 30 31 | In 2.7, in the second column, I suggest using 2°C and 1.5°C instead of 2.6 Wm-2 and 1.9 W m-2 [Canserini Stefano, Italy] | Taken into account - this information is now presented following an updated scenario classification which separates these different classes
4843 30 | 40 30 2 | The Annual rate of change 2010-2030 needs to be aligned with the 2030-2050 rates. Fossil CCS and BECCS will need build out time to establish 0.2-0.6 GT/a contribtions and need substantial 2010-2030 rates [Wieland Maas, Netherlands] | Taken into account - the annual rate of change for fossil CCS and BECCS is included. This information has been corrected.
4847 30 | 40 30 2 | Reference [EGHIS CS] Industry Build-Out Rates – Comparison with Industry Analouges (2017) that it is technically feasible that the anticipated CCS (BECCS) build-out rates can be realised in a supporting environment [Wieland Maas, Netherlands] | Accepted - this comparison, however, is for the assessment of Chapter 4
2209 31 | 1 | The slice year of BECCS and corresponding rate of carbon removal should be included in the executive summary. [Kenneth Möllersten, Sweden] | Taken into account - this is clarified here and in more detail in the subsection on the energy sector.
9440 31 | 31 31 | I think the right column of the table, it should be written 'Fossil and Industry' CCS (not Fossil only). This will be consistent with the paragraph on page 29 from line 15 to 25. [Isabelle Czernichowski-Lauro, France] | Accepted - this has been corrected.
20401 31 | 1 31 1 | What is FFAI? [Derville Boucher, France] | Accepted - this has been clarified
6365 31 | 3 31 3 | This sentence contradicts the sentence on line 3 of the same page. Insert "In some sectors" since currently, mitigation options are quite limited in some sectors. [Andy Reisinger, New Zealand] | Accepted - this clarification has been included.
6366 31 | 10 31 10 | This sentence contradicts the sentence on line 3 of the same page. Insert "In some sectors" since currently, mitigation options are quite limited in some sectors. [Andy Reisinger, New Zealand] | Accepted - this clarification has been included.
6367 31 | 14 31 15 | As per comment on line 3 on same page, add "currently" and clarify that this is based on a very static technology assumption especially in agriculture which can vary. I think this would be clearer. (Weekly Collins, United Kingdom) | Accepted - this has been clarified.
19374 31 | 20 31 20 | The start year of BECCS and corresponding rate of carbon removal should be included in the executive summary. [Kenneth Möllersten, Sweden] | Accepted - this information is now presented following an updated scenario classification which separates these different classes
19375 31 | 21 31 31 | It is not obvious that reducing aerosols decreases regional disruptions. If farmers in equatorial regions have adapted to the southward movement of the ITCZ from aerosols over the last 30 years, they might be equally disrupted if the ITCZ moves back north as aerosols are reduced. (William Collins, United Kingdom) | Accepted - this sentence has been modified as to not to suggest an unambiguous benefit or reduced disruption

Notes: - the mandate of the SR1.5 report is to take AR5 as a basis and assess the more recent literature related to 1.5°C. We have, though, included a reference to these two studies.

1976 31 23 32 2 It might be useful to clarify whether reduction in traditional stoves or kerosene lamps is assumed or not in the IAM-generated scenarios. (William Collins, United Kingdom of Great Britain and Northern Ireland)

883 31 38 32 21 I am surprised that aerosols are grouped together here. Why not discuss OC, BC and other aerosols separately, as they have different warming/cooling properties? Additionally, by bringing the material from ch 4 to this section a more balanced and elaborative discussion would be possible, which would benefit the chapter. (Bert Meij, Netherlands)

4534 32 Fig 2.10 - Add index format to “CO2”, “N2O” and “Wm-2” (2x) (Radim Tolasz, Czech Republic)

Notes: - the figure has been updated.

What is ‘SLCFs’? It should be SLCPs, is that correct? (Elena Georgopoulou, Greece)

16205 32 5 32 8 Regarding the further elimination of warming aerosols, the amount of black carbon emissions that can be reduced is really quite large, even in the US. There are significant emissions from aircraft and diesel engines/generators that can be reduced—see also from trees, etc. Shindell et al. also list quite a number of sources that could be controlled, etc., so much so that their Collective effect was able to cut the projected warming from 2010 to 2050 in half. [Michael MacCready, United States of America]

Notes: - Shindell et al. list measures relative to a no-mitigation baseline. Compared to that reference a large potential for reductions exists. However, compared to the reductions assumed in the 1.5°C pathways, this potential is limited.

2544 32 5 32 8 This sweeping statement calls for more detailed explanation. What kind of policies? Eg. the CDM, as a climate policy, has delivered conversion from many proposed measures should be “many proposed measures” (Robert Shapiro, United States of America)

Notes: - the sectoral section on agriculture now expands on further reductions in residual non-CO2 emissions.

9795 32 12 32 13 The word “results” in “in such cases, the large reduction in mainly cooling aerosol precursors (sulphur dioxide and nitrogen dioxide) can results” may be singular as “result”. (Bir KLAB, Denmark)

Notes: - this influence has been further highlighted.

1978 32 12 32 8 This section seems dismissive of methane, as if the issue is solved. However the methane emissions in figure 2.10 seem to vary by a factor of 6. This section ought to expand on the different methane scenarios further, as to why the different scenarios give different emphasis to methane. Presumably in the scenarios with high methane emissions there is scope for even further climate reduction through bringing methane emissions down in line with the scenarios with the strongest mitigation. (William Collins, United Kingdom of Great Britain and Northern Ireland)

Notes: - the sectoral section on agriculture now expands on further reductions in residual non-CO2 emissions.

13518 32 15 32 17 The large reduction of sulfate and nitrate aerosols is not for ‘additional warming’. It is one of the major warming factors in the near-to-mid term climate change. For example, SO2 emission is begin reduced even from China. Therefore it should be stated stronger in order to tell policy makers and public. (Toshikio Takemura, Japan)

Notes: - the sectoral section on agriculture now expands on further reductions in residual non-CO2 emissions.

9302 32 16 32 17 The word “results” in “in such cases, the large reduction in mainly cooling aerosol precursors (sulphur dioxide and nitrogen dioxide) can results” may be singular as “result”. (Bir KLAB, Denmark)

Notes: - this influence has been further highlighted.

14772 32 17 32 17 What is “SLCFs”? It should be “SLCPs”, is that correct? (Irena Georgopoulou, Greece)

Notes: - SLCFs refer only to a subset of warming short-lived climate forcers (SLCFs).

12745 32 18 32 18 SLCP (Vassilis Daskopoulos, Netherlands)

Notes: - the sectoral section on agriculture now expands on further reductions in residual non-CO2 emissions.


Notes: - this influence has been further highlighted.

13314 32 23 32 33 (33) The influence of methane and its reduction in the CH2 pathways is also provided. This is important to show its role for different sectors. (Deger Saygin, Turkey)

Notes: - the sectoral section on agriculture now expands on further reductions in residual non-CO2 emissions.

17326 32 24 32 24 Subsection 2.3.1 highlights the diversity in pathways compatible with 1.5°C. From figure 2.10, it’s not difficult to catch the different among scenarios. However, it’s not easy to find the differences among pathways compatible with 1.5? and features of each pathway. (Young-Hwan Ahn, Republic of Korea)

Notes: - this influence has been further highlighted.

17469 32 25 32 26 A (Tom Gabriel Johansen, Norway)

Notes: - the sectoral section on agriculture now expands on further reductions in residual non-CO2 emissions.

17509 32 25 32 26 AK (Atle M. Masera, Norway)

Notes: - the sectoral section on agriculture now expands on further reductions in residual non-CO2 emissions.

4535 32 25 32 26 Change “grey” to “black” (Radim Tolasz, Czech Republic)

Notes: - the figure has been updated.

9944 32 25 32 25 For figure 2.10 the grey colour doesn’t appear. it only appears in the description of the figure. I think it must be black [Olga Alcaraz, Spain]

Notes: - the figure has been updated.

7906 32 25 32 25 no-climate policy baselines (grey) appears black, not grey. [Robert Shapiro, United States of America]

Notes: - the figure has been updated.

19380 32 25 32 33 For figure 2.10 the authors should consider using the GWp formulation of Allen et al. 2016 to calculate CO2 equivalence. (William Collins, United Kingdom of Great Britain and Northern Ireland)

Notes: - the sectoral section on agriculture now expands on further reductions in residual non-CO2 emissions.

6884 32 32 32 33 The caption of figure 2.10 says that GWPs from AR4 are used. Is this the case throughout the chapter or do studies use different GWPs; and if so, does the chapter harmonise the GWp-data? (Bert Meij, Netherlands)

Notes: - the sectoral section on agriculture now expands on further reductions in residual non-CO2 emissions.

13910 33 Text mentions the magnitude of renewable energy use in the energy sector. It would help if the breakdown of its use for energy supply and energy demand (ideally with a split by transport, buildings and industry) is also provided. This is important to show its role for different sectors. (Diego Saygin, Turkey)

Notes: - the sectoral section on agriculture now expands on further reductions in residual non-CO2 emissions.

4538 33 Fig 2.11 - Add index format to “Wm-2” (Radim Tolasz, Czech Republic)

Notes: - the figure has been updated.
Sub chapter 2.3.4: As a whole, this subchapter has covered almost all sectors (e.g., Energy, Industry, Building, Transport, Agricultural Sectors) which play important and essential role in mitigation aspect. It is suggested to include Marine and Fisheries Sector which must have a huge mitigation role e.g. open ocean with phytoplankton (microalgae) that absorb CO2 from the environment during photosynthesis and also mangrove, seaweed (macroalgae) & seagrass ecosystem, as well as seaweed aquaculture activities and microalgae culture for biofuels which can integrate with industries for carbon supply; as many recent research have reported. The micro- and macroalgae culture activities (using bioreactors, opened-point raceway, etc.) have been carried out by several huge company to produce biofuels by using CO2 discharge from other industries. Thereby, it is an important sector in carbon capturing process for 1.5 °C mitigation pathway regarding techno-economic and sustainable development aspects. [Elianeta Erlania, Indonesia]

It seems that figures in this subsection show results from each scenarios calculated by different models. Without any explaining the features of each model, showing results from different models may be redundant. It may be enough to show summarized results from different models. [Young-Hwan Ahn, Republic of Korea] will be discussed in next revision

Figs 2.11 to 2.14, are they global? Are there corresponding regional figures available? [Érika Mata, Sweden] global one, due to space limit, we did not get regional data, tried to use a national pathway box

Needs a discussion of the primary energy accounting used, and the implications of this. [Glen Peters, Norway] Noted

2.3.4: In the section on Energy, the following statement "a rapid transition towards a zero or negative CO2 emissions energy system is crucial" appears. There are a couple of questions here that could be addressed to add clarity to this section. First, an example or illustration of what is meant by negative emissions energy systems. Second, as the evolution of primary energy contributions over time discusses the mixture of energy sources. This is highly reliant on political and social decisions, policies, and decisions. It would be valuable to discuss how these decisions intersect the evolution of the energy mix. For example, CCS might be a competitor for 'green' dollars which would sap progress on renewable energy. Resurgence of nuclear energy is highly reliant on the public acceptability (and this is also geographically sensitive). It is not clear in the report how the models discussed handle these complexities and what assumptions are being made. [Joshua Loughman, United States of America]

Two aspects are typically emphasised in 1.5°C pathways: one is rapid growth in the share of energy derived from low carbon sources including renewables, nuclear, and fossil fuels with CCS; the other is BECCS which can provide carbon dioxide removal. For both aspects, the rate of change and the required spending are important potential limitations of models that are designed to portray the current energy system, and they should not be interpreted by the reader as the universe of possible scenarios. [Jan Cofré-Mortot, France]

I can not find the relationship with SDG No. 7 and demand for energy, in the real world, in matters of finance and public policy, changing the only primary energy will be discussed in section 2.3.4. As for the investment need will be discussed in chapter 4.

I consider before discussing the scenarios of the renewable and their impact on the various sectors, it is essential to discuss ENERGY EFFICIENCY, and the end of the oil is and will be the primary source of energy, renewable without efficiency are not useful. It is also indispensable that further indicate that the USA is one of the countries that demand energy / power and if this country does not change its energy matrix, the other countries will only continue to clean the CO2 that causes the burning of fuel. [Fátima Castañeda, Guatemala]

Two aspects are typically emphasised in 1.5°C pathways: one is rapid growth in the share of energy derived from low carbon sources including renewables, nuclear, and fossil fuels with CCS; the other is BECCS which can provide carbon dioxide removal. For both aspects, the rate of change and the required spending are important potential frontlines. Throughout the entire chapter, renewable energies (the single most important technology group in regard to zero-carbon energy production from new installed capacities) are only mentioned in connection with nuclear and CCS as "low carbon technologies". Renewables have nothing to do with nuclear and CCS and therefore they should be mentioned without these technologies. It seems a highly biased scheme throughout the entire document to play down renewables and artificially increase technologies which are unsuccessful on the energy market over the past decade. Request: Replace "low carbon technologies" with "renewables and energy efficiency" wherever possible. [Trevor Morrice, Australia]

The discussion on the database and models, together with scenarios will be given in the chapter

The discussion about the database and models, together with scenarios will be given in chapter 4. A revised text in chapter 2.3.4 will keep balance

The discussion on energy efficiency will be in sector sessions

The discussion on energy efficiency will be in sector sessions

The discussion on SDG linking with scenario will be discussed in chapter 5, chapter 2 will provide information to support them

This will be discussed in technology session

In model study, all options are available, but in the real world this is not always true. Especially, I have concerns on large deployment of CCS, bioenergy, and BECCS. I suggest that the report review global potentials, costs, matching sources and sinks, and feasibility of these options. [Masahiro TAKAGI, Japan]

In chapter 2, the discussion for key technologies in real progress will be done in chapter 4, by linking with chapter 2, we will co-ordinate on this with chapter 2

The discussion will be in technology session

This will be discussed in technology session

This will be discussed in technology session

The discussion on energy efficiency and the impact on the various sectors, it is essential to discuss ENERGY EFFICIENCY, and the end of the oil is and will be the primary source of energy, renewable without efficiency are not useful. It is also indispensable that further indicate that the USA is one of the countries that demand energy / power and if this country does not change its energy matrix, the other countries will only continue to clean the CO2 that causes the burning of fuel. [Fátima Castañeda, Guatemala]

The discussion about the database and models, together with scenarios will be given in the chapter

The discussion on SDG linking with scenario will be discussed among authors

The reason to give this table is to show data with rate of change, which is important data to analyse feasibility

The discussion on SDG linking with scenario will be discussed in chapter 5, chapter 2 will provide information to support them

The discussion about the database and models, together with scenarios will be given in the chapter

The discussion will be in technology session
In this section, it should be mentioned that some authors believe that solar energy contribution to mitigation is being underestimated in scenarios (see Hertel et al. (2017)). The underestimation of solar energy to mitigate climate change. Nature Energy, https://www.nature.com/articles/s41560-017-0074.) The implications of greater solar energy contribution to mitigation should also be discussed. On the other hand, it should be noted that costs for nuclear energy, CCS and BECCS have been underestimated in the past, and their rate of deployment overestimated. (Nieminen, Belgium)

All the figures in these sections are only for 1.5DS. If possible, comparison with 2DS or higher temperature target scenarios are useful to judge the feasibility of the 1.5DS. (Shiho KOBAYAH, Japan)

There is no definition of what is meant by “zero emissions”. Given that there will always be a carbon footprint of running a generation facility, even if the facility is a solar farm, it has to be managed and therefore the workers have to use up co2 to manage the facility. Also given that nuclear power will be used, running these systems has to have a carbon footprint. If it means that the world daily carbon footprint to operate all generation and distribution systems will be offset by CCS or some other decarbonisation method this should be explained. see page 52 figure 21-22 (Mashe Kinn, United Kingdom [of Great Britain and Northern Ireland])

Here it is mentioned that the difference in results are based on the model differences. However, such differences may occur due to the pathways taken by each model to achieve the target. (Kanichi Matsumoto, Japan)

Installed capacity isn’t the same as generation. If renewable energy is to provide half of the energy by 2050, then we must make significant investments and realise proper storage capacity in the near future. If investments into storage and the successful deployment of storage cannot be guaranteed by 2050, then we will most certainly miss all mitigation pathways, especially if absolute capacity from nuclear generations declines and there is no uptake in hydro investment. Current renewable energy is backed up by gas or coal which has a much larger carbon footprint than hydro or nuclear. In fact, even some renewable energies have larger carbon footprints when the entire lifecycle is taken into account. Additionally, the waste issue needs to be addressed. Currently there is no recycling program in place for solar etc. which will cause detrimental environmental impacts if not figured out. What will be done with all the hydrofluoric acid and what are the impacts on land and water supplies from such toxic chemicals which can currently be not removed from the water supply? If renewable energy is to account for half of all energy by 2050 this will have to be looked at in depth in order to ensure sustainable development and environmental protection. Look at Inner Mongolia, where over 90% of the rare earths for panels used in North America are mined. While data is missing or deficient, there has been severe environmental ramifications that will undoubtedly influence climate mitigation and most certainly demonstrate the opposite of sustainable development. (Michelle Leslie, Canada)

The largest part of renewable energy is assumed to come from biomass in all scenarios. Since it takes decades for forests to absorb the carbon released from combustion, there will be a net positive amount of emissions every year. In a very long term, a net zero emission level could be reached, if the amount of biomass combustion remains constant. However, since the amount of biomass use keeps increasing every year after the year, the emissions will similarly keep growing and the forests of the world will always struggle to absorb the additional carbon. How can negative emissions be achieved if the emissions from biomass combustion keep increasing? (Jaime Hinnov, Finland)

Why is the focus here on increasing the use of combustion, when that is the one thing that should be avoided to mitigate climate change? (Jaime Hinnov, Finland)

The role of biomass is contested, as everyone knows well. The model produce this result under certain assumptions (e.g. high yield growth, and good global and local land use governance). If these conditions are invalid, biomass deployment might fall socially, or from a mitigation perspective (e.g. ILUC emissions). So this sentence should be phrased much more carefully. e.g. “in the IAMs considered…” (Felix Creutzig, Germany)

If it means that the world daily carbon footprint to operate all generation and distribution systems will be offset by CCS or some other decarbonisation method this should be explained. (Mashe Kinn, United Kingdom [of Great Britain and Northern Ireland])

The choice of different low carbon power generation were decided by modeling teams, hence in chapter 2 we will review all the scenario analysis, but will also discuss the various options. Nuclear will be addressed in the chapter.
<table>
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<th>Comment No</th>
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<th>Comment</th>
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</thead>
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<tr>
<td>6887</td>
<td>33</td>
<td>23</td>
<td>33</td>
<td>33</td>
<td>Clarify if the low or declining use of nuclear and biomass in some trajectories is caused by limits imposed by the models or if this is the result of least cost calculations. And use bottom-up studies (e.g. [moved here from Ch 4] to discuss sustainability limits on biomass and on CDR [Bert Metz, Netherlands])</td>
<td>not noted, author will discuss this</td>
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<td>13191</td>
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<td>25</td>
<td>If possible, please quantify how much the decline in nuclear power would be. [Deger Saygin, Turkey]</td>
<td>nuclear power will not be specified treated, we will try to see how to make this in the text, for all key technologies from scenarios</td>
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<td>10845</td>
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<td>31</td>
<td>Fig. 2.11: why is there not single IAM scenario with 100% RE? (while an entire community with about 60 peer-reviewed articles exists. The IAMs have to catch up with the progress of the energy sector focused community. A clear disclaimer should be added that energy sector analyses exist with a high RE share (and some of them even show that the fossil-CCS and nuclear option cost more, hence the cost argument against 100% RE passed away. [Christian Breyer, Finland])</td>
<td>IPCC report is a assessment report, we will analyse based on the lecture, not questioning lectures. 100% scenario will be discussion, or add to the figure by including modeling results from outside IAMs</td>
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<td>1945</td>
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<td>Figure 2.11 must be updated for clarity. Legend box size and text size to not rely on MS Excel: e.g. match preceding figs. This also applies to figs 2.12, 2.13 and 2.14 [Andrew Smyeley, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>editorial</td>
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<td>13315</td>
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<td>32</td>
<td>Figure 2.11: Suggest simplifying these plots to aid communication. Does each scenario need to be differentiated here - could that information be provided in an annex perhaps? [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>noted, we will discuss how to improve</td>
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<td>13316</td>
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<td>Figure 2.11: Explain EJ acronym used in graph to readers. [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>noted</td>
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<td>9497</td>
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<td>Figure 2.11: is complicated. The figure does not always have all models results. More improvements for better understanding are requested. [Masato Takagi, Japan]</td>
<td>noted</td>
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<td>10575</td>
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<td>32</td>
<td>Figure 2.11 cites: \textit{\textcopyright Rogelj et al.2017a} Such reference is missing in the reference list. Additionally, the figure cites \textit{\textcopyright Rogelj et al.2017} as source data. The scenarios and projections are not compatible when comparing information from the article and the figure 2.11. The change to a low carbon or renewables is clear, as an independent chapter the units (EJ) need to be more explicit to the reader, as mentioned the first time. [Elmer Briceño-Elizondo, Costa Rica]</td>
<td>noted</td>
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<td>5173</td>
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<td>26</td>
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<td>34</td>
<td>Figure 2.11: add &quot;Hydro&quot; as stand-alone figure [Sven Teske, Australia]</td>
<td>editorial</td>
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<td>5174</td>
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<td>Figure 2.11: present all sources with the same scale to make them comparable [Sven Teske, Australia]</td>
<td>editorial</td>
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<tr>
<td>5175</td>
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<td>Figure 2.11: present values in final energy, not primary energy as this mis-reads the shares of thermal processes versus electric only processes (e.g. solar pv, wind, hydro) [Sven Teske, Australia]</td>
<td>editorial</td>
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<tr>
<td>14222</td>
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<td>27</td>
<td>Note are figures (a) and (b) different? What's being included in 'renewable' in (a)? Could more of a description be put in the caption? [Jason Donev, Canada]</td>
<td>noted</td>
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<td>17470</td>
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<td>A [Tom Gabriel Johansen, Norway] noted</td>
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<td>A [Angela Morelli, Norway] noted</td>
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<td>4240</td>
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<td>Why &quot;demand&quot;? Isn't this the supply? Also I am not sure the numbers are up-to-date. The relevant data on renewables are from Petzold et al.2017 and should be used. Robert C. can correct the comparison of the high power integration of wind and solar power in Integrated Assessment Models: A cross-model evaluation of new approaches. [Energy Economics (2017): 583-599. The role of PV had been underestimated both by IEA and IAMs, and could be 30-50% in 2050. [Felix Credtzig, Germany]</td>
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<td>17224</td>
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<td>Figure 2.11: Images are too small and it is difficult to understand the scenarios. [Himenganga Gupta, India]</td>
<td>will be revised</td>
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<tr>
<td>6888</td>
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<td>11</td>
<td>Please discuss what the implications are of the high cost use trajectories in terms of CCS and CDR requirements. Would limits on CDR not disqualify such high coal scenarios? [Bert Metz, Netherlands]</td>
<td>this will be discussed</td>
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<td>12988</td>
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<td>38</td>
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<td>38</td>
<td>Natural gas trend is – (instead of natural gas) [Costello Stefano, Italy]</td>
<td>editorial</td>
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<td>3715</td>
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<td>38</td>
<td>Refer to time frame up to 2050 once (Harald Winkler, South Africa)</td>
<td>noted</td>
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<td>13192</td>
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<td>Given this large variation in natural gas demand projections, it would help if the underlying reasons are explained in more detail. [Deger Saygin, Turkey]</td>
<td>noted</td>
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<td>13193</td>
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<td>The file of Table 2.8 mentions supply whereas the headings say demand. It is therefore also not clear what the 2020 share refers to. Please also mention the period annual growth rate to. It also would help if the left in 2015 is included in the table. [Deger Saygin, Turkey]</td>
<td>Accept</td>
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<td>4537</td>
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<td>34</td>
<td>Fig 2.12: Add index format to &quot;Wm-2&quot; [Radim Tolasz, Czech Republic]</td>
<td>editorial</td>
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<td>6954</td>
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<td>Table 2.8 &quot;Notes &quot;Renewables&quot;, &quot;Wind+solar&quot; and &quot;Biomass&quot; are not practical and actually obfuscating as Renewables encompass all and there should not be any reason to lump wind and solar together. Preferably the categories could be Hydro, Wind, Solar, Biomass, also other renewable if distinction eg with geoenergy etc cannot be done. [Ville Tulkki, Finland]</td>
<td>Accept</td>
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<td>10331</td>
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<td>Table 2.8. averages do not mean much, what it is important is the range. It should be provided in all cases. [Maria Jose Sanz Sanchez, Spain]</td>
<td>see 1049</td>
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<td>10441</td>
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<td>Table 2.8. Notes &quot;Renewables&quot;, &quot;Wind+solar&quot; and &quot;Biomass&quot; are not practical and actually obfuscating as Renewables encompass all and there should not be any reason to lump wind and solar together. Preferably the categories could be Hydro, Wind, Solar, Biomass, also other renewable if distinction eg with geoenergy etc cannot be done. [Ville Tulkki, Finland]</td>
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<td>Figure 2.12: Suggest simplifying these plots to aid communication. Does each scenario need to be differentiated here - could that information be provided in an annex perhaps? [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>revised</td>
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<td>Figure 2.12: Explain EJ acronym used in graph to readers. [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>accepted</td>
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<tr>
<td>10575</td>
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<td>4</td>
<td>34</td>
<td>11</td>
<td>For figure 2.12 similar comments on units as to figure 2.11 and the use of the source material. [Elemer Briceño-Elizondo, Costa Rica]</td>
<td>accepted</td>
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<td>9498</td>
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<td>Figure 2.12 is complicated. The figure does not always have all models results. More improvements for better understanding are requested. [Masato Takagi, Japan]</td>
<td>accepted</td>
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<td>17471</td>
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<td>4243</td>
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<td>It would be good to distinguish wind and solar, as they have a quite different generation profile, and different learning curves. PV growth rates are around 38%, and that does not look compatible with the 9.5% cited. PV 2050 estimates in EJ is 67-130EJ (without wind or CSP) [Creutzig, F., Agoston, P., Goldschmidt, J. C., Luderer, G., Nieret, G., &amp; Petzack, R. C. (2017). The underestimated potential of solar energy to mitigate climate change. Nature Energy, 2(9), nwenergy20171140] [Felix Credtzig, Germany]</td>
<td>accepted</td>
</tr>
</tbody>
</table>
In the table, make 2 separate lines for wind and solar. [Noé Lecocq, Belgium] accepted

It is not clear why only CCS is considered but not more energy efficiency or renewable energy. Is it because of costs, lack of resource availability, or other studies from outside IAM will be included [Kristin Campbell, United States of America] noted

Table 2.8 could benefit from bolding the aggregation of renewables versus fossil fuels [Marco Mazzotti, Switzerland] text modified to state that CCS is in all 1.5 pathways assessed in this section

Something should be said about feasibility of such large extent of CCS. [Skea Jim, United Kingdom (of Great Britain and Northern Ireland)] text has been changed to refer to the pathways not what will happen in the future. See comment

The sum of renewables, nuclear and fossil fuels in the column for 2050 Share is 103.1 %. Should have been 100 %. [Aage Stangeland, Norway] will be revised

Why are hydropower, geothermal and tidal not included in this? Especially hydro, which contributes quite a bit currently! Will they be shut off? [Jason Done, Canada] revised

Table 2.8: the highest share of solar+wind is 44% in that table for the year 2050 - this is really extremely conservative - much more progressive peer-reviewed studies exist in the 100% RE community, which are fully ignored in the entire chapter. This is from the scientific point of view a clear deficit and has to be overcome. [Christian Breyer, Finland] other studies from outside IAM will be included

Deployment of CCS: More careful language is needed here! Riahi et al. 2017: "CCS plays an important role in many of the mitigation scenarios even though its deployment is subject to large uncertainties." AR5-WGIII-SPM. "Overhaul scenarios typically rely on the availability and widespread deployment of BECCS and afforestation in the second half of the century. The... technologies and methods are, to varying degrees, associated with challenges and risks (see Section SPM 4.2) (high confidence). Therefore, e.g.: Deployment of CCS plays an important role in CO2 many emission reduction pathways consistent with 1.5°C. In these pathways the carbon budget limitation requires a rapid implementation of CCS, soon after 2020. It should also be noted, that the relevant technologies and methods are uncertain, and to varying degrees, associated with challenges and risks [IPCC 2014, Riahi et al. 2017] (Tibor Farago, Hungary) see 1049

The sub-section only talks about the projections for CCS in fossil fuel generation (e.g., coal, natural gas) by 2020 without referring to the actual state of the technology and rate of deployment as well as associated legal and policy implications which are key to any prospect of deployment of CCS. These have to be integrated in the discussions. [Elenita Daño, Philippines] paragraph added on the state of tech and policy to advance CCS with reference to CH4

The topic of storage capacity is covered in the section on CDR sustainability [Nikolay Onuchko, Ukraine] see 1049

The geographical problem is not considered; sites available for CCS are not evenly distributed. The countries without (or with limited) possibility of CCS will have greater difficulties in decarbonizing the electric sector and the industrial sector, and they cannot implement BECCS or DACS. [Cassini Stefano, Italy] see 1049

It is not clear why only CCS is considered but not more energy efficiency or renewable energy. Is it because of costs, lack of resource availability, technology? [Deger Saygin, Turkey] no use of likelihood language is used here. See comment 1049

Need to state very clearly that it is essential (if it is)! [Skea Jim, United Kingdom (of Great Britain and Northern Ireland)] text has been changed to refer to the pathways not what will happen in the future. See comment 1049 on status of CCS

Something should be said about feasibility of such large extent of CCS. [Marcos Mazzotti, Switzerland] text modified to state that CCS is in all 1.5 pathways assessed in this section

<table>
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<th>Comment</th>
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Table 2.8 could benefit from bolding the aggregation of renewables versus fossil fuels [Marco Mazzotti, Switzerland] text modified to state that CCS is in all 1.5 pathways assessed in this section
Comment No | From Page | From Line | To Page | To Line | Comment | Response
--- | --- | --- | --- | --- | --- | ---
6699 | 34 | 20 | 34 | 22 | Most question whether a pathway can be considered ‘likely’ to limit warming to 1.5 degrees if it relies on NEI that may not have a ‘likely’ chance of proving feasible and providing reliable reductions at the needed scale. See: https://www.ipcc wg3.org/mediamanager/documents/Publications/Climate-SEI-WP-2018-08-Negative-emissions.pdf SUPPLEMENTAL COMMENTS: See, e.g. Fuss et al. (2014), Betting on negative emissions, Nature Climate Change. Available at: http://www.nature.com/nclimate/journal/v4/n10/full/nclimate2932.html#fulltextback-to-top. In this commentary, Fuss et al. state, among other things, that the “credibility of BECCS as a climate change mitigation option is unproven and its widespread deployment in climate stabilization scenarios might become a dangerous distraction.” For example, as of 2015, there was only a single BECCS plant operating at scale but based on a different technology (using CO2 released from an ethanol production process). This project only captures only 11–13% of the carbon in the fuelstock. See, Doughty and Vaughan (2015), Synthesizing Existing Knowledge on the Feasibility of BECCS (D1a) | AVOID 2 Climate Change Research Program. AVOID2, WP5d. Some studies have also found carbon positive as well as carbon negative effects of BECCS. See, e.g. Fairly and Mack-Dowell (2017), Can BECCS deliver sustainable and negative emission reductions. Available at: http://pubs.nrc.ca/content/articlelanding/2017/Nov/3/40046594/fullAbstract. Available at: http://www.avoid.uk.net/2015/07/synthesizing-existing-knowledge-on-the-feasibility-of-beccs/ What’s more, climate change introduces further uncertainty into low-carbon energy potential. See, e.g. Smith, P.; Boustani, M.; Ahammad, H.; Clark, H.; Dong, H.; et al. (2014), Agriculture, forestry and other land use (AFOLU). In Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, O. Edenhofer, R. Pichs-Madruga, Y. Sokona, S. Schlömer, C. A. von Ste But Roy H. S. Kadner, et al. (eds.), Cambridge University Press, Cambridge, UK, and New York. https://www.ipcc.ch/report/ar5/wg3/ Because of this, some have noted that the “response of bio-energy crops to climate and CO2 fertilization is a leading order uncertainty in the feasibility of BECCS”. See Whitmore and Davies-Barnard (2015), Planetary Limits to BECCS Negative Emissions, 1104872 / AVOID 2 WP7a Report 1, V1.1. AVOID 2 programme. (Jennifer Morgan, Netherlands) | see 1049
6890 | 34 | 20 | 35 | 2 | Are models taking into account the low capacities of coal and gas plants in a situation with high renewables penetration and the implied high costs of installing CCS for such low-operation hours? Please clarify and if they do not clarify, please explain why they still have high CCS usage. If the models do not take this into account, would that not disqualify their findings? (Bert Metz, Netherlands) | see 1049
17419 | 34 | 21 | 34 | 22 | If there is somewhere in this report the detailed description how this large deployment of CCS takes place within this timeframe? (Yves Kulkikoski, Finland) | this sub-section is on CCS: Demand reduction and RE are considered in the oversupply section on energy
2212 | 34 | 21 | 34 | 22 | The deployment of CCS soon after 2020 is not many years ahead. This report needs to critically analyse such outcomes of the IAMs simulations. While IEA is theoretically possible in WMs it may not be feasible in the real world considering load times, planning, financing, obtaining permits, construction and commissioning). It is probably possible to make a fairly exact estimate when substantial contributions from CCS can start at the earliest and this kind of reality check should be included: Implications of failure to meet the IAMs outcomes should then be analysed as appropriate. (Kenneth Millenstien, Sweden) | see 1049
13196 | 34 | 22 | 34 | 24 | Text mentions that CCS should be deployed soon after 2020, meaning this needs to start in the next 3 years. Here authors may consider adding the level of CCS capacity achieved today (and in which sectors) to show the challenge to 2050/2100. (Degar Saygin, Turkey) | see 1049
6889 | 34 | 24 | 34 | 25 | Why are other models able to estimate the remaining emissions from coal/CCS (Bert Metz, Netherlands) | the draft text that was contingent on assumed capture extent has been removed
7940 | 34 | 24 | 34 | 26 | SGI and IEAGHG both have looked at looking at the residual emissions issue. The first study (IEAGHG/SGI 2016) was originally on the unburnable carbon concept, and residual emissions from CCS flagged as an issue in models seems more limited than expected: IEAGHG is currently working on a follow up study, but unfortunately it is not citable yet. Capture technology developers to-date have largely focused on designing for capture rates reaching 85% to 90%, leaving 10-15% residual emissions. However, there should be no severe technical or economic drawbacks to get capture to 98% and above. In case residual emissions from CO2 capture cannot be addressed, CDR options become even more important. (Jasmien Kemper, United Kingdom of Great Britain and Northern Ireland) | see 1049
11128 | 34 | 24 | 34 | 26 | “Some models consider the residual emissions that are not captured when using coal with CCS to be too high for 1.5°C scenarios.” Another way of presenting the same results would be to show the amount of coal without CCS in 2050. I would expect CCS without CCS to approach zero by 2050. I would also suggest to mention this in the executive summary as it would be a clear indication to investors and policy makers. (Michel Schaeffer, Netherlands) | there is discussion of this particular pathway in a following subsection
20194 | 34 | 27 | 34 | 28 | Have a very fast phase out… (Ton Widenberg, Netherlands) | corrected
5008 | 34 | 27 | 34 | 27 | Spelling error. Remove the “w” before “have” (Kage Stangeland, Norway) | corrected
9441 | 34 | 27 | 34 | 28 | Supers “w” before “have” (Isolotta Czernichowski-Jauregui, Finland) | see 1049
4538 | 35 | Fig 2.13 - Add index format to “Wm-2” (Radim Tolasz, Czech Republic) | see comment 1101
6955 | 35 | 35 | 35 | Fig 2.14 a) and b) are most likely wrong as they do not match the text description. (Ville Tulikivi, Finland) | see comment 1035
10332 | 35 | 36 | 36 | Figure 2.14 a) make the figure more readable and suggest to use sam colour code in both graphs for same items. Why in the bottom figure the 2015-20 period is not considered? (Maria Sanso Sanchez, Spain) | see comment 1011
4909 | 35 | 3 | 3 | 11 | Figure 2.13 is complicated. The figure does not always have all models results. More improvements for better understanding are requested. (Masato Takagi, Japan) | agree. figure to be modified
14223 | 35 | 3 | 3 | 3 | Graphs go to 120%, that’s not appropriate, can’t have more than 100% in this case. (Jason Donev, Canada) | see 1076
13139 | 35 | 4 | 35 | 10 | Figure 2.13: Suggest simplifying these plots to aid communication. Does each scenario need to be differentiated here - could that information be provided in an annex perhaps? (Jordi Harlot, United Kingdom of Great Britain and Northern Ireland) | see 1076
13320 | 35 | 4 | 35 | 10 | Figure 2.13: Explain EJ acronym used in graph to readers. (Jordi Harlot, United Kingdom of Great Britain and Northern Ireland) | see 1076
6691 | 35 | 4 | 35 | 10 | Also show the absolute usage of CCS (in terms of CO2 stored) (Bert Metz, Netherlands) | see 1076
4224 | 35 | 4 | 35 | 4 | Different graphs change scale, one is 75% at the top and the other 120%. (Jason Donev, Canada) | see 1076
7941 | 35 | 4 | 35 | 8 | Fig. 2.13: I suggest to remove the 120% on the x-axis, as CCS deployment cannot exceed 100%. (Jasmien Kemper, United Kingdom of Great Britain and Northern Ireland) | NO CHANGE EJ is common unit for energy
In figure 2.14b please use the same colours as are used in figure a! Figure a is difficult to read, but the same colours would make a & b easier. (Glen Peters, Norway)

What about industry CCS? Can you please do an assessment of that too? (Glen Peters, Norway)

And in the same time the global forest cover will either stay the same as currently or increase? This is hard to believe. And although forests will stay as forest... (Angela Morelli, Norway)


This text has been modified.

This discussion of BECCS implies that the only way to have limited reliance on BECCS is to have a more rapid phaseout of fossil fuels, besides that, for greater deployment of wind and solar could alleviate some of this need. (Kris Kristensen, United States of America)

Higher reliance on BECCS is associated with higher fossil fuel demand. I would suggest to invert the order: e.g. “Higher fossil fuel demand is associated with higher reliance on BECCS”. This would give a clearer picture about the feasibility of these scenarios I think it’s necessary to explain the current degree of development and implementation of these technologies, and to provide some figures about the amount of CO2 that nowadays is captured using them. (Ola Alcaraz, Spain)

Most mention the land use dimensions of BECCS here (by x-referring) not the energy system aspects. (Skea Jim, United Kingdom (of Great Britain and Northern Ireland))

This is discussed in the section on CDR sustainability.

Figure 2.13b shows shares with almost 100% of power generation with CCS by 2050 are virtually impossible even in extreme scenarios, given to the existent installed capacity worldwide and the necessary time to retrofit them all, as well as current power plant locations vis-à-vis their distance of geological storage (or aquifers) sites, amortization periods, and the industrial manufacturing speed for building sufficient CCS plants worldwide. Therefore, including extremely speculative curves in the graphs may be misleading, by transmitting the idea for policy makers that they are somehow possible to be achieved by 2050. (Alexandre Strapasson, Brazil)

This text has been modified.

This paragraph is on CDR, so insert a new title before line 12. The discussion should be broadened to all CDR options, not just BECCS, even if the scenario runs only use BECCS. By bringing the material on CDR from chapter 4 here (and partly in section 2.4.2), a balanced discussion on the role of CDR can be presented, where limits on biomass and land requirements can be dealt with by using agricultural soil carbon enhancement, biochar and land restoration, as well as possibility other options. (Bar Metz, Netherlands)

This text has been modified.

In the same time the global forest cover will either stay the same as currently or increase? This is hard to believe. And although forests will stay as forest it is totally different story what is their carbon storage compared to the current one. (Tuomo Kalliokoski, Finland)

Higher reliance on BECCS is associated with higher fossil fuel demand. I would suggest to invert the order: e.g. “Higher fossil fuel demand is associated with higher reliance on BECCS”. This would give a clearer picture about the implications of these technologies associated with sustained fossil fuel demand, and in a sense a better reflection of the causal chain. (Michiel Schaeffer, Netherlands)

This text has been modified.

Sentences between 18 and 21 do not well describe Figure 2.14(a) and (b). For example, in higher BECCS scenario (a) gas+oil is larger than that in lower BECCS scenario in 2050, and lower BECCS scenario (b) have a larger primary energy consumption than higher BECCS scenario (a) (Makoto TAKAGI, Japan)

This text has been modified, and the topic of space moved the section on space.

It says in the text that one case includes a “rapid increase” of nuclear capacity. However, based on the referenced figure 2.14, nuclear capacity is roughly doubled in 40 years, which seems very close compared to extreme emission reductions that are needed.

In the second case, fossil fuels are not phased out at all and nuclear power capacity is actually decreased, while the proportion of wind and solar energy is smaller than in the first case. Only a very small part of energy generation by combustion is combined with CCS. How can this scenario then have similar carbon budget as the first one, which contained almost no fossil fuels and the biomass was combined with CCS? (Jame Hovinon, Finland)

This text has been modified to better describe the pathways in the figure.

In figure 2.14a please group the stacked line charts in the same order as the key. They key makes sense (gas and CCS gas together, but it should be natural gas, and it should specify unabated), but the unabated gas, coal and oil are together in the graph, not in the order of the key! Also, the choice of colours make it difficult to distinguish among gas, wind, hydro and biomass. (Jason Donner, Canada)

This text has been modified to better describe the pathways in the figure.

Figure to be modified to make easier to compare panels… particularly the colour and order of the wedges between panels should match; in addition the definition of average and high need to be explained in panel c.

Figure 2.14b please use the same colours as are used in figure 2.14a. It is difficult to read, but the same colours would make it a bit easier. (Jason Donner, Canada)

These panels communicate quite well with policymakers. (Silvia Jim, United Kingdom (of Great Britain and Northern Ireland))

See comment 1100.
Comment | Response
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6152 | 35 26 35 28
Comment No | From Page | From Line | To Page | To Line | Comment | Response
11130 | 35 26 35 28 | (Figure 2.14): Please use the same color coding for the two figures (2.14a and 2.14b). Otherwise, they seem to have a different fuel mix already at the base year (2005). [Michel Schaeffer, Netherlands] see comment 1101
1513 | 35 20 35 28 | The legend of the figure should be consistent in each panel. [Kenich Nakumura, Japan] see comment 1100
13321 | 35 26 36 6 | Figure 2.14: Panel c: explain what average and high relate to (i.e. average of what)? [Jordan Hardt, United Kingdom (of Great Britain and Northern Ireland)] see comment 1101
13322 | 35 26 36 6 | Figure 2.14: The area graph packs in a lot of information in small space; difficult to match up tables with colours, suggest exploring alternative layout for easier comprehension. [Jordan Hardt, United Kingdom (of Great Britain and Northern Ireland)] see comment 1100
7982 | 36 | In figure 2.11 a maximum amount of up to 300 EJ of biomass for energy appears. This amount represents approx. 13 Gt dry matter, which represents the total present production of agricultural crops. In other terms, this production would need the exploitation of 30% up to 60% of the total forest surface on Earth. In figure 2.25 and in chapter 4 p 33, biomass production for use in energy is more realistic: 50 to 100 EJ, which requires 500 to 1000 Mt land conversion that is taken on food production land and on pastures. In some cases agricultural land surface seems to decrease by -50%, which seems clearly unrealistic. [Jean Marie Saliére, France] This is not for this section, but we will revise the whole figures.
4539 | 36 | Fig 2.14: - Probably errors in the columns for "Nuclear-High" - high has to be higher than average. [Radim Tlada, Czech Republic] This is not for this section, but we will revise the whole figures.
4540 | 36 | Fig 2.14: - I suggest adding format to "Nim" for "Radim Tlada, Czech Republic" This is not for this section, but we will revise the whole figures.
20307 | 36 36 | Fig 2.14: The newly installed capacity figure seems to be misplaced here, as the discussion and other two graphs refer to the linkage of the deployment of BECCS to fossil energy use. Perhaps, better to split in two separate figures. [Marine Gorner, France] This is not for this section, but we will revise the whole figures.
6509 | 36 1 36 1 | Suggested to include CCS in the figure in order to get an illustrative comparison between biomass, solar, wind, nuclear and CCS [Aage Stangeland, Norway] This has been added to mention capacity differences
14229 | 36 1 36 1 | Figure 2.14: talks about capacity which makes both wind and solar look far better than they will deliver. The capacity factor for both wind and solar is quite a bit below that of nuclear or biomass. Presenting capacity as opposed to delivered output is quite misleading. [Jason Donev, Canada] see comment 1100
12990 | 36 1 36 6 | Fig 2.14: Please explain in the caption the meaning of "average" and "high" [Cassene Stefano, Italy] NO CHANGE this figure is on share of CCS not CCS vs other energy sources
12991 | 36 1 36 6 | Fig 2.14: Ysis is an important comparison; I suggest adding also the 2015-2016 data, (or maybe the data for the year 2017), they should be available in the Second Draft [Cassene Stefano, Italy] see comment 1101
17473 | 36 4 | A [Tom Gabriel Johansen, Norway] No comment provided
17513 | 36 4 | A [Angela Moeoi, Norway] No comment provided
20196 | 36 4 36 36 | All Figure 2.14: Add explanation of "average" and "high" in figure captions [Tom Wöldenberg, Netherlands] see comment 1100
20596 | 36 4 36 4 | The graph showing the new capacity installed per year is probably misleading to appreciate the role of the different technology. The load factor of low carbon technologies (biomass, wind, solar, nuclear) is very different, and it is important to speak in GW to consider investment but in TWh to appreciate the production of the different technologies. [Eric Vidiclanc, France] Accepted
12741 | 36 4 36 4 | It is very unclear what panel (c) actually shows. What are "average" and "high"? [Vassilisa Danoglu, Netherlands] Consider for final draft if data is available
12747 | 36 4 36 4 | Legend should mention what the scenarios (a) and (b) actually are. [Vassilisa Danoglu, Netherlands] see comment 1101
6944 | 36 4 36 7 | What do the Average and High refer to in Figure 2.14 (a)? [Marine Gorner, France] See comment 1100
3169 | 36 9 36 17 | This paragraph still has to be changed dramatically once some 1.5 degree c non-overshoot scenarios are included in the report. [Richard Rosen, Germany] Revised
19093 | 36 9 36 17 | Seems like the only place where power sector transition is discussed and this is very short. This should come earlier and be expanded. [Elina Levina, France] accepted
6893 | 36 9 36 17 | This paragraph suggests that models that do not contain the full technology option portfolio would show unrealistic rates of change. Have they been filtered out in figure 2.14? [Bert Metz, Netherlands] Discussed
<table>
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<tr>
<td>20304</td>
<td>36</td>
<td>9</td>
<td>36</td>
<td>9</td>
<td>Some arguments could be added why the power sector is considered the most important sector in the transition, e.g. largest source of FF+I CO2 emissions across all energy sectors or largest demand for fossil fuels. In my view, a less absolute statement, e.g. “central” or “key” would also work here, instead of “most important”.</td>
<td>see comment 1101</td>
</tr>
<tr>
<td>13197</td>
<td>36</td>
<td>10</td>
<td>36</td>
<td>11</td>
<td>It is mentioned that power sector is the most important one. This could potentially be misleading and may give the reader a wrong impression that the challenge in end-use sectors (energy demand) is less, which is a conclusion that does not necessarily come from this chapter. It is suggested that authors rephrase this.</td>
<td>the words will be carefully checked, to avoid this misunderstanding</td>
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<td>9164</td>
<td>36</td>
<td>10</td>
<td>36</td>
<td>17</td>
<td>I am the opinion a few considerations about how realistic the indicated paces of change are and related challenges should be included here. Examples discussions are Greenpeace's “Energy Revolution” (<a href="http://bit.ly/2bWd4kL">http://bit.ly/2bWd4kL</a>), ODI's “The sky is the limit” (<a href="http://bit.ly/2WUgDpd">http://bit.ly/2WUgDpd</a>), ODI's “Beyond Coal” and others (Yilmaz et al. 2016. Impacts of a UK and German coal phase-out on the electricity mix and CO2 emissions in Europe. Insight Energy Info (TIE).renairam et al. 2016. Fossil fuels, employment, and support for climate policies. Energy Policy, 96: 364–371). If the consideration are done somewhere else, please make the reference here.</td>
<td>will be referred</td>
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<td>13198</td>
<td>36</td>
<td>13</td>
<td>36</td>
<td>13</td>
<td>Earlier it was mentioned that in projections nuclear, one of the low-carbon power generation resource, capacity is decreasing. Here, the sentence says the opposite.</td>
<td>will be revised</td>
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<td>12992</td>
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<td>16</td>
<td>This is an important point and I suggest more attention; also in Fig. 2.14 is clear that the pace of change in 2014-2105 is for wind and solar comparable to the average for the period 2020-2030. The pace of change in the years 2015-2016 or 2016-2017 is still higher (Cesaretti Stefano, Italy)</td>
<td>noted</td>
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<td>914</td>
<td>36</td>
<td>14</td>
<td>36</td>
<td>15</td>
<td>This statement is of great importance for near-term developments and should be substantiated. (David Infield, United Kingdom (of Great Britain and Northern Ireland))</td>
<td>will be revised</td>
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<td>14230</td>
<td>36</td>
<td>15</td>
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<td>16</td>
<td>This phrase “For nuclear power, however, these full 16 portfolio scenarios assume a departure in near future.” This statement implies that nuclear power will no longer be used. This is inconsistent with both presented data and the opinion of knowledgeable experts in the field. Nuclear can’t do it all, but we can’t do it at all without nuclear.</td>
<td>will be discussed</td>
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<td>6956</td>
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<td>16</td>
<td>For nuclear power, however, these full 16 portfolio scenarios assume a departure in near future. Is it clear what is meant with this. A departure, where? Full portfolio scenarios should be referenced better to understand what is meant from context, it would indicate that the rate of nuclear installations would grow from the current rate, but this should be clearly written. (Ville Tuluki, Finland)</td>
<td>this will be discussed</td>
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<td>6945</td>
<td>36</td>
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<td>17</td>
<td>Why is the pace of installations so much higher today? (Jaanne Hirvenson, Finland)</td>
<td>this means rapid transition for energy system in 1.5C is needed</td>
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<td>14231</td>
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<td>17</td>
<td>Proposed advancements in nuclear technology like small modular reactors should be considered. (Jason Donev, Canada)</td>
<td>this data comes from scenario database: detailed technologies will be discussed in Chapter 4</td>
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<tr>
<td>7436</td>
<td>36</td>
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<td>36</td>
<td>17</td>
<td>Consider to merge 2.3.4.1.2 and 2.3.4.3. For us the split between primary energy production and “end-use sectors” seems somewhat unnecessary. The strong focus on primary energy production in this chapter might understate the need for GHG-emission reductions in the all sectors. According to the IEA (ETP2017 p161) countries’ deep decarbonisation targets underscore the importance of industry. Many actors in the industry sector base their climate strategies on reducing the energy demand of process technologies with large inherent GHG-emissions, when developing new low emission processes, finding ways to substitute fossil feedstocks with renewable alternatives, and/or developing CCS solutions should be their focus. Stranded assets is a very real possibility in the industry sector, as the lifetime of the infrastructure is use is comparable to that of primary energy production facilities, and retrofitting CCS might not be feasible unless facilities have been built with this from mind from the start. (Brynd Christorphersen, Norway)</td>
<td>this will be discussed</td>
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<tr>
<td>21099</td>
<td>36</td>
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<td>36</td>
<td>17</td>
<td>Consider to merge 2.3.4.1.2 and 2.3.4.3. For us the split between primary energy production and “end-use sectors” seems somewhat unnecessary. The strong focus on primary energy production in this chapter might understate the need for GHG-emission reductions in the all sectors. According to the IEA (ETP2017 p161) countries’ deep decarbonisation targets underscore the importance of industry. Many actors in the industry sector base their climate strategies on reducing the energy demand of process technologies with large inherent GHG-emissions, when developing new low emission processes, finding ways to substitute fossil feedstocks with renewable alternatives, and/or developing CCS solutions should be their focus. Stranded assets is a very real possibility in the industry sector, as the lifetime of the infrastructure is use is comparable to that of primary energy production facilities, and retrofitting CCS might not be feasible unless facilities have been built with this from mind from the start. (Brynd Christorphersen, Norway)</td>
<td>this is a wrong reference, will be corrected.</td>
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<td>20305</td>
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<td>Shouldn’t section 2.3.4.2 be called “Energy end-use sectors”, noting that the parent title does not relate to energy and that the meaning here is not “end-use” in all regards but as regard to energy only? For example, it includes cement production. WRT cement I would regard end-use as being the construction of infrastructure, not the production of cement, hence my suggestion to call it is end-use WRT energy. (Philippe Marban, Belgium)</td>
<td>noted; in the new chapter structure, no section title of end-use sectors. Only individual end-use sectors exist.</td>
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<td>12943</td>
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<td>47</td>
<td>Related to the issue of energy demand is the share of direct emissions from the five energy-intensive industries (iron and steel, cement, chemicals, non-ferrous metals and pulp and paper) account for about 69% of total industrial emissions, and that this share is increasing. Given that emissions from these industries are very hard to mitigate without CCS or other innovative solutions, and that fuel switch and energy efficiency in manufacturing is uncomplicated, it would be prudent to split the industrial sector into energy-intensive process industry and other industries. The hard to mitigate process industries on which products the modern world current rely on should receive special attention in this chapter. (Brynd Christorphersen, Norway)</td>
<td>noted; Since there is a page limit, at this stage, we don’t have enough space to discuss the details.</td>
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<td>7437</td>
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<td>IEA report in ETP2017 p163 states that the share of direct emissions from the five energy-intensive industries (iron and steel, cement, chemicals, non-ferrous metals and pulp and paper) account for about 69% of total industrial emissions, and that this share is increasing. Given that emissions from these industries are very hard to mitigate without CCS or other innovative solutions, and that fuel switch and energy efficiency in manufacturing is uncomplicated, it would be prudent to split the industrial sector into energy-intensive process industry and other industries. The hard to mitigate process industries on which products the modern world current rely on should receive special attention in this chapter. (Brynd Christorphersen, Norway)</td>
<td>noted; in the new chapter structure, no section title of end-use sectors. Only individual end-use sectors exist.</td>
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</table>
This extensive discussion of the role of various major end-use sectors might play in various scenarios should be shortened. One problem is that a long section spends more time describing numerous studies that have been performed related to that section, than to make it clear to policy makers what these studies along with similar assumptions in the various IAMs that were relied on imply for what kinds of decisions policy makers need to make. Since the main focus of the SR15 report should be to educate policy makers as to the type and timing of decisions they will need to make, particularly in the medium term, the emphasis on particular studies should be changed. For example, if energy efficiency improvements are needed from industry to help meet a 1.5 degree scenario, which industries, and what processes should be initiated to achieve these goals? What feedstocks would be most affected? And the report should make it clear that sophisticated modeling of many industrial processes, transport, etc. will be necessary to come from renewable energy resources, including the possibility that wood and biomass could provide for most if not all feedstocks for the chemical industry which previously relied on oil and gas. Again, organize all this material around the kinds and timing of policy decisions that must be made, and the pros and cons of different choices. To the extent that previous studies help to inform that discussion, then they should be briefly mentioned, again, in end-notes, not in parentheses within sentence which only serve to distract readers. [Richard Rosen, Germany]

3199 37 36 32 32 Industry Chapter represents a good template for how sectoral measures can be discussed. The particular merit is its inclusion of reduced industrial production as a result of 1.5-scenario. This outcome is topical for most sectors. [Taran Fæhn, Norway]

20306 36 36 36 36 Iron making would be included in material industries. Is there any specific reason why pulp and paper is not included? Chemicals is repeated twice in the text. [Marine Gorner, France]

11051 37 37 37 37 Chemicals mentioned twice [Jakob Wachsmuth, Germany] Fixed.

13199 37 37 37 37 <2050 we a base year is either odd, it would help to update this with newer data. [Keiji Sugiyama, Turkey] Fixed.

7438 37 37 37 37 Please use up-to-date data. IEA report in ETP17 p.763 states that the share of direct emissions from the five energy-intensive industries (iron and steel, cement, chemicals, non-ferrous metals and pulp and paper) account for about 69% of total industrial emissions, and should also be included as a reference. [Byrond Christophersen, Norway] Fixed.

11052 37 37 37 37 Use of the word “encouragement” may be misleading here. Better use “additional” [Jakob Wachsmuth, Germany] Fixed.

7997 37 37 37 37 Only few studies analysed should be “Only a few studies analysed” [Robert Shapiro, United States of America] Fixed.

6271 37 37 37 37 The chapter concludes that industry may be the largest GHG reducer, but hides this important conclusion among several other sector. It’s better to highlight it. [Miton Nogueira da Silva, Brazil] Taken into account.

6894 37 37 37 37 This sentence is a key finding that should be part of the exec summary. [Bert Metz, Netherlands] Taken into account.

5227 37 37 37 37 (ii) could be the first (i) option; energy efficiency while reductions in demand could be the (v) option as it is not consistent with development. [Jakob Wachsmuth, Germany] Included discussion on it.

1411 37 37 37 37 The shape of industries will change significantly as a consequence of indirect effects of the energy transition on every energy intensive industry. I.e. Electric cars do not need refineries. We have found in our research significant and climate positive effect on the energy intensive industry as a consequence of these indirect effects/savings. Roughly causing a 50% reduction in greenhouse emissions before actions being taken in the industry itself. See https://quintel.com/industry or https://rfm-energytransitionmodel.com/publications/2037 (English version available on request). [John Kenkhoven, Netherlands] Taken into account.

1412 37 37 37 37 The text on what will happen to energy intensive industries in a climate neutral society in the IPCC report is to outdated make adequate given the contribution of this industry to global warming. See previous comment for how to possibly address this omission. Do not hesitate to call me if further explanation is needed. Dr. C. G. John Kenkoven, +31 6 53 29 8433 or john.kenkoven@quintel.com [John Kenkhoven, Netherlands] Taken into account.

20309 37 37 37 37 The deployment of low-carbon innovative process technologies (e.g. inert anodes for aluminium smelting, bio-based chemicals process routes, etc) should also be considered as carbon mitigation strategies beyond the integration of carbon capture and storage. [Marine Gorner, France] Included discussion on it.

11053 37 37 37 37 Process innovations like the DRI-EAF route for steel production and low-carbon clinker production should be mentioned as a separate item here. They overlap with some of the other items, but require special attention for complete decarbonization of the industry (see e.g. Lechtenböhmer et al.) [Jakob Wachsmuth, Germany] Taken into account.

9087 37 37 37 37 Sustainable production and consumption—whether it comes under strategy no.1 [Suchandita Banerth, India] Not only strategy 1, but all other strategies can be related.

6957 37 37 37 37 As per IEA ETP 2017 p. 295-296 of IEA ETP 2017 which is referenced explicitly says nuclear process heat is not analyzed. It would represent a sixth potential mitigation possibility for many industrial processes, and therefore should be mentioned as an unexploited potential. [Jakob Wachsmuth, Germany] Taken into account.

15030 37 37 37 37 It should be noted that IEA ETP 2017 (pp. 259-296 of IEA ETP 2017) which is referenced explicitly says nuclear process heat is not analyzed. It would represent a sixth potential mitigation possibility for many industrial processes, and therefore should be mentioned as an unexploited potential. As per IEA ETP 2017 p. 295: "In addition to being a recognized low-carbon electricity source, nuclear energy is also a low-carbon source of heat and can play a relevant role in decarbonizing other parts of the energy system where heat is being consumed, e.g. district heating, seawater desalination, industrial production processes and fuel synthesis." [Ville Tuukk, Finland] Taken into account.

17226 37 37 37 37 (ii) could be the first (i) option; energy efficiency while reductions in demand could be the (iv) option as it is not consistent with development. [Himangana Gupta, India] Strategy (ii) include both the reduction of products in the end-use and reduction of materials in the industry sector. So the later can be part of efficiency improvement. But strategy (i) is mainly focused on the process efficiency.

7988 37 37 37 37 Reducing of the fossil carbon content should be “Reducing the fossil carbon content” [Robert Shapiro, United States of America] Fixed.
### Comment Response

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<td>4246</td>
<td>37 13</td>
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<td>Consider looking into Creuzig et al. (2016) who try to systematically extract demand-side estimates from the AHS end-use chapters Creuzig, Felix, et al. “Beyond technology: demand-side solutions for climate change mitigation.” Annual Review of Environment and Resources 41 (2016): 173-198. (Felix Creuzig, Germany) noted; we are looking for the information for 1.5Ds, not for 2Ds.</td>
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<td>5228</td>
<td>37 14</td>
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<td>As is Comment 3, be careful not to confuse IEA Energy Technology Perspectives and IEA 85% Well Below 2 Degrees Scenario from Chapter 2 of Perspectives for the energy transition – investment needs for a low-carbon energy system (IEA, 2017). If you are indeed quoting IEA ETP, an additional reference should be added. (Bianka SHOA-i-TEHRANI, Japan) Yes, we quote ETP2017.</td>
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<td>9165</td>
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<td>I believe raw material substitution (fossil by renewable materials, for example, fossil CO2 by bio-CO2 in the beverage industry or bio-plastics) should be included in here. See for example a CDM methodology describing example project at <a href="http://bit.ly/2vWvnAt">http://bit.ly/2vWvnAt</a> [Adelino Ricardo Jacintho Esparta, Brazil] yes, included.</td>
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<td>17227</td>
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<td>Not possible for all countries. While the economies of most developed countries are shifting towards service sectors, developing economies are focusing the manufacturing sectors. A further shift to more service intensive economy will only shift emissions, rather than reduce. [Mihangana Gupta, India] noted; Yes, emissions form the industry will increase without proper reduction actions, so very challenging.</td>
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<td>17421</td>
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<td>What about the rebound effect? We need revolution in lifestyle in order to have material service reduction instead of huge increase in Asia during efficiency potentials are with reference to what base year and what future date and to what cost level? [Bert Metz, Netherlands] replaced with more specific data of IEA 2017.</td>
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<td>Statements in this paragraph are quite obvious - is the literature completely missing, making it impossible to be more concrete regarding the potential for material efficiency improvement and/or material service demand reduction? [Philipe Machet, Belgium] added</td>
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<td>20597</td>
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<td>Functionally economy is a strong lever to reduce material demand in future lifestyle. For instance, carsharing can reduce cars, and material needs, for mobility by a factor 5 (ADEME - 6T, 2017) [Erik Vidalenc, France] added</td>
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<td>20310</td>
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<td>Material efficiency strategies would also include approaches related to the improvement of the material production yields from manufacturing processes by minimizing material losses. (Marine Gorner, France) added</td>
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<td>It would be good to list other levers which can deliver material efficiency outcomes, such as behaviour change (eg changes in preferences of packaging); new business models and new production processes (see comment #3 for detail). This section also doesn't seem to mention material substitution (eg potential to shift to timber-based buildings, which could significantly reduce the demand for cement and other building materials, see Lehmann, S. (2013). Low carbon construction systems using prefabricated engineered solid wood panels for urban infill to significantly reduce greenhouse gas emissions. Sustainable Cities and Society, 6, 57-67. doi:10.1016/j.scs.2012.08.004) [Amandine Denis-Ryan, Australia] added</td>
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<td>Even though further research is needed on the quantification of the energy demand and carbon emissions impact of a wider uptake of material efficiency strategies throughout the whole system. It would be interesting to include in the report analytical findings for specific strategies. For instance, IEA Energy Technology Perspectives 2017, includes analysis on the impact of recycling of different materials and the improvement of metal production yields in smelting and finishing processes. (Marine Gorner, France) added</td>
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<td></td>
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<td>Some research already exists that provides some quantification of the potential, especially for Steel. An article I published with some colleagues in 2016, building upon the literature available, assessed that total Steel demand could be reduced by up to 58% through material efficiency levers, even after discounting activities which interfere with other decarbonisation actions. The range we used in our analysis was 40-58% to account for uncertainty, and based upon other literature sources. See page 3-4 in “Amandine Denis-Ryan, Chris Batalle &amp; Frank Jozi (2016): Managing carbon-intensive materials in a decarbonizing world without a global price on carbon, Climate Policy, DOI: 10.1080/14693062.2016.1176008”, and the full range of references we cited. [Amandine Denis-Ryan, Australia] added</td>
</tr>
<tr>
<td>7999</td>
<td>37 28</td>
<td></td>
<td></td>
<td></td>
<td>an aggregate energy efficiency potentials for industry' should be 'an aggregate energy efficiency potential for industry' [Robert Shapiro, United States of America] noted; this sentence was removed.</td>
</tr>
<tr>
<td>11917</td>
<td>37 28</td>
<td></td>
<td></td>
<td></td>
<td>It would be good in this section to mention some more ambitious studies. Indeed, energy efficiency improvements will not be limited to those identified today, as new technologies and process improvements are developed constantly (eg. recent improvements achieved through data analytics). As such we do not use absolute percentages to present the potential to improve energy efficiency but rather annual improvement rates, with the assumption that new potential will be found once the potential we know today is all used up. For example, UNIDO identified that an improvement rate of 1.7 percent per annum corresponds to deployment of Best Available Technology (BAT), which would deliver energy efficiency improvements of over 40% by 2050 compared to today's levels. (United Nations Industrial Development Organisation (UNIDO) 2010. Global Industrial Energy Efficiency Benchmarking, An Energy Policy Tool, Working Paper, Vienna.) Another good reference would be studies which discuss the thermodynamic efficiency limits for common processes. [Amandine Denis-Ryan, Australia] noted; we will add, if space allows.</td>
</tr>
<tr>
<td>13200</td>
<td>37 29</td>
<td></td>
<td></td>
<td></td>
<td>The paper by Sanyin et al. (2011) cited here refers to the chemical and petrochemical sector only. Another paper (<a href="https://doi.org/10.1016/j.energy.2011.08.025">https://doi.org/10.1016/j.energy.2011.08.025</a>) from the same authors covers all sectors of the industry and estimates an energy saving potential of 27%. [Deger Saygin, Turkey] noted; thank you for the information, but global data is preferable</td>
</tr>
<tr>
<td>6272</td>
<td>37 29</td>
<td></td>
<td></td>
<td></td>
<td>The short-term impact, of obvious policy formulation, should be mentioned in executive summary. [Milton Nogueira da Silva, Brazil] mentioned in ES</td>
</tr>
<tr>
<td>20998</td>
<td>37 29</td>
<td></td>
<td></td>
<td></td>
<td>In its foresight scenarios, ADEME, evaluate the best technologies diffusion in the french context (fossil) the energy reduction by unit produced more than 19% from 7% to 30% considering the different sector (ADEME. 2012) [Erik Vidalenc, France] noted; thank you for the information, but global data is preferable</td>
</tr>
<tr>
<td>5229</td>
<td>37 30</td>
<td></td>
<td></td>
<td></td>
<td>Same comment on IEA reference: ETP or Well Below 2050? [Bianka SHOA-i-TEHRANI, Japan] noted; ETP2017</td>
</tr>
<tr>
<td>17422</td>
<td>37 32</td>
<td></td>
<td></td>
<td></td>
<td>In its foresight scenarios, ADEME, evaluate the best technologies diffusion in the french context: the energy reduction by unit produced more than 19% from 7% to 30% considering the different sector (ADEME. 2012) [Erik Vidalenc, France] noted; thank you for the information, but global data is preferable</td>
</tr>
<tr>
<td>6897</td>
<td>37 31</td>
<td></td>
<td></td>
<td></td>
<td>3.1 what is the &quot;beyond 2C&quot; scenario? [Bert Metz, Netherlands] added; 1.75DS scenario, this was clarified in the text.</td>
</tr>
<tr>
<td>8000</td>
<td>37 31</td>
<td></td>
<td></td>
<td></td>
<td>emissions reductions achieved 'until 2030 in their beyond 2C scenario 'until can't be right! [Robert Shapiro, United States of America] noted; this sentence was deleted.</td>
</tr>
<tr>
<td>Comment No</td>
<td>From Page</td>
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<td>5230</td>
<td>38</td>
<td>3</td>
<td>38</td>
<td>3</td>
<td>Same comment on IEA reference: ETP or Well Below 2057? [Blank Shono-Teran, Japan]</td>
</tr>
<tr>
<td>13201</td>
<td>38</td>
<td>10</td>
<td>38</td>
<td>21</td>
<td>Does material demand reduction refer to recycling? [Deger Saygin, Turkey]</td>
</tr>
<tr>
<td>9650</td>
<td>38</td>
<td>13</td>
<td>38</td>
<td>21</td>
<td>Decarbonising the energy intensive basic materials industry through electricity-implications for future EU electricity demand. Stefan Lechtenboehmer, Lar J. Nielsen, et al., Energy <a href="http://dx.doi.org/10.1016/j.energy.2016.07.110">http://dx.doi.org/10.1016/j.energy.2016.07.110</a> will be a good reference [Shuzo Nishioka, Japan]</td>
</tr>
<tr>
<td>20312</td>
<td>38</td>
<td>13</td>
<td>38</td>
<td>21</td>
<td>Please elaborate on which industrial sub-sectors or applications are prone to absorb the greatest share of additional electricity consumption in the industrial sector vis-a-vis the low-carbon innovative process technologies considered in the scenarios scope. Greater electricity shares of industrial demand are limited by factors such as availability of relevant raw materials (e.g. metal scrap), technology cost-effectiveness and readiness in the case of new technologies. [Marine Gorner, France]</td>
</tr>
<tr>
<td>9677</td>
<td>38</td>
<td>13</td>
<td>38</td>
<td>21</td>
<td>Decarbonising the energy intensive basic materials industry through electricity-implications for future EU electricity demand. Stefan Lechtenboehmer, Lar J. Nielsen, et al., Energy <a href="http://dx.doi.org/10.1016/j.energy.2016.07.110">http://dx.doi.org/10.1016/j.energy.2016.07.110</a> will be a good reference [Shuzo Nishioka, Japan]</td>
</tr>
<tr>
<td>11918</td>
<td>38</td>
<td>14</td>
<td>38</td>
<td>21</td>
<td>It would be good to add a sentence about the end uses which can be electrified in this section. In particular, heating processes and material handling processes (ag in mining) are good candidates (see comment 4), but others such as compression, and other processes already provided by direct fuels or electricity could be mentioned as well. [Amandine Danis-Ryan, Australia]</td>
</tr>
<tr>
<td>7439</td>
<td>38</td>
<td>23</td>
<td>38</td>
<td>23</td>
<td>Consider adding feedstock to this heading, so that it reads: &quot;Reducing the fossil carbon content of non-electric fuels and feedstocks&quot; [Myrild Christophersen, Norway]</td>
</tr>
<tr>
<td>12749</td>
<td>38</td>
<td>25</td>
<td>38</td>
<td>26</td>
<td>For the 1.5 scenarios it is stated that the fossil carbon intensity should be ~30, while ranges are given for reference policies and the ADVANCE scenario. This should be consistent. [Vassilis Daioglou, Netherlands]</td>
</tr>
<tr>
<td>8001</td>
<td>38</td>
<td>27</td>
<td>38</td>
<td>27</td>
<td>This are' cant be right. Either &quot;These are&quot; or &quot;This is&quot;. I prefer the latter. [Robert Shapiro, United States of America]</td>
</tr>
<tr>
<td>20640</td>
<td>38</td>
<td>30</td>
<td>38</td>
<td>32</td>
<td>what about power to gas technologies and their potential to provide synthetic hydrogen fuels for transport including shipping and air traffic? [Hansa Poerntner, Germany]</td>
</tr>
<tr>
<td>9651</td>
<td>38</td>
<td>31</td>
<td>38</td>
<td>31</td>
<td>Origin (primary energy) of for producing hydrogen needs to be mentioned [electrolysis, chemical processing, ( refer to line 53-55 ?)] [Shuzo Nishioka, Japan]</td>
</tr>
<tr>
<td>9678</td>
<td>38</td>
<td>31</td>
<td>38</td>
<td>31</td>
<td>Origin (primary energy) of for producing hydrogen needs to be mentioned [electrolysis, chemical processing, ( refer to line 53-55 ?)] [Shuzo Nishioka, Japan]</td>
</tr>
<tr>
<td>8787</td>
<td>38</td>
<td>31</td>
<td>38</td>
<td>32</td>
<td>Hydrogen is no energy source, but an energy vector. How will the hydrogen be produced? [Arnulf Jaeger-Waldaus, Italy]</td>
</tr>
<tr>
<td>15031</td>
<td>38</td>
<td>31</td>
<td>38</td>
<td>32</td>
<td>Not familiar with hydrogen as a substitute for fossil-based non-electric energy demands – can the authors clarify what type of technology this refers to? [Kathleen Aikins, United States of America]</td>
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<tr>
<td>13508</td>
<td>38</td>
<td>31</td>
<td>38</td>
<td>31</td>
<td>Details on how decarbonized hydrogen is produced is produced in these scenarios should be added [Caserini Stefano, Italy]</td>
</tr>
<tr>
<td>7944</td>
<td>38</td>
<td>34</td>
<td>38</td>
<td>39</td>
<td>The whole section on CCS could do with more references to specific case studies from the industry sector, and more general discussion of CCS is done in section 2.3. [Jasmin Kemper, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
<tr>
<td>17423</td>
<td>38</td>
<td>35</td>
<td>38</td>
<td>36</td>
<td>Here should be more details of CCS in order to increase credibility [Tuomo Kalliokoski, Finland]</td>
</tr>
<tr>
<td>5910</td>
<td>38</td>
<td>38</td>
<td>38</td>
<td>38</td>
<td>Suggest adding the following text: &quot;For many industrial processes (e.g. cement production) CO2 is a process product and wide deployment of CCS is a prerequisite for deep CO2 emission reductions in addition to energy efficiency measures.&quot; [Agata Stangeland, Norway]</td>
</tr>
<tr>
<td>15685</td>
<td>38</td>
<td>40</td>
<td>38</td>
<td>46</td>
<td>It is incomplete to describe the current state of deployment of CCS as &quot;slow&quot; without referring to factors that made it so, such as the state of the technology, serious technical problems encountered (i.e., In Salah CCS in Algeria, see: <a href="https://sequestration.mit.edu/tools/projects/in_salah.html">https://sequestration.mit.edu/tools/projects/in_salah.html</a>) and legal hurdles. The paragraph implies that the only obstacle for large-scale deployment of CCS about costs which can be addressed by &quot;carbon pricing&quot; – an assertion belied by current experiences in large-scale CCS development and deployment. [Elenita Daño, Philippines]</td>
</tr>
<tr>
<td>15438</td>
<td>38</td>
<td>40</td>
<td>38</td>
<td>46</td>
<td>It is incomplete to describe the current state of deployment of CCS as &quot;slow&quot; without referring to factors that made it so, such as the state of the technology, serious technical problems encountered (i.e., In Salah CCS in Algeria, see: <a href="https://sequestration.mit.edu/tools/projects/in_salah.html">https://sequestration.mit.edu/tools/projects/in_salah.html</a>) and legal hurdles. The paragraph implies that the only obstacle for large-scale deployment of CCS about costs which can be addressed by &quot;carbon pricing&quot; – an assertion belied by current experiences in large-scale CCS development and deployment. [Elenita Daño, Philippines]</td>
</tr>
<tr>
<td>15094</td>
<td>38</td>
<td>40</td>
<td>38</td>
<td>46</td>
<td>Good section. Remark on final sentence only: carbon pricing has not delivered on deploying CCS, and is still far away from doing so. Hence the concluding sentence could include reference to other types of policy as well. For example: &quot;Incentives, standards and carbon pricing are...&quot; [Éléna Léchitenboehmer, Lar J. Nielsen, et al., Energy <a href="http://dx.doi.org/10.1016/j.energy.2016.07.110">http://dx.doi.org/10.1016/j.energy.2016.07.110</a> will be a good reference]</td>
</tr>
<tr>
<td>6154</td>
<td>38</td>
<td>41</td>
<td>38</td>
<td>42</td>
<td>Badly designed sentence: &quot;In stark contrast&quot; then refers to the current point, not the contrasting point. Rewire by simply deleting &quot;for industrial activities&quot;. [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
<tr>
<td>5177</td>
<td>38</td>
<td>42</td>
<td>38</td>
<td>42</td>
<td>Hidden in one single line on page 38 that one of the &quot;most important climate mitigation technologies&quot; is a total market failure. Only 2 installations. Again, it is simply irresponsible to continue to develop climate change technologies with CCS as one of the centre-stage technologies, when the authors themselves acknowledge that this technology is not even close to market ready. [Sven Teske, Austria]</td>
</tr>
<tr>
<td>731</td>
<td>38</td>
<td>44</td>
<td>38</td>
<td>44</td>
<td>There is a need to elaborate what &quot;once mature&quot; will roughly mean as COSYS. It is a very important to discuss in decarbonisation. Furthermore it is important to know what will happen to the 1.5C scenario if there is a delay in proliferation of CCS technology [Mohsen Kinn, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
<tr>
<td>7942</td>
<td>38</td>
<td>44</td>
<td>38</td>
<td>45</td>
<td>It is not helpful to conclude a single number for all industrial sectors. The impact that carbon pricing has on an industrial sector depends hugely on manufacturing cost per tonne of product and sales prices/margins. These can vary greatly between the different industrial sectors, i.e. cement, steel, oil &amp; gas, chemicals. [Jasmin Kemper, United Kingdom (of Great Britain and Northern Ireland)]</td>
</tr>
</tbody>
</table>
The statement "hydrogen is relatively expensive" is due to assumptions taken. The prices of alternative fuels including hydrogen depend largely on the price of energy carriers and the price of CCS per ton of CO₂, but rather the impact of CCS on the price of the commodity costs within the sector within which the commodity plays a role. For example, the literature suggests that CCS would raise the price of cracker production by 50 - 100%, which in turn raises the cost of carbonless-bonded construction by 10 - 20%. The latter is a non-trivial number, and yet also not out of range from sectoral effects that other regulations (e.g. emissions and safety standards for cars) have had. And by the way, if we are aiming for 1.5°C, then we know that we do need to completely decarbonize things like cement and steel, ultimately with no flexibility in terms of reducing the carbon footprint as to where the marginal costs are least. So I find the policy-prescriptiveness in this section (i.e. around carbon pricing) to have little justification, since the economic arguments for a carbon price versus a regulatory standard, in terms of allowing this kind of flexibility, to be inapplicable. [Anthony Patt, Switzerland]

The statement "Electrifying some energy services, most importantly high temperature heating, has a substantial exergy penalty as it converts a high-quality electricity into low-quality heat. This is thermodynamically most wasteful for lower-temperature heat." But of course anyone who probably realises this, but it is not what the text actually says. Rewrite as "Electrifying some industrial processes has a substantial penalty as it converts high-quality electricity into low-quality heat. This is thermodynamically most wasteful for lower-temperature heat." But of course anyone who knows what "energy" is already known this, hence removing that word. [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)]

Do Not Quote, Cite, or Distribute Page 70 of 107
Comment No | From Page | From Line | To Page | To Line | Comment | Response
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732 | 38 | 53 | 38 | 54 | Given that according to McAlister (The Solar Hydrogen Economy, ISBN:0-9728375-0-4), hydrogen burns at approximately 585 degrees C, which is higher than gasoline (Table 3.5 page 39) and given that McAlister has tested ordinary ICE cars and has shown that the emission particulates on exhaust are less than that on the ordinary air intake, why is hydrogen "an imperfect substitute" for gasoline or LPG for transportation? This statement needs clarification with citations. See also The Philosopher Mechanic ISBN-13: 978-1603220446 about using hydrogen in ordinary cars to clean the exhaust are less than that on the ordinary air intake, why is hydrogen "an imperfect substitute" for gasoline or LPG for transportation? This statement needs clarification with citations. See also The Philosopher Mechanic ISBN-13: 978-1603220446 about using hydrogen in ordinary cars to clean the exhaust |

noted; we are discussing hydrogen use in the industry, not in the transport. But we deleted this because H2 is not major issue in the industry sector.

21153 | 38 | 53 | 38 | 55 | In term of cost of the hydrogen energy carrier produced from renewable primary energy sources. I observe that—without considering possible future technological developments in hydrogen production (for which it would be enough to refer only to the article: (2015) Peter Rewell, Harvard Staff Writer "A leap for artificial leaf! New technique could open door to producing alternative-energy devices more cheaply" <https://news.harvard.edu/gazette/story2015/04/a-leap-for-artificial-leaf/>). I suggest to consider the articles (2017) IEA, Cédric P. in which he observe that: "Thanks to the recent cost reductions of solar and wind technologies, ammonia production in large-scale plants based on electrolysis of water can compete with ammonia production based on natural gas, in areas with world-best combined solar and wind resources" and "similar H2 prices could be reached in countries with lower-quality renewable resources if "surplus" electricity is considered free". IEA, Cédric P.- "Commentary: Producing industrial hydrogen from renewable energy" <http://www.iea.org/newsroom/news/2017/april/producing-industrial-hydrogen-from-renewable-energy.html>, IEA, Cédric P.: "Producing ammonia and fertilizers: new opportunities from renewable" <http://www.iiea.org/media/news/2017/FertilizermanufacturingRenewables_1605.pdf> — Maria Valentino Romei, Italy |

noted; we are discussing hydrogen use in the industry, not in the transport. But we deleted this because H2 is not major issue in the industry sector.

734 | 38 | 53 | 38 | 55 | In general this statement: "If it is a puts a negative spin on the use of hydrogen as a substitute for conventional liquid fuels. However hydrogen is |

noted; we are discussing hydrogen use in the industry, not in the transport. But we deleted this because H2 is not major issue in the industry sector.

6157 | 38 | 54 | 38 | 54 | (vi) Reducing the HFC emissions [Isabelle Czernichowski-Lauriol, France] noted; here we are describing the items additional to the issues already discussed, not only |

added '(vi) Reducing the HFC emissions' 
[Isabelle Czernichowski-Lauriol, France] noted; here we are describing the items additional to the issues already discussed, not only

8033 | 38 | 54 | 38 | 54 | A relative expensive energy carrier should be a "relatively expensive energy carrier" [Robert Shapiro, United States of America] deleted this sentence |

added "relative" to the energy carrier

733 | 38 | 54 | 38 | 55 | (vii) Conclusion for industry’s emissions [Isabelle Czernichowski-Lauriol, France] noted |

added '(vii) Conclusion for industry’s emissions' 
[Isabelle Czernichowski-Lauriol, France] noted

6899 | 39 | 1 | 39 | 5 | A separate discussion on reducing/eliminating fossil fuel as feedstock in industry (particularly steel and chemicals) is needed. This one sentence does not do justice to the importance of the issue. [Bert Metz, Netherlands] |

noted; we discussed this in the demand reduction subsection.

4844 | 39 | 4 | 39 | 5 | It states that hydrogen is a relative expensive energy carrier relative to what? i.e. how does it compare to CCS in mitigating CO2? Perhaps this statement could do with a citation or two and some qualification. Is it relatively expensive today as the proliferation of the technology does not benefit from scale economy? How is it relative compared to CCS technology, or to what is it relative? [Moshe Kinn, United Kingdom (of Great Britain and Northern Ireland)] |

noted; this is taken into account in the models

1528 | 39 | 5 | 39 | 6 | But with cement, it is worth noting the CO2 absorption of concrete over time could easily exceed the lack of completeness of CCS, meaning that the concrete production with CCS could actually turn out to be CO2 negative over the time scale of 100 years by which we analyze GHGs. [Anthony Patt, Switzerland] |

noted; thank you for the information.

9442 | 39 | 7 | 39 | 7 | add (v) Reducing the HFC emissions [Isabelle Czernichowski-Lauriol, France] |

noted; here we are describing the items additional to the issues already discussed, not only HFCs.

10660 | 39 | 14 | 39 | 14 | (v) - Kigali [Kristin Campbell, United States of America] |

add

10661 | 39 | 15 | 39 | 15 | The Montreal Protocol has historically been a landmark-strengthening treaty, and as such, there exists potential for further mitigation beyond the present phase-down under the Kigali Amendment (Zaelke et al 2012, Strengthening Ambition for Climate Mitigation: The Role of the Montreal Protocol in Reducing Short-lived Climate Pollutants, RECIEL, doi:10.11111/160332010). [Kristin Campbell, United States of America] |

noted; thank you for the information.

10692 | 39 | 15 | 39 | 15 | Switching to more climate friendly refrigerants as mandated by the Kigali Amendment provides an opportunity for redesigning cooling appliances (air conditioners, refrigerators, coolers) to be more efficient for even greater benefit to the climate [Shafi et al 2015] [Kristin Campbell, United States of America] |

noted; thank you for the information.

9443 | 39 | 16 | 39 | 16 | add (v) Conclusion for industry’s emissions [Isabelle Czernichowski-Lauriol, France] |

noted

6900 | 39 | 20 | 39 | 21 | Industrial coal use needs to be differentiated between coke for steel making and other coal usage, as the approach to eliminating them is different. [Bert Metz, Netherlands] |

noted; if space allows it, we will add the discussion on coal.

7943 | 39 | 22 | 39 | 23 | I think the wording "long-term" might be confusing here. What is longer term, can you quantify? It also slightly contradicts the statement on p. 381: 40-41, that "early setup of GCC is essential". [Isaak Kemper, United Kingdom (of Great Britain and Northern Ireland)] |

noted; we deleted "long-term".

735 | 39 | 23 | 39 | 23 | It seems like in this paragraph, the use of hydrogen does not play any role in decarbonisation to 2100. Is this scientifically correct? [Moshe Kinn, United Kingdom (of Great Britain and Northern Ireland)] |

noted; some scenario studies show relatively high reliance on the hydrogen, but in the most of studies, hydrogen role is not so important compared with other options.
<table>
<thead>
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<th>Comment</th>
<th>Response</th>
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</thead>
<tbody>
<tr>
<td>7440</td>
<td>39</td>
<td>24</td>
<td>39</td>
<td>24</td>
<td>Consider adding a paragraph at the end of 2.3.4.2.1 to explain what the pathways imply for near-term policy action, such as:</td>
<td>noted; Since the policy issues are discussed in section 2.5, so if space allows it, we will add.</td>
</tr>
<tr>
<td>7040</td>
<td>39</td>
<td>26</td>
<td>34</td>
<td>30</td>
<td>&quot;Not necessarily risk. Several studies have shown that many measures related to retrofit of the existing building stock in developed regions are 'win' in terms of their net cost per ton of CO2 equiv.&quot;</td>
<td>rejected; No, it is important to stress the lock-in.</td>
</tr>
<tr>
<td>13204</td>
<td>39</td>
<td>26</td>
<td>40</td>
<td>28</td>
<td>Authors may consider referring to the data from 2015 instead of 2010.</td>
<td>updated by 2014 data.</td>
</tr>
<tr>
<td>14322</td>
<td>39</td>
<td>26</td>
<td>39</td>
<td>26</td>
<td>The way that this is written at the moment it's confusing how this number (33%) is larger than the contribution of industry (chapter 2, pg 96 it is said); I understand it how is possible, but it look some work. A figure, perhaps a pie chart or stacked bar chart, could clarify the different contributions.</td>
<td>noted; this is for energy consumption, not for CO2 emissions.</td>
</tr>
<tr>
<td>20313</td>
<td>39</td>
<td>26</td>
<td>39</td>
<td>31</td>
<td>Possible to use more recent year than 2010 here?</td>
<td>updated by 2014 data.</td>
</tr>
<tr>
<td>5231</td>
<td>39</td>
<td>27</td>
<td>39</td>
<td>27</td>
<td>Black carbon: is there a definition of black carbon before this occurrence?</td>
<td>noted; Since recent data on BC is not available, so we will cut this part to update all the data in this paragraph.</td>
</tr>
<tr>
<td>6901</td>
<td>39</td>
<td>36</td>
<td>39</td>
<td>50</td>
<td>The statement in line 44-46 sounds contradictory to what is said in lines 42-44. More importantly this paragraph does not do a good job in drawing clear conclusions about the reduction potential of energy usage from top-down and bottom-up studies. What is a reasonable number for 2030 and for 2050?</td>
<td>noted; we are comparing the three different scenarios here, and no contradictions. But we will rewrite by using the updated figure.</td>
</tr>
<tr>
<td>7042</td>
<td>39</td>
<td>44</td>
<td>40</td>
<td>44</td>
<td>A summary of these recent IEA studies would be more interesting than a repetition of AR5</td>
<td>noted; thank you</td>
</tr>
<tr>
<td>7043</td>
<td>39</td>
<td>40</td>
<td>39</td>
<td>46</td>
<td>It would help to mention more explicitly how growing demand for energy for building cooling and emissions from its generation could be mitigated.</td>
<td>noted; Yes, it is considered here and also many sectoral studies do in the similar way. See also line 23-28.</td>
</tr>
<tr>
<td>6158</td>
<td>39</td>
<td>46</td>
<td>39</td>
<td>46</td>
<td>This sentence &quot;change option to &quot;options&quot; [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>fixed</td>
</tr>
<tr>
<td>7044</td>
<td>39</td>
<td>48</td>
<td>39</td>
<td>48</td>
<td>Refs are missing [Érika Mata, Sweden]</td>
<td>added</td>
</tr>
<tr>
<td>20599</td>
<td>39</td>
<td>48</td>
<td>39</td>
<td>48</td>
<td>Would it help to mention more explicitly how growing demand for energy for building cooling and emissions from its generation could be mitigated.</td>
<td>fixed</td>
</tr>
<tr>
<td>13205</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>The discussion on Btu vs TJ's settings is unclear; please present best estimates for the impact of decarbonisation of the energy used.</td>
<td>rewritten</td>
</tr>
<tr>
<td>7045</td>
<td>40</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>Does this stronger electrification apply to all regions? [Érika Mata, Sweden]</td>
<td>noted; Yes, the rate of change is different.</td>
</tr>
<tr>
<td>7046</td>
<td>40</td>
<td>11</td>
<td>11</td>
<td>13</td>
<td>Which sectoral model? Could you elaborate why [Érika Mata, Sweden]</td>
<td>noted; including IEA-EOP and other bottom-up studies, for example cited in AR5.</td>
</tr>
<tr>
<td>7047</td>
<td>40</td>
<td>18</td>
<td>18</td>
<td>22</td>
<td>Do not think a ref is needed for these three general statements [Érika Mata, Sweden]</td>
<td>rewritten</td>
</tr>
<tr>
<td>15033</td>
<td>40</td>
<td>18</td>
<td>20</td>
<td>28</td>
<td>Many measures which measures? [Érika Mata, Sweden]</td>
<td>removed old ref. Since it is more general and ETP2017 cited below covers this too.</td>
</tr>
<tr>
<td>1528</td>
<td>40</td>
<td>18</td>
<td>18</td>
<td>28</td>
<td>No, it is not considered here and also many sectoral studies do in the similar way. See also line 29-28.</td>
<td>noted; No, it is considered here and also many sectoral studies do in the similar way. See also line 29-28.</td>
</tr>
<tr>
<td>3884</td>
<td>40</td>
<td>18</td>
<td>40</td>
<td>38</td>
<td>More issues and references should be covered. As an example, I suggest two references that show the large potential of significant insulation and solar energy even at very northern latitudes: Renewable Energy Volume 113, December 2017, Pages 479-489. A long-term performance analysis of three different configurations for community-sized solar heating systems in high latitudes. Rahman, H.U., Hirvonen, J., Seine, K. Applied Energy Volume 107, April 01, 2013, Pages 255-269. Zero energy level and economic potential of small-scale building-integrated PV with different heating systems in Nordic conditions. Hirvonen, J., Kayo, G., Hasan, A., Seine, K. [Sarma Syn, Finland].</td>
<td>noted; because of page limits, we cannot extend the discussion into the detailed measures to specific areas.</td>
</tr>
<tr>
<td>7312</td>
<td>40</td>
<td>19</td>
<td>40</td>
<td>19</td>
<td>Delete the text &quot;lock-in of&quot; [Eleni Kaditi, Austria]</td>
<td>rejected; No, it is important to stress the lock-in.</td>
</tr>
</tbody>
</table>

**IPCC WGI SR15 First Order Draft Review Comments And Responses - Chapter 2**
<table>
<thead>
<tr>
<th>Comment No</th>
<th>From Page</th>
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<th>To Line</th>
<th>Comment</th>
<th>Response</th>
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</thead>
<tbody>
<tr>
<td>6093</td>
<td>40</td>
<td>23</td>
<td>40</td>
<td>25</td>
<td>This sentence seems to suggest that waiting with deep renovation could be the best strategy, as newer technologies would then be available. Is that really the message you want to send? [Bert Metz, Netherlands]</td>
<td>noted; if space allows it, we will add it.</td>
</tr>
<tr>
<td>7049</td>
<td>40</td>
<td>24</td>
<td>40</td>
<td>25</td>
<td>It would be more interesting to also present the regional results from Güneralp et al. The statement chosen appears kind of evident unless it is properly contextualized and explained. [Erika Mata, Sweden]</td>
<td>noted; EIA model includes the detailed subsector models to consider interaction of energy demand and selection of technologies.</td>
</tr>
<tr>
<td>7050</td>
<td>40</td>
<td>26</td>
<td>40</td>
<td>28</td>
<td>It is difficult to understand from where exactly in IEA 2017 this conclusion is drawn, but IEA is most definitely using a non-detailed model that disregards the interactions between electricity use and space heating demand, and that therefore unrealistically shows electrification (heat pumps, LEDS) as a straight-forward wining option (which is not the case). [Erika Mata, Sweden]</td>
<td>same as the comment of 1276</td>
</tr>
<tr>
<td>7133</td>
<td>40</td>
<td>25</td>
<td>40</td>
<td>25</td>
<td>Please consider deleting the text &quot;lock-in into&quot;. [Eleni Kaditi, Austria]</td>
<td>same as the comment of 1276</td>
</tr>
<tr>
<td>7441</td>
<td>40</td>
<td>25</td>
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<td>17</td>
<td>Please consider to give a more thorough treatment of strategies related to improved insulation of buildings. This is important in relation to both the demand for heating and for air-conditioning. [Byrdn Christophersen, Norway]</td>
<td>noted; we added these.</td>
</tr>
<tr>
<td>7462</td>
<td>40</td>
<td>28</td>
<td>40</td>
<td>28</td>
<td>Please consider adding a sentence as follows: &quot;In addition, requirements for low-carbon building materials and solutions could increase the need for implementation of low emission solutions in other sectors, e.g. industry and transport.&quot; Reasoning: Making clear that policy instruments directed towards lowering the carbon footprint of the building sector (building codes, support schemes, etc) could have indirect emission effects in other sectors, and that this effect is not specifically accounted for in the figure. Figures and text can potentially be interpreted as to include these indirect effects, if not specifically mentioned. Also, policy relevant in terms of national and EU policy, to show the linkages between sectors, increasing the focus also on the demand side for climate solutions. Low-carbon building materials has been documented for instance in the ZE-Bau research project <a href="http://www.zsb.innokom.de/">http://www.zsb.innokom.de/</a> [Byrdn Christophersen, Norway]</td>
<td>fixed</td>
</tr>
<tr>
<td>7051</td>
<td>40</td>
<td>30</td>
<td>40</td>
<td>38</td>
<td>Could the authors explain why these refs are considered “behavioral literature” this categorization does not match my own understanding of what behavioral literature? Could they be presented homogenously, i.e. with proportional savings, metod and regional scope for all of them? In anycase, the literature review is rather limited, and could include other studies with estimates in any of the world regions, emission pathways considered, etc. E.g. for EU: O'Brien E, Gísladóttir A, Mata E, Johnson F. The effect of improved efficiency on energy savings in EU-27 buildings. Energy (2013) 57: 134-144, Mata E, Sasid Kalagadas A, Johnson F. Energy savings and CO2 emission reductions from building retrofiting in five European countries – Modelling and review of estimates (in review) [Erika Mata, Sweden]</td>
<td>take in to account; rewritten.</td>
</tr>
<tr>
<td>16206</td>
<td>40</td>
<td>30</td>
<td>40</td>
<td>38</td>
<td>And what about solar roofs for which Musk/Yes are already producing solar roof shingles? And what about solar siding for buildings? Lots seems to be happening that should enable it. It would seem, greater savings than indicated here. [Michael MacCracken, United States of America]</td>
<td>noted; if space allows, we will add these.</td>
</tr>
<tr>
<td>6094</td>
<td>40</td>
<td>30</td>
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<td>38</td>
<td>This paragraph is suggested to be drawing on literature about behaviour (line 30), but it discusses technical measures on energy efficiency. More importantly, the paragraph is very shallow in discussing energy efficiency measures. A much broader and deeper reduction is warranted. [Bert Metz, Netherlands]</td>
<td>take in to account; here we are discussing the effect of individuals behaviour to select technologies, working.</td>
</tr>
<tr>
<td>12993</td>
<td>40</td>
<td>32</td>
<td>40</td>
<td>35</td>
<td>The example reported for the USA in the sentence “By the...thermostat” is not interesting, and is too old: better deleting it. [Cassenti Stefano, Italy]</td>
<td>rewritten</td>
</tr>
<tr>
<td>915</td>
<td>40</td>
<td>35</td>
<td>40</td>
<td>35</td>
<td>How much must thermostats be set back to achieve this saving? [David Infield, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>noted; this ref is relatively old, we will replace by new appropriate ref.</td>
</tr>
<tr>
<td>4541</td>
<td>41</td>
<td>2</td>
<td>40</td>
<td>15</td>
<td>Figure 2.16: Add index ref to “GO2” and “Win-2” city format to “Case Study format - Czech Republic” [Harold, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>noted; we use the same format in the entire chapter.</td>
</tr>
<tr>
<td>13323</td>
<td>41</td>
<td>1</td>
<td>40</td>
<td>15</td>
<td>Figure 2.16: Use a legend to explain the meaning of the symbols in the plots - this should be easier for readers than the explanations in text. [Jordan Harlton, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>made new figures</td>
</tr>
<tr>
<td>13324</td>
<td>41</td>
<td>1</td>
<td>40</td>
<td>15</td>
<td>Figure 2.16: Use a legend to explain the meaning of the symbols in the plots - this should be easier for readers than the explanations in text. [Jordan Harlton, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>made new figures</td>
</tr>
<tr>
<td>11134</td>
<td>41</td>
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<td>Due to schemes that avoid deforestation, mitigation that demands land (such as biomass production for BECCS and afforestation) is mainly taking place at the cost of agricultural land for food and feed production. To my knowledge, most of biomass consumption from BECCS - around 100 EJ/yr (IPCC SRRN 2012) - can be extracted from agricultural and forestry residues and organic waste alone. This would be sufficient for about half of the needs in 1.5C and 2 scenarios (Schaeffer et al. 2015, <a href="http://climemanaalytics.org/files/feasibility_15c_2c.pdf">http://climemanaalytics.org/files/feasibility_15c_2c.pdf</a>). [Michiel Sengers, Netherlands]</td>
<td>this comment is not for this section.</td>
</tr>
<tr>
<td>17275</td>
<td>41</td>
<td>3</td>
<td>40</td>
<td>3</td>
<td>[Tom Gabriel Johansen, Norway]</td>
<td>made new figures</td>
</tr>
<tr>
<td>17575</td>
<td>41</td>
<td>3</td>
<td>40</td>
<td>3</td>
<td>[Agata Mirek, Norway]</td>
<td>made new figures</td>
</tr>
<tr>
<td>7052</td>
<td>41</td>
<td>7</td>
<td>40</td>
<td>9</td>
<td>Could the “single model studies” of Clarke et al. be given here to facilitate the understanding by the reader? And again, regional results and detailed on scenarions would be appreciated, as the authors already point out. [Erika Mata, Sweden]</td>
<td>noted; if space allows it, we will add it.</td>
</tr>
<tr>
<td>20314</td>
<td>41</td>
<td>11</td>
<td>40</td>
<td>11</td>
<td>Name of the scenario in ETP 2017 is Beyond 2°C Scenario (B2DS). [Marine Gorner, France]</td>
<td>noted; the reference you mentioned is IPCC-AR5, so we only use this to give the essence of the conclusions.</td>
</tr>
<tr>
<td>14777</td>
<td>41</td>
<td>18</td>
<td>40</td>
<td>18</td>
<td>Some new alternative references may be useful for subsection 2.3.4.2.2.3. For example, the paper recently published by Cooper et al. (2016): Cooper, E.; Lefèvre, B.; Li, X. (2016). Can Transport Deliver GHG Reductions at Scale? an Analysis of Global Transport Initiatives. WRI working paper. Washington D.C., United States. 40p.</td>
<td>noted; thank you, when we add some introduction of transport sector, we will consider this.</td>
</tr>
<tr>
<td>17437</td>
<td>41</td>
<td>18</td>
<td>43</td>
<td>27</td>
<td>Emission mitigation options for shipping should also be mentioned as the challenges for aviation, shipping, freight and passenger road transport are quite different: Bouman, E. A., Lindeijer, E.,栗田, A. I., &amp; Strommen, A. H. (2017). State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping-a review. Transportation Research Part D: Transport and Environment, 52, 408-421. [Aki Kachi, Germany]</td>
<td>noted; we will include some introduction here.</td>
</tr>
</tbody>
</table>
For consistency to the B2DS mentioned in the previous sentence, it would be good to use here the 2DS results from ETP 2017 as well. [Marine Gorner, France] noted; we will add more discussion on the comparison of IAM and sectoral scenarios.

After description on transport, special mention needs to be made about energy consumption on the air transport sector which is enjoying an optimistic growth rate while at the same time eliciting growing concern, due to its environmental impact and its vulnerability with respect to energy security. These issues have put the sector at the forefront of the tide in achieving energy efficiency. Efforts have been made on every front to improve efficiency through better technology, optimized operation, as well as energy-saving infrastructure. [Mishra Santosh Kumar, India] rewritten

The Transport Chapter would gain from distinguishing between international and national transportation, because of very different political conditions. [Taran Fahn, Norway] noted; Since the space is limited, we can only focus on the subsector-level.

This section does not discuss the role of electric vehicle penetration as one of the key strategies to eliminate CO2 from the transport sector. That is a major omission, as it is obvious that that is one of the most promising options that all actors are betting on and where remarkable progress is being made. It is also important to specifically discuss the potential for hydrogen fuel cells and biofuels for the heavy transport, shipping and air transport sector. The paragraph on page 42, lines 1-15 contains so many numbers that the message gets lost. Also here the different SSP baselines create challenges for the policy message: what should policy makers do with the very different results for different SSPs? The material on page 44, lines 18-24 is on policy instruments and should be moved to chapter 4 (see also my comments on the entire report structure). There seems to be a contradiction between page 41, lines 24-25 (no in-depth study available) and page 44, lines 9-15. It would make sense to involve prof David Lee from Manchester Metropolitan University as a contributor, as he is one of the top experts on aviation. (Bert Metz, Netherlands) rewritten

After description on transport, special mention needs to be made about energy consumption on the air transport sector which is enjoying an optimistic growth rate while at the same time eliciting growing concern, due to its environmental impact and its vulnerability with respect to energy security. These issues have put the sector at the forefront of the tide in achieving energy efficiency. Efforts have been made on every front to improve efficiency through better technology, optimized operation, as well as energy-saving infrastructure. [Mishra Santosh Kumar, India] rewritten

Reduced transportation - e.g. substitution by digital communication, city-planning, less demand/expensive aviation etc. - is not discussed. [Taran Fahn, Norway] noted; take into account; added more discussion on ETP.

The year 2016 should be enclosed in brackets, i.e (2016) [Victor Ongoma, Kenya] fixed

Reached in this paragraph; not noted.

The Transport Chapter would gain from distinguishing between international and national transportation, because of very different political conditions. [Taran Fahn, Norway] noted; Since the space is limited, we can only focus on the subsector-level.

This section does not discuss the role of electric vehicle penetration as one of the key strategies to eliminate CO2 from the transport sector. That is a major omission, as it is obvious that that is one of the most promising options that all actors are betting on and where remarkable progress is being made. It is also important to specifically discuss the potential for hydrogen fuel cells and biofuels for the heavy transport, shipping and air transport sector. The paragraph on page 42, lines 1-15 contains so many numbers that the message gets lost. Also here the different SSP baselines create challenges for the policy message: what should policy makers do with the very different results for different SSPs? The material on page 44, lines 18-24 is on policy instruments and should be moved to chapter 4 (see also my comments on the entire report structure). There seems to be a contradiction between page 41, lines 24-25 (no in-depth study available) and page 44, lines 9-15. It would make sense to involve prof David Lee from Manchester Metropolitan University as a contributor, as he is one of the top experts on aviation. (Bert Metz, Netherlands) rewritten
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<tr>
<td>11133</td>
<td>42</td>
<td>10</td>
<td>42</td>
<td>15</td>
<td>This, according to these results from multiple models, there exists a fair amount of uncertainty regarding whether transport sector CO2 emissions by the end of the century need to be actually no lower than in 2015 [...]. These results are to be seen in sharp contrast with other findings based on the RESMIND and MESSAGE models (Rogelj et al. 2015). For further comparison (Sustainable Future 6), showing emissions from transport at around 2GtCO2 in 2050 (compared to 7 GtCO2 in 2010). Would you assume that this uncertainty is mostly driven by model characteristics rather than scenario design, correct (lines 13-15)? Or how can we reconcile those findings? [Michel Schaffner, Netherlands]</td>
<td>noted: Since each model assumes a different set of many important variables in the modeling, the exact results should be different. Therefore, we focus on the range of results of IAM and sectoral studies.</td>
</tr>
<tr>
<td>17424</td>
<td>42</td>
<td>11</td>
<td>42</td>
<td>13</td>
<td>Why the uncertainty in transport sector is larger in this term or in other sectors? [Tusso Kikkikoski, Finland]</td>
<td>noted: This is probably due to the recent high pace of change in vehicle technologies, including the passenger fuel economy and electric vehicles. This make the future projections more dificult.</td>
</tr>
<tr>
<td>4978</td>
<td>42</td>
<td>17</td>
<td>42</td>
<td>17</td>
<td>Would it be helpful to also look at quite ambitious national scenarios (grey literature), e.g. for Germany by Öko-Institut: Erhard, J. et al (2014): Klimaschonreicher Verkehr in Deutschland - Weichenstellungen bis 2050. Herausgeber: WWF Deutschland, Berlin, Juni 2014, 75 S. [Manfred Treber, Germany]</td>
<td>noted: you. We think the existing sectoral scenarios are already very ambitious and optimistic.</td>
</tr>
<tr>
<td>9761</td>
<td>42</td>
<td>17</td>
<td>42</td>
<td>17</td>
<td>Would it be helpful to also look at quite ambitious national scenarios (grey literature), e.g. for Germany by Öko-Institut: Erhard, J. et al (2014): Klimaschonreicher Verkehr in Deutschland - Weichenstellungen bis 2050. Herausgeber: WWF Deutschland, Berlin, Juni 2014, 75 S. [Manfred Treber, Germany]</td>
<td>same as the above</td>
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<tr>
<td>11054</td>
<td>42</td>
<td>17</td>
<td>42</td>
<td>21</td>
<td>Thought it is true that technology-focused measures show up in all scenarios, there are certain technology options that show up only in a few scenarios but in particular not in global IAM scenarios, e.g. the use of hydrogen in combustion-engine-based navigation and the electrification of HDVs via trolley trucks (see e.g. the German Climate Protection Scenario 2050). For the latter, there are already demonstration projects in Sweden and Germany. These options may become important to increase ambition in the transport sector. It would therefore be worthwhile to elaborate on additional technology options in this paragraph. [Jakob Wachsmuth, Germany]</td>
<td>noted: In the IEA scenarios, this is include in their 26GtS. We will add some discussion on this.</td>
</tr>
<tr>
<td>10240</td>
<td>42</td>
<td>17</td>
<td>42</td>
<td>30</td>
<td>Ferry transport between islands in island archipelagos cannot be replaced with other modes as it simply represents a lifeline to many islanders on small islands. Only super rich countries can do so, e.g. the royal family in the Maldives. [This is worth noting. I think, e.g. I wrote paper (Mendas, Z. (2015) “Tracing socio-economic impact of ferry provision in Zadar island archipelago”. Journal of Marine and Island Cultures, Vol. 4, Issue 1, pp. 10-26. Available at: <a href="http://dx.doi.org/10.1016/j.imic.2015.06.002">http://dx.doi.org/10.1016/j.imic.2015.06.002</a>) [Mendas Zrinka, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>noted: These region specific issues are very important, but in this report, we should limit the issues whose impact is larger in global scale.</td>
</tr>
<tr>
<td>1559</td>
<td>42</td>
<td>17</td>
<td>42</td>
<td>30</td>
<td>Important paragraph. An example of a very rapid and unexpected behavioral change that reduce transport emission is the boom of dockless bike sharing in China. <a href="https://www.theatlantic.com/cities/2017/07/made-22-bikesharing-dockless-china-millions-of-cycles-hangzhou/">https://www.theatlantic.com/cities/2017/07/made-22-bikesharing-dockless-china-millions-of-cycles-hangzhou/</a>... This new trend should be mentioned in the report. [Not Lecoq, Belgium]</td>
<td>noted: yes this is a good example of behavioural change, but the impact of actual reduction of energy and emissions are still very unclear.</td>
</tr>
<tr>
<td>2613</td>
<td>42</td>
<td>17</td>
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<td>30</td>
<td>how does this apply regionally? Transformational changes here are all described in a very general, globalised manner with little reference to how they can be implemented regionally. [Zur Blaasce, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>noted: Yes, regional difference is important, but because of the space limitation, we can not discuss detailed in this report.</td>
</tr>
<tr>
<td>13306</td>
<td>42</td>
<td>19</td>
<td>42</td>
<td>24</td>
<td>It may not be a given that modal shift provides low carbon transportation therefore it may help to add the sentence, provided that the alternative mode is less emission intensive. [Depar Sargen, Turkey]</td>
<td>noted: thank you.</td>
</tr>
<tr>
<td>562</td>
<td>42</td>
<td>23</td>
<td>42</td>
<td>24</td>
<td>A few papers have investigated road freight and have explored whether it is an obstacle to a range of climate policy targets. None of these have been tougher than a target of about 2 degrees by 2100, so it should be noted that the later half of the century. Road freight is likely to be an obstacle to tougher climate targets in a world with increased innovation and transformation of urban supply chains. You correctly mention rail as having a role, but decreasing the number of freight vehicles entering town centres and replacing them with a lower number of low emission vehicles or encouraging intermodal freight will also be important. [Note that while this chapter has been careful in making sure that the studies cited have focused on 1.5 degree targets, I did not notice that some of the discussion in chapter 4 has focused on less ambitious targets. Here is a list of the papers that I refer to: DeStefan P, van Vuuren, Oana Y. Edekerbosch, David L. McCollum, Keywan Riahi. A special issue on model-based long-term transport scenarios: Model comparison and new methodological developments to improve energy and climate policy analysis, Transportation Research Part D: Transport and Environment, Volume 55, 2017, Pages 277-395; O.Y. Edekerbosch, D.P. van Vuuren, C. Bertram, S. Carrara, J. Emmerting, H. Daly, A. Kluita, D.L. McCollum, N. Saadi Fakali; Transport fuel demand responses to fuel price and income projections: Comparison of integrated assessment models, Transportation Research Part D: Transport and Environment, Volume 55, 2017, Pages 310-321; S. Carrara, T. Longden. Freight futures: The potential impact of road freight on climate policy, Transportation Research Part D: Transport and Environment, Volume 55, 2017, Pages 359-372; Pietzcker, R. C., Longden, T., Chen, W., Fu, S., Krieger, E., Kyle, P., &amp; Luders, G. (2014). Long-term transport energy demand and climate policy: alternative visions on transport decarbonization in energy-economy models. Energy, 64, 96-108. [Thomas Longden, Australia]</td>
<td>noted: IEA ETP2017 considered detailed in the transport sector, including the freight transport. They suggested options compatible with the 1.5DS target.</td>
</tr>
<tr>
<td>11920</td>
<td>42</td>
<td>26</td>
<td>42</td>
<td>27</td>
<td>It would be good to mention other possible sources of reductions in travel demand, for example consumer behaviour change to locally sourced products and economic structure change towards more local production (e.g. through higher recycling rates and increased shift of production towards 3D printing). [Amandine Denis-Ryan, Australia]</td>
<td>noted: if space allows, we will add.</td>
</tr>
<tr>
<td>20600</td>
<td>42</td>
<td>28</td>
<td>42</td>
<td>28</td>
<td>But if we consider the necessity of a rapid shift toward less emissions pattern, behavioural measures have huge potentials compared to technological ones. For instance, carpooling reduce the energy consumption and GHG emissions by a factor 2 immediately. In comparison, we need more than 15 years to renew the entire vehicles fleet in Europe. [Eric Vidalenc, France]</td>
<td>noted: yes, behavioural measures are important and in fact, this is taken into account in IEA’s recent mitigation scenarios.</td>
</tr>
<tr>
<td>6533</td>
<td>42</td>
<td>28</td>
<td>42</td>
<td>28</td>
<td>(Creutzig 2016) should be modified to Creutzig (2016) [Victor Ongoma, Kenya]</td>
<td>fixed</td>
</tr>
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</table>
IPCC WGI SR15 First Order Draft Review Comments And Responses - Chapter 2

<table>
<thead>
<tr>
<th>Comment No</th>
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<tr>
<td>8536</td>
<td>42</td>
<td>28</td>
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<td>28</td>
<td>I suggest that the word 'debate' be replaced with 'investigation', by so doing, the statement shows that there remains need for confirmation of truth in the current status of the reports. The word 'debate' provokes discussions in cases where something can not be proved with ease such as in democratic process where majority have their way. [Victor Ongoma, Kenya] done</td>
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<tr>
<td>2104</td>
<td>42</td>
<td>32</td>
<td>42</td>
<td>44</td>
<td>The second sentence, about activity growth, could be confusing: I assume that increase in emissions that you indicate relates to the change attributed to, to the growth in activity, but expect that non-expert readers may believe that due to the increased activity, there is a net increase in emissions in all models (which is not the finding from Edenroesch et al or your own figures). Please consider wording. I also have the impression that if you could already refer to the net change in emissions (&lt; than in most models there can be a decrease in transport sector emissions in spite of the increased activity), it would be clearer. [Philippe Marbaix, Belgium] rewritten</td>
</tr>
<tr>
<td>737</td>
<td>42</td>
<td>33</td>
<td>42</td>
<td>33</td>
<td>When the name of an author is given in Chapters 1 and 3 (which I have so far looked at) the year is given in brackets, in this chapter the brackets are left out. [Mooshe Kim, United Kingdom (of Great Britain and Northern Ireland)] fixed</td>
</tr>
<tr>
<td>4172</td>
<td>42</td>
<td>46</td>
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<td>55</td>
<td>What plans are in place to reduce fossil fuel mix by 2030 and what will the implications be of electrification of transport systems? Electrification will require added resources for battery production as well as increased energy demands and investments in infrastructure. For hydrogen some future technologies are looking at dual uses i.e. energy and hydrogen production. The World Nuclear Agency highlighted this recently. The Ontario government also recently announced plans to undertake a feasibility study on the use of hydrogen fuel cells to power electric trains. [Michelle Leslie, Canada] noted; since space is limited, we can not extend our discussions into details.</td>
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<td>6525</td>
<td>42</td>
<td>46</td>
<td>42</td>
<td>46</td>
<td>The year 2015 should be enclosed in brackets, i.e (2015). The same applies to Lines 15 and 18 on the same page. [Victor Ongoma, Kenya] noted; this is a paper in review</td>
</tr>
<tr>
<td>13049</td>
<td>42</td>
<td>48</td>
<td>42</td>
<td>51</td>
<td>Social and technical barriers to the transformations needed for moving from 2°C to 1.5°C should be discussed here, as many mitigation solutions are not currently available. [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)] fixed</td>
</tr>
<tr>
<td>20317</td>
<td>42</td>
<td>49</td>
<td>42</td>
<td>49</td>
<td>Name of the scenario in ETP 2017 is Beyond 2°C Scenario (B2DS). [Marine Gorner, France] fixed</td>
</tr>
<tr>
<td>16207</td>
<td>42</td>
<td>49</td>
<td>42</td>
<td>54</td>
<td>There is an interesting demo project underway in Pakistan that replaces the tuk-tuk with an electric vehicle that is powered by solar panels mounted on the roof of the vehicle. This would save money for all and help reduce air pollution. [Deger Saygin, Turkey] noted; we will use the new definition of scenarios.</td>
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<tr>
<td>5911</td>
<td>42</td>
<td>54</td>
<td>42</td>
<td>55</td>
<td>Suggest including the following sentences between line 54 and 55: &quot;Fuel switching to hydrogen and increased share of electrification should be accompanied by CCS. Hydrogen and electricity produced from fossil fuels or biomass should include CCS deployment to ensure as low carbon footprint as possible.&quot; [Sarge Stangland, Norway] Considered, text revised to reflect this.</td>
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<tr>
<td>13008</td>
<td>43</td>
<td>6</td>
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<td>30</td>
<td>It would be helpful if the electric vehicle use is split for Evs and for other modes (in the Figure 2.17-right). Please also clarify whether biomethane falls under the category 'gases' or 'bioliquids'. [Deger Saygin, Turkey] noted; unfortunately most of models did not provide such a detailed data. The share of biomethane is small, and in the most of models, this is ignored or included biofuels.</td>
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<td>4543</td>
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<td>43</td>
<td>In Figure 2.17, a number of scenarios project a large growth of hydrogen use for transport. Does this mean its application is cheaper for transport than for industry? [Dager Saygin, Turkey] noted; the growth of hydrogen use will be accelerated by cross-sectoral usage. Power sector is a key sector for this.</td>
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<tr>
<td>16208</td>
<td>43</td>
<td>7</td>
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<td>8</td>
<td>Figure 2.17 - Add italic format to &quot;Wm&quot; (2L) [Radin Tomas, Czech Republic] noted; added more discussion on Evs.</td>
</tr>
<tr>
<td>21105</td>
<td>43</td>
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<td>11</td>
<td>Figure 2.17: wouldn't it be relevant to add a panel for the net change in emissions here, so that the reader does not need to wait until figure 2.20 to see the net result of those changing factors - and done for buildings in F 2.16 ? (I did not even see a reference to 2.20 in the discussion on transport). [Philippe Marbaix, Belgium] made new figures</td>
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<tr>
<td>13325</td>
<td>43</td>
<td>11</td>
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<td>30</td>
<td>Figure 2.17: Unclear how coloured dots in right hand plot relate to coloured dots in left hand plots. Needs explaining (e.g. figure legend). Include legend to explain symbols too, as easier reading text in caption. [Jordan Harold, United Kingdom (of Great Britain and Northern Ireland)] made new figures</td>
</tr>
<tr>
<td>9230</td>
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<td>12</td>
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<td>12</td>
<td>Figure, right panel. What causes the differences between models? For an assessment, not enough to just show results, also have to explain differences between results? [Dfen Peters, Norway] noted; more general discussion on the modelling is given in the section 2.1 and 2.6.</td>
</tr>
<tr>
<td>11747</td>
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<td>14</td>
<td>43</td>
<td>14</td>
<td>8 [Tom Gabriel Johannsen, Norway] made new figures</td>
</tr>
<tr>
<td>17515</td>
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<td>43</td>
<td>14</td>
<td>8 [Angela Morill, Norway] made new figures</td>
</tr>
<tr>
<td>1529</td>
<td>43</td>
<td>33</td>
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<td>But isn't it important to reflect on what these numbers mean if in fact there is also fuel switching taking place, e.g. from gasoline/diesel to decarbonized electricity? If we need the latter to achieve a 1.5°C target, then the emissions reductions associated with behavioural change may be large in the short term, but ultimately much less (or even zero) after fuel switching has taken place. [Anthony Pratt, Switzerland] noted; behavioral change is very important to reduce the demand. Even in the long-term, this is true, because production of vehicles and fuels needs energy and emits CO2 if energy is not fully decarbonized.</td>
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<td>4775</td>
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<td>Such large savings can be achieved only with large-scale switching and are rather theoretical as numerous barriers (e.g. infrastructure, social-demographic, etc.) exist. Could lead instead of 'would lead' is more appropriate. [Elena Georgopoulou, Greece] fixed</td>
</tr>
<tr>
<td>4776</td>
<td>43</td>
<td>4</td>
<td>43</td>
<td>24</td>
<td>Social and technical barriers to the transformations needed for moving from 2°C to 1.5°C should be discussed here, as many mitigation solutions are mentioned require large-scale behavioural changes and infrastructure modifications. [Elena Georgopoulou, Greece] technical issues are discussed in other paragraph.</td>
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<tr>
<td>8577</td>
<td>44</td>
<td>13</td>
<td>44</td>
<td>13</td>
<td>Station not clear. [Elemer Briacho-Eizendorf, Costa Rica] made new figures</td>
</tr>
<tr>
<td>6537</td>
<td>44</td>
<td>13</td>
<td>44</td>
<td>13</td>
<td>The year in which Kauppila et al was published is missing. The same applies to Lines 15 and 18 on the same page. [Victor Ongoma, Kenya] noted; this is a paper in review</td>
</tr>
<tr>
<td>738</td>
<td>44</td>
<td>13</td>
<td>44</td>
<td>13</td>
<td>No date on Kaupilla paper, also can't find the paper (Mooshe Kim, United Kingdom (of Great Britain and Northern Ireland)] noted; this is a paper in review</td>
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<tr>
<td>9305</td>
<td>44</td>
<td>13</td>
<td>44</td>
<td>32</td>
<td>The reference formats between these lines are not unified. The reference Kauppila et al require an insertion of the year and &quot;Havlík et al. 2014&quot; may be &quot;Havlík et al. (2014)&quot; [St KKLS, Turkey] noted; this is a paper in review</td>
</tr>
<tr>
<td>17381</td>
<td>44</td>
<td>18</td>
<td>44</td>
<td>24</td>
<td>No mention made here of inland waterway transport or coastal/deep water shipping [Gavin Argemill, United Kingdom (of Great Britain and Northern Ireland)] noted; Since space is limited, we should focus on the important modes only.</td>
</tr>
</tbody>
</table>
Literature does not specifically address the 1.5 degree target, but it does address the 2 degree target resulting ambition level would need to be more ambitious - Boes,T.,A., Mander, S. L., Traud, M. B., Anderson, K. L., Wood, F. R. (2016). Aviation and Climate Change-The Continuing Challenge. Encyclopedia of aerospace engineering. [All Kachi, Germany]

Technological options for international aviation are not completely different from domestic aviation (except where modal shift alternatives exist). Domestic measures cannot be completely separated from international bunkers see EU ETS, efforts for port electrification, etc. [All Kachi, Germany]

One of the mitigation options should include nuclear powered crafts, which are already in small use. This is not yet included in analysis, as is noted in Box 5.6 of IEA ETP2017, however its omission should be noted here. [Veita Tuki, Finland]

A recent paper with proposal of regional targets for international bunkers in grey literature. https://hal.archives-ouvertes.fr/hal-01459060 [Eric Vitalien, France]

The chapter and considered scenarios usually do not specify how much of the considered CDR activities happen in tropical/subtropical landscapes, temperate landscapes and boreal landscapes. This would be important due to the different socio-economic consequences and implication for the wider sustainable development goals and agenda. [Jennifer Morgan, Netherlands]

This section purports to be about land-use and land-use transitions, but it mostly deals with land-use change. It is disappointing to see no information on changes in e.g. CH4 from agriculture - there must be relevant literature out there, or information that can be extracted from the scenario database? I'm missing a much more substantive discussion about the extent to which mitigation of agricultural non-CO2 emissions could help, or may even by necessary to, achieve 1.5 goals, including by increasing the allowable CO2 budget from other sectors consistent with the temperature limit. [Andy Reisinger, New Zealand]

Section 2.3.4.3 would do well to address that emissions from land are dependent on very local factors. The analysis is focused on global and regional (supra-national) scale, while variation - e.g. in soil types, species, crops etc varie significantly at the sub-national scale. Have you looked available literature from AgMIP http://www.agmip.org. And see Rosa M’Hlieva, A M 2015. A compilation of agricultural models assessing sectoral dynamics, GHG emissions and abatement opportunities: The cases of Brazil, Chile, Colombia and Peru under the MAPS Programme. Cape Town, MAPS programme. http://www.mapsprogramme.org/wp-content/uploads/Paper_ACompilation-of-Agricultural-models-assessing-sectoral-dynamics.pdf [Harald Winkler, South Africa]

Various agricultural techniques such as agroforestry, soil carbon sequestration and even increasing investments into local farms could all help to fight the mitigation pathways. Investments and promotion of local agricultural communities will provide food security and lower emissions footprints as produce will not be required to be transported long distances. [Michelle Leslie, Canada]

I would recommend to consider including Strassman et al. (2017, DOI 10.1111/1365-2664.12969) here, too, because it is very much in line with this content, providing an alternative whole-system modeling approach based on system dynamics and at global level. See full citation above. [Alexandre Strapasson, Brazil]

Afforestation and Reforestation have not really be differentiated despite their fundamentally different implications on biodiversity and permanence of the carbon sequestration. Reforestation of former forest lands with native vegetation is usually beneficial for biodiversity and has a high resilience of the sequestered carbon against droughts and heatwaves contrary to afforestation. Despite this fundamental difference the text and scenarios mostly only use the term afforestation assuming that this includes reforestation which leaves usually unclear how much of it is afforestation and how much reforestation. [Jennifer Morgan, Netherlands]

Restoration of existing secondary forests is not considered at all in the scenarios despite its significant potential for CDR, which has been estimated by the Stockholm Environment Institute to be 220-330 Gt CO2 during the rest of this century (www.sei-international.org/mediamanager/documents/Publications/Climate/SEI-WP-2016-08-Negative-emissions.pdf). Restoration comes with strong biodiversity benefits and a high resilience of the sequestered carbon against droughts and heatwaves similarly to reforestation of former forest lands. Moreover the restoration of existing forests does not require any additional land opposite to BECCS, afforestation and reforestation. Despite this fundamental difference the text and scenarios mostly only use the term afforestation assuming that this includes reforestation which leaves usually unclear how much of it is afforestation and how much reforestation. [Jennifer Morgan, Netherlands]

Restoration of existing secondary forests is not considered at all in the scenarios despite its significant potential for CDR, which has been estimated by the Stockholm Environment Institute to be 220-330 Gt CO2 during the rest of this century (www.sei-international.org/mediamanager/documents/Publications/Climate/SEI-WP-2016-08-Negative-emissions.pdf). Restoration comes with strong biodiversity benefits and a high resilience of the sequestered carbon against droughts and heatwaves similarly to reforestation of former forest lands. Moreover the restoration of existing forests does not require any additional land opposite to BECCS, afforestation and reforestation. [Jennifer Morgan, Netherlands]

We adapted the text by now always talking about afforestation and reforestation. Due to space limitations a more comprehensive and detailed representation in chapter 2 is not possible. However chapter 4 will talk in more detail about the potential consequences of different land-based mitigation options (incl biodiversity). [Jennifer Morgan, Netherlands]

Restoration of forests is indeed not considered in the IAMs. But some of the models consider (non-assisted) regrowth of natural vegetation very differently (afforestation or reforestation). The models treat induced regrowth of natural vegetation very differently (afforestation or reforestation). We adapted the text by now always talking about afforestation and reforestation. [Jennifer Morgan, Netherlands]

This is a very important function for 1.5C trajectories and cross reference to page 35, where CDR is being discussed and where I suggested to include the whole range of CDR options, not just BECCS) [Bert Metz, Netherlands]

Move the discussion from chapter 3.3 here, so that there is one integrated discussion, rather than having it in two different places (see also my remarks on structural change for the entire report). [Bert Metz, Netherlands]
Comment: In relying on IAMs, there has been no discussion here of their reliability—how well they have been able to predict/project changes over the last 25-50 years, etc. Should there not be some section of this chapter that presents a critical examination of the performance of these models in predicting changes in terms of crops and land use change. The IPCC report that discusses these issues for climate models used in WG I reports? Somewhere I think it needs to be made clear that IAMs are not based on purely fundamental physical laws but have specific features which are related to their ability to predict land use change. These features are likely to be different from those of climate models. An example of this is the way IAMs handle farmers' decision-making processes, which may be influenced by local factors such as soil type, climate, and market conditions. Such factors are not considered in climate models. 

Response: Accepted. The section has been modified by adding a discussion of the limitations and uncertainties of IAMs. The section has also been extended to include a discussion of drivers for decreasing agricultural land. The text has been revised to reflect these changes.

Comment: The section on land pathways. A more detailed comparison and discussion of simulated results is needed to provide a comprehensive understanding of the factors driving land use change. The section should also include a more detailed comparison of the models and tools referred to in this section operate at the sub-national scale with spatial explicit and heterogeneous drivers of decreasing agricultural land. A more detailed comparison and discussion of simulated results is needed to provide a comprehensive understanding of the factors driving land use change.

Response: Rejected. The section 2.3.4.3.3 described at the global level but the models and tools referred to in this section operate at the sub-national scale with spatial explicit and heterogeneous drivers like soil types, climatic conditions, crops etc.

Comment: This is a very strong statement and needs quantification and ample referencing to give an indication about the certainty of this statement. What is missing at this point is a discussion about the availability (incl. quantification if possible) of marginal lands, waste feedstocks, so-called additional biomass (i.e. biomass that can lead to a GHG reduction without competing with / replacing other ecosystem services) for BECCS. Several studies have shown that these resources can be a significant contributor to climate mitigation. An example is the work of Pacala and Socolow (2004) who estimated that the USA could reduce its greenhouse gas emissions by 20% by 2050 with the use of additional biomass. 

Response: Accepted. This section has been extended by a clarification on drivers for decreasing agricultural land.

Comment: This section has been extended by a clarification on drivers for decreasing agricultural land.

Response: Rejected. The section 2.3.4.3.3 described at the global level but the models and tools referred to in this section operate at the sub-national scale with spatial explicit and heterogeneous drivers like soil types, climatic conditions, crops etc.

Comment: It is not cropland decreasing but mainly pastureland. Sentence added for listing the drivers of decreasing agricultural land. A more detailed comparison and discussion of simulated results is needed to provide a comprehensive understanding of the factors driving land use change.

Response: Rejected. The section 2.3.4.3.3 described at the global level but the models and tools referred to in this section operate at the sub-national scale with spatial explicit and heterogeneous drivers like soil types, climatic conditions, crops etc.
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<tr>
<td>6703</td>
<td>46</td>
<td>5</td>
<td>47</td>
<td>40</td>
<td>Factors affecting the AFOLU sector should also include efficiency of use. Less wasteful use of wood and other biomass resources and increasing efficiency of energy from e.g., more waste and residue based biomass for energy production can limit overall demand for wood and other biomass which is a crucial precondition for the successful restoration of forests and other ecosystems. This affects the bio-economy at large way beyond issues like food waste. In this context it is also important to indicate the share of waste- and residue-based bioenergy assumed for BECCS which is currently missing in the text and most scenarios, as it has implications for land demand. [Jenni Zenger, Netherlands]</td>
<td>Accepted - We modified this section accordingly.</td>
</tr>
<tr>
<td>14236</td>
<td>46</td>
<td>23</td>
<td>46</td>
<td>23</td>
<td>What are the units for pasture it 7 and 9.0? Likewise total cropland 4.6 0.6? Are these Wm-2 Percent? [Jason Donev, Canada]</td>
<td>Editorial - as indicated in both the caption and the table, these values are in Mha/yr unless stated otherwise.</td>
</tr>
<tr>
<td>6538</td>
<td>46</td>
<td>25</td>
<td>46</td>
<td>25</td>
<td>2017 should be enclosed in brackets. The same applies to 2014 in Line 32 on the same page. [Victor Ongoma, Kenya]</td>
<td>Accepted - No, the scenarios did not account for albedo. We added biophysical effects (albedo) to further quantify the importance of mitigation portfolios even more.</td>
</tr>
<tr>
<td>10426</td>
<td>46</td>
<td>25</td>
<td>46</td>
<td>32</td>
<td>I must be stated clearly which region these studies refer to beside reference point. It is subjective to say that this study relate to a whole world. I would advise inserting the key words on the particular region the study refers to and apply this to the rest of the report. [Menelas Zirnis, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Accepted - references are formatted automatically by the reference software and will be harmonized</td>
</tr>
<tr>
<td>10334</td>
<td>46</td>
<td>25</td>
<td>46</td>
<td>32</td>
<td>When quoting percentages of reduction, it will be good is it is clearly stated “of what” or related to what. [Maria Jose Sanz Sanchez, Spain]</td>
<td>Accepted - Changed accordingly.</td>
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<td>20068</td>
<td>46</td>
<td>26</td>
<td></td>
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<td>Year missing from Wendi et al. citation [Aaron Glenn, Canada]</td>
<td>Editorial - references are formatted automatically by the reference software and will be harmonized</td>
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<tr>
<td>6369</td>
<td>46</td>
<td>29</td>
<td>46</td>
<td>40</td>
<td>Substantial CO2 emission abatement: presumably you mean CO2 eq, not CO2!? Most of the abatement comes from reduced emissions intensity of CH4/Audit of product. Also, please remove (or provide convincing reference) for the claim that the abatement potential in intensive systems is limited because of trade-offs with soil carbon stocks. I don’t think there is clear evidence that it’s soil carbon stocks that are the issue. The abatement potential is limited simply because intensive systems are already quite productive and lifecycle assessments (e.g. Gerber et al. 2011, 2013) show that the emissions per unit of product reach an asymptote beyond a certain level simply because of emissions in generating additional animal feed, fertilizer use, and N2O from livestock excreta offset any further gains from increased productivity. [Andy Reasinger, New Zealand]</td>
<td>Accepted - references are made to synergies and trade-offs which the various strategies can provide. These should help decisionmakers understand which strategy would be preferred</td>
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<tr>
<td>10335</td>
<td>47</td>
<td>12</td>
<td>47</td>
<td>15</td>
<td>This is an extremely important point that should be inserted right at the beginning. [Maria Jose Sanz Sanchez, Spain]</td>
<td>Taken into account - we agree that this is an important point, but feel it is better included at this point of the text.</td>
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<td>7946</td>
<td>47</td>
<td>17</td>
<td>47</td>
<td>40</td>
<td>These results are somehow concerning, in that there is a strong focus on BECCS in a scenario that seems to be least able to afford the land resource for it, among all scenarios. It might be interesting to elaborate more on alternative scenario designs, i.e. where the amount of BECCS does not vary that much but is rather constrained to more constant, sustainable values and complemented by other mitigation options. Nevertheless, it would be good to highlight the importance of mitigation portfolios at this point. [Jasmin Kemer, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Accepted - This section aims to display different land-based mitigation portfolios and hence is not based on diagnostic bioenergy scenarios only. We adapted this section to highlight the importance of mitigation portfolios even more.</td>
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<tr>
<td>6911</td>
<td>47</td>
<td>17</td>
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<td>40</td>
<td>Be more from this paragraph is rather confusing for policy makers. Four different strategies are sketched, but how should policy makers choose between them? It is important to assist the reader in identifying what would be the best strategy for what circumstances. [Bert Metz, Netherlands]</td>
<td>Accepted - references are made to synergies and trade-offs which the various strategies can provide. These should help decisionmakers understand which strategy would be preferred</td>
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<td>12753</td>
<td>47</td>
<td>20</td>
<td>48</td>
<td>11</td>
<td>This entire paragraph and figure 2.19 use the terminology “scenario 1”, “scenario 2”, “scenario 3”. Are these base don the SSIPs, which are the basis for the rest of the results? If not, then what exactly are these scenarios? [Vassilis Dasogiou, Netherlands]</td>
<td>Taken into account - these scenarios have been selected based on their archetypical characteristics for various land mitigation strategies. They are in part based on the SSIPs, but this is only coincidental, because the SSIPs show an important variation across socioeconomic assumptions and strategies.</td>
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<tr>
<td>10579</td>
<td>47</td>
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<td>Is it to be understood that dedicated bioenergy crops are considered agriculture? If this is the case, I must be considered that a bioenergy crop can include woody biomass forestry plantations which by definition are not considered agriculture, but different silvicultural package. Other bioenergy crops (such as jatropha curcas) are oily crops or Agricultural Organic Waste (AOW) which demand a different technological package to be processed into energy. It would be better to include bioenergy crops of woody biomass within the use of forest biomass, or to speak of dedicated forest biomass. [Elmer Broacho-Elizondo, Costa Rica]</td>
<td>Accepted - No, the scenarios did not account for albedo. We added biophysical effects (albedo) to further quantify the importance of mitigation portfolios even more.</td>
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<td>8004</td>
<td>47</td>
<td>29</td>
<td>47</td>
<td>30</td>
<td>By 2050, global food production is reduced to 19%?? Shouldn’t it be by 10%? [Robert Shapiro, United States of America]</td>
<td>Taken into account - this was a typo</td>
</tr>
<tr>
<td>16210</td>
<td>47</td>
<td>29</td>
<td>47</td>
<td>31</td>
<td>How can this be right--global food production is reduced to 19%?? Shouldn’t it be by 10%? and the world population will survive? Is the phrasing here correct? [Michael McCauley, United States of America]</td>
<td>Taken into account - this was a typo</td>
</tr>
<tr>
<td>10492</td>
<td>47</td>
<td>29</td>
<td>47</td>
<td>31</td>
<td>I suppose that global food production is reduced with, or by 10%, not to 10% as written in the text. [Hendrik Leefhets, Norway]</td>
<td>Accepted - we corrected.</td>
</tr>
<tr>
<td>7444</td>
<td>47</td>
<td>37</td>
<td>48</td>
<td>10</td>
<td>Are you mean for the first line a new scenario, Scenario 4? Please consider presenting the characteristics of this scenario in a manner similar to the one provided for scenario 1-3 in figure 2.5. One could think that this is a scenario based on SSIP, but then again Scenario 3 is also based on SSIP: if the scenario is based on SSP5 og SSP4, please consider providing the characteristic of the SSP. It would be useful to have the characteristics of all the five SSPs presented early in this chapter, as all are referred to later. [Sylvie Christensen, Norway]</td>
<td>Accepted - references are made to synergies and trade-offs which the various strategies can provide. These should help decisionmakers understand which strategy would be preferred</td>
</tr>
<tr>
<td>7947</td>
<td>47</td>
<td>38</td>
<td>47</td>
<td>40</td>
<td>Did the scenarios have constraints with regards to AR7 i.e. did the design make sure only AR options that do not lead to detrimental changes in albedo were considered? [Jasmin Kemer, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Accepted - No, the scenarios did not account for albedo. We added biophysical effects (albedo) to the overview table of potential mitigation measures in Section 2.3</td>
</tr>
<tr>
<td>9652</td>
<td>48</td>
<td></td>
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<td></td>
<td>Figure 2.19: This figure is important to grasp 4 scenarios, but illustration is not big enough to understand right and below figures of each box. [Shuzo Nishioka, Japan]</td>
<td>Accepted - references are formatted automatically by the reference software and will be harmonized</td>
</tr>
<tr>
<td>9679</td>
<td>48</td>
<td></td>
<td></td>
<td></td>
<td>Figure 2.19: This figure is important to grasp 4 scenarios, but illustration is not big enough to understand right and below figures of each box. [Shuzo Nishioka, Japan]</td>
<td>Accepted - we modified this section accordingly.</td>
</tr>
<tr>
<td>4544</td>
<td>48</td>
<td></td>
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<td></td>
<td>Fig 2.19 - Add index format to “Wm-2 “(B) [Radim Tojascz, Czech Republic]</td>
<td>Accepted - editorial and layout consistency will be ensured for the final draft</td>
</tr>
<tr>
<td>10336</td>
<td>48</td>
<td></td>
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<td></td>
<td>Figure 2.19: How this pathways types fit with the pathways indicated right at the start of the chapter? [Maria Jose Sanz Sanchez, Spain]</td>
<td>Not relevant anymore as the pathways at the start of the chapter have been removed</td>
</tr>
</tbody>
</table>
IPCC WGI SR15 First Order Draft Review Comments And Responses - Chapter 2

Comment No 12944
From Page 48
From Line 49
To Page 49
To Line 49
Comment 2.3.4.4.1. tails of mitigation portfolios as a new concept but in AR5 it was used quite often that mitigation portfolio can have system wide economy wide impact and SPM also developed figures to show how across sectors investment needs can be expected to change under various concentration targets. It needs to be placed in right perspective instead of posing this as a new category. Continuation of AR5 is needed. [Jayashree Roy, India]
Response Accepted - a reference and link to AR5 WGI SPM was included

Comment No 13327
From Page 48
From Line 1
To Page 10
To Line 10
Comment Figure 2.19. Plot background colours are distracting - drawing attention away from the data. Suggest removing background colours (can retain colour for the Scenarios heading banners) [Jonard Harrold, United Kingdom (of Great Britain and Northern Ireland)]
Response Accepted - background colours have been removed

Comment No 10579
From Page 48
From Line 1
To Page 10
To Line 10
Comment Figure 2.19. An increase in relation to baseline indicates teh increase of energy crops. Woody energy crops, which would not compete with agricultural area can be a freesty activity. If a new conceptual over/energy crops/ and these compete with agricultural land. Bio mass feedstock from forestry activities are an additional important feedstock. To account for this we added and analysed scenario 2 where forest area in comparison to the other scenarios is strongly increasing for mitigation purposes (feedback provision).
Response Noted. Dedicated woody 2nd generation energy crops (such as poplar, eucalyptus) are included in the category over/energy crops/ and these compete with agricultural land. Biomass feedstock from forestry activities are an additional important feedstock. To account for this we added and analysed scenario 2 where forest area in comparison to the other scenarios is strongly increasing for mitigation purposes (feedback provision).

Comment No 1946
From Page 48
From Line 1
To Page 10
To Line 10
Comment Background colour behind figure makes this figure harder to read and understand [Andrew Smedley, United Kingdom (of Great Britain and Northern Ireland)]
Response Accepted - background colours have been removed

Comment No 17478
From Page 48
From Line 3
To Page 10
To Line 10
Comment [Tom Gabriel Johannsen, Norway] Editorial
Response Accepted - background colours have been removed

Comment No 17518
From Page 48
From Line 3
To Page 10
To Line 10
Comment [Angela Morel, Norway] Editorial
Response Accepted - background colours have been removed

Comment No 6159
From Page 48
From Line 3
To Page 10
To Line 10
Comment Figure 2.19. Existing contradictory labelling in a figure caption, e.g. allways refer to the different sub-figures. But here they are used to refer to the 3 sub-parts of each of the 4 subfigures. Refer to describe the 4 scenarios first as a.b.c.d then the sub-figures as i.e. ii. iii. iv. [Philip Trentg, United Kingdom (of Great Britain and Northern Ireland)]
Response Accepted - the layout and description of the figure has been updated

Comment No 5912
From Page 48
From Line 3
To Page 10
To Line 10
Comment Why situation is different in different scenarios? It undermines the credibility of these analyses. Moreover, I personally do not like the idea of using year 2010 as the first year of these scenarios. [Tuomo Keilola, Finland]
Response Taken into account - Due to the uncertainty in LU, models differ in the amounts the sequestration in land use sector in the SSP5 run in figure 2.20 by 2050 is around 20 GtCO2/yr, leading to net CO2 emissions of minus 12 Gt/yr. These are extremely high numbers, whose realism could be questioned. It would be important to discuss this or, even better, put limits on CO2 sequestration in the land use sector in the SSP5 run in figure 2.20 by 2050.

Comment No 1183
From Page 48
From Line 10
To Page 11
To Line 11
Comment Here needs to be a better communication between C and D to avoid undue overlaps when discussing mitigation measures and their implications for non-climate policy objectives. Ch 5 discusses synergies and trade-offs of M measures with SDGs in section 5.4. Link to 5.4 needed in paragraph p. 49, l5-23 [Petra Tschakert, Austria]
Response Noted

Comment No 1184
From Page 48
From Line 15
To Page 11
To Line 11
Comment A clear distinction between individual mitigation ‘measures’, ‘portfolios’ and ‘pathways’ would be helpful here and in other chapters. We understand measures to be individual M response options, portfolios to be combinations of individual M response options (or clusters) and pathways to be the dynamic implementation of an individual response option, or the interplay between M measures within a portfolio, over time. This should either be discussed here, or in Ch 1 on Scenario and pathways. [Petra Tschakert, Austria]
Response Accepted - should be discussed in the Chapter 1 box on scenarios and pathways

Comment No 4777
From Page 48
From Line 16
To Page 23
To Line 23
Comment The purpose of section 2.3.4.4.1 is not clear. The link with societal objectives is not elaborated in detail. [Elena Georgopoulou, Greece]
Response Noted

Comment No 9646
From Page 48
From Line 21
To Page 21
To Line 21
Comment I think it's not necessary to put two times the word "model" [Olga Alcaraz, Spain]
Response Accepted - one "model" was removed

Comment No 4545
From Page 48
From Line 21
To Page 21
To Line 21
Comment Pg 2.20 - Add italic format to "CO2" and "Wm-2" (2x) [Radim Tolasz, Czech Republic]
Response Accepted - editorial and layout consistency will be ensured for the final draft

Comment No 6612
From Page 49
From Line 23
To Page 23
To Line 23
Comment This paragraph addresses two different issues (1) implications for other non-climate and sustainability issues; (2) the implications of different socio-economic baselines (SSPs). It would be much more legible to deal with issue (2) here and leave the discussion on the implications of other and SD issues to chapter 5 (not section 2.5 that should be moved to chapter 5) [Petra Tschakert, Austria]
Response Taken into account - Due to the uncertainty in LU, models differ in the amounts the sequestration in land use sector in the SSP5 run in figure 2.20 by 2050 is around 20 GtCO2/yr, leading to net CO2 emissions of minus 12 Gt/yr. These are extremely high numbers, whose realism could be questioned. It would be important to discuss this or, even better, put limits on CO2 sequestration in the land use sector in the SSP5 run in figure 2.20 by 2050.

Comment No 10337
From Page 49
From Line 49
To Page 49
To Line 49
Comment Due, but here these implications can be properly assessed at the state of the implementation in this chapter, rather than in the previous one. Other words how to make the right choice? - is the key question. What is preventing this, can we link this to identified gaps at the end of the chapter more closely? [Maria Jose Sanz Sanchez, Spain]
Response Taken into account - we highlight that being aware of these links and of their interactions can be an important first step.

Comment No 7053
From Page 49
From Line 6
To Page 6
To Line 6
Comment It does not seem accurate to label as “recently integrated studies” a reference from 2014 that only includes literature before e.g. 2012. [Joyashree Roy, India]
Response Taken into account and partially rejected - The SSPs indeed show differences in the near term depending on socio-economic assumptions, as well as policy assumptions. SSP5 assumes not only high energy demand, but also a slower phase-in of climate policy than SSP1. Both are leviers on which policymakers can act. We have tried to make this clearer in the paragraph. The restructuring between chapters was not possible, but part of this discussion has been moved to Section 2.5.3. Furthermore, this section has been condensed.

Comment No 13210
From Page 49
From Line 7
To Page 7
To Line 7
Comment The sentence reads as if ‘decarbonisation’ and ‘energy efficiency’ are comparable. This could be rephrased since energy efficiency is one way of realising a decarbonisation. [Deger Saygin, Turkey]
Response Taken into account - we have included more adequate “recent” references

Comment No 8005
From Page 49
From Line 11
To Page 12
To Line 12
Comment He highlights the importance of mitigation portfolio choices, particular when should be ‘particularly when’ or ‘in particular when’ [Robert Shapiro, United States of America]
Response Noted

Comment No 13211
From Page 49
From Line 20
To Page 20
To Line 20
Comment It would be important to mention which emissions are difficult to mitigate from which sectors and what options would be required to deal with them. [Deger Saygin, Turkey]
Response Rejected - while important it does not seem to add to the point made in this subsection

Comment No 6160
From Page 49
From Line 20
To Page 20
To Line 20
Comment Change ‘mitigation’ to ‘mitigate’ [Philipp Sargen, United Kingdom (of Great Britain and Northern Ireland)]
Response Rejected - the suggestion does not seem to be correct either

Comment No 13328
From Page 49
From Line 24
To Page 24
To Line 24
Comment Figure 2.20. Use a legend to explain the meaning of the symbols in the plot - this should be easier for readers than the explanations in text. [Jonard Harrold, United Kingdom (of Great Britain and Northern Ireland)]
Response Taken into account - we agree that both the real-world achievability and desirability of such large amounts of CDR vary strongly between scenarios. In the SSP5 we discuss several scenario options. Chapter 4 provides an assessment of the potential of measures.

Comment No 10560
From Page 49
From Line 24
To Page 25
To Line 25
Comment Figure 2.20 shows a concerning AFOLU, a significant emission reduction from 2030 to 2050 (1.5°C reduction scenario), however the range on reduction to 2050 is too ample. The scenarios in the bottom right panel indicate a significant contribution to emission reduction from the AFOLU sector (purple dots, purple line). Could it be possible to specify this beyond refering to technological use?. Is there a shift in land use policies involved? [Elemer Briceño-Elizondo, Costa Rica]
Response Taken into account - this section only speaks to the portfolio of measures and how they fit together. Details about the land-use sector transition are provided in Section 2.4

Comment No 17479
From Page 49
From Line 26
To Page 26
To Line 26
Comment [Tom Gabriel Johannsen, Norway]
Response Noted

Comment No 17519
From Page 49
From Line 26
To Page 26
To Line 26
Comment [Angela Morel, Norway]
Response Noted
It is not clear from the text whether the investment needs are not or additional to baseline. Please clarify what the values refer to. [Değer Saygin, Turkey]

The section on 'investments' will be key part of the chapter, however, as it currently reads it is not very easy to follow. Therefore authors may consider editing the text and focusing on the key results. [Değer Saygin, Turkey]

It is important to clarify the system boundaries of what 'supply side' includes (e.g. Oil refineries, T&D network, power plants etc) and it would also be important to mention the investments in the demand side. Please also provide more recent data. [Deger Saygin, Turkey]


The message from this section seems to be that investments needs to be increased drastically both at the supply and the demand side. This is contrary to most other studies (see for instance the Better Energy from the Energy Transition Commission) that indicate it is more a matter of shifting investments (from fossil fuel exploitation, production and usage to renewable energy supply and demand side efficiency) than a matter of large increases. this needs to be corrected. When presenting numbers for the amounts needed, please add the baseline numbers for comparison. [Barth Mütz, Netherlands]

Do not cite any investment totals from IAMs since they are wrong, in part for the reasons cited above. Mark Jacobson and others have some numbers that are much lower. [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)]

Do not quote, cite, or distribute page 81 of 107.

Comment No  From Page  To Page  Comment  Response
13214  50 51  It is not clear from the text whether the investment needs are not or additional to baseline. Please clarify what the values refer to. [Değer Saygin, Turkey] Taken into account - The numbers are total. Baseline numbers are now also shown, in order to make it clearer.
13215  50 51  The section on 'investments' will be key part of the chapter, however, as it currently reads it is not very easy to follow. Therefore authors may consider editing the text and focusing on the key results. [Değer Saygin, Turkey] Editorial - We have simplified the text.
6161  5 5 5  Change "good to half" to "highly uncertain" [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)] Accepted
14180  50 51 29 It might be useful to elaborate a bit more the investment analysis for carbon mitigation. For example, there is no clear consideration about the different interest rates, oil price and GDP growth trends used, which can significantly distort a balanced comparative analysis. [Alexandre Struppa, Brazil] Rejected - The assessment of interest rates, oil price and GDP growth trends is outside the scope of this Special Report focussing on 1.5°C. It might be part of the AR6.
4778  50 51 29 Th regional distribution of investments needed should also be discussed here. [Elina Georgopoulou, Greece] Taken into account - A small discussion of investment needs at the regional level has been added to the text.
20318  50 50 14 Besides the challenge to scale-up investment in low-carbon technologies, there is also the risk of creating stranded assets, especially in a 1.5 degree scenario. The IEA/RENA study "Perspectives for the Energy Transition" estimates for a 66% 2°C scenario that "In the power sector, stranded assets in the 66% 2°C Scenario would total USD 320 billion worldwide over the period to 2050 in terms of fossil fuelled power plants that would need to be retired prior to recovering their capital investment." [Marina Gomez, France]

Accepted - A sentence has been added to make the point that there is a risk that some unvaluated fossil investments that will be made over the next few years – or those made in the last few – will need to be "stranded" at some point in the future (i.e., retired prior to fully recovering their capital investment).


5178  50 51 34 This section obscures the investment trends of the energy sector over the past 10 years and confuses the reader. It conveys the incorrect impression that there is no data. Chapter 2.3.4.4 must therefore be completely rewritten in the next draft to recommend to use publicly available data such as REN21 Renewable Energy Status Reports, Bloomberg New Energy Finance and the IEA. [Steven Tsakas, Australia]

Accepted - We now cite the IEA's 'World Energy Investment 2016' report and a recent report by the Fraunhofer ISE/UNEP Centre/BNEF (2017), which looks at global trends in renewable energy investment. The "data" from these reports are in many cases only estimates, calculated in a similar way as the global models do (i.e., known capacity installations multiplied by estimated capital costs per capacity unit).

9036  50 50 18 The statement, 'literature on climate change mitigation investments is sparse, with most detailed literature still focusing on 2°C pathways is valid in a relative sense but may be modified to represent such scenarios as the ‘Beyond 2 degrees Scenario – BD2050’ of the Energy Technology Perspectives 2017 (ETP 2017)” and other scenarios from the scientific literature on renewable energy systems. The need to double zero-carbon shares in the energy system every 5.5 years as paramount for scenarios with a fair chance of compliance with 1.5°C targets, which be emphasized based on the reference: ’Roschel, J., Gaffney, O., Rogel-Joseph, J., Meinshausen, M, Nakićenovic, N, Schönhuber, H. A roadmap for rapid decarbonization. Science, Vol. 355, Issue 6331, pp. 1269-1271, 2017.’ The importance of energy system transitions may further be emphasized by quoting ’Roigel, J., Luckner, G., Fleitz, R., Kriegler, E., Schartel, M., Krey, V., Rahl, K., Energy system transformations for limiting end-of-century warming to below 1.5°C. Nature Climate Change, Vol. 5, pp. 519-27, 2015.” [SW HOLKIS, Turkey]

Accepted - We now cite the IEA's 'World Energy Investment 2016' report and a recent report by the Fraunhofer ISE/UNEP Centre/BNEF (2017), which looks at global trends in renewable energy investment. The "data" from these reports are in many cases only estimates, calculated in a similar way as the global models do (i.e., known capacity installations multiplied by estimated capital costs per capacity unit).

3169  50 50 20 Most IAMs leave out a lot of the investments required for a full transition to a highly efficient energy system, and a complete transition to renewable energy. This should be acknowledged here, implying that any investment total that is derived by IAMs is far too low. Investments that I believe are typically omitted are: the incremental costs of high efficiency end-use technologies, the costs of converting all vehicles to electric vehicles and mass transit, the costs of adaptation to climate change, etc... [Richard Rosen, Germany]

Accepted - An acknowledgement of this limitation has been made. Incidentally, the McCollum et al. (in review) paper shows that when put on a level playing field the investment estimates from the IEA and IRENA are actually on the low end of the range of the IAMs (when comparing 2C scenarios from the IAMs and IEA/IRENA).

7055  50 50 34 Our work agrees on demand side investments being uncertain and on that profitability may not be a solid parameter to determine investments in energy efficiency (Mate E, Wannerer J, Nik V, Sasic Katagasida A. Mitigation potentials from building retrofits – A techno-economic study of climate change scenarios in Sweden (in review).) [Erka Met溢价, Sweden]

Note

3170  50 50 39 Do not cite any investment totals from IAMs since they are wrong, in part for the reasons cited above. Mark Jacobson and others have some numbers that are likely to be closer to the truth. (10-15% of global GDP per year to avoid overshoot?) [Richard Rosen, Germany]

Rejected - Based on the evidence available to the authors and estimates of both the IEA and IAMs, investment totals do not seem to be fundamentally wrong.

3171  50 50 10 This report should focus on incremental investment totals, and not the total scale in reference cases. Also, the report needs to differentiate between the investment requirements of a 1.5 degree non-overshoot versus overshoot scenarios, since the former will need to be much higher, and earlier in time. [Richard Rosen, Germany]

Taken into account - In as far as data is available in the literature. We now provide an assessment of current levels of investments compared to projected investments to 2030 and 2050.

17426  50 50 18 How about saying something about last seven years? If the trend has been approximately the needed one? [Tuomo Kalliokoski, Finland] Accepted - a statement on recent trends has been added.

12313  50 50 38 If historical investments were between USD 0.7-1 trillion, it would not be a ‘significant upscaling’ to reach USD 1.1 trillion for the period 2010-2050. [Değer Saygin, Turkey]

Accepted - We now cite different numbers from a newer study. The sentence has been reformulated.

Do Not Quote, Cite, or Distribute Page 81 of 107
Comment No | From Page | From Line | To Page | To Line | Comment | Response
--- | --- | --- | --- | --- | --- | ---
5179 | 51 | 40 | 50 | 42 | Incorrect statement. Current investments in energy systems are available in great detail. IEA, Bloomberg New Energy Finance and REN21 report regularly about investment by technology and region. (see above) [Sven Teske, Australia] | Taken into account - We have added a statement to the text to clarify that historical investment numbers are estimated and are uncertain. This is a common misconception: that investment “data” are as certain as new capacity installations or energy flows. For some sectors, the data is known, but for others it is not. Much data is not reported publicly by companies, and therefore has to be estimated ex-ante. This is what the both the IEA and the global models do. See the “Methodology Annex” to the IEA’s “World Energy Investment 2017” report for a brief discussion.
4548 | 51 | 2 | 51 | 2 | Fig 2.21. Add index format to “CO2” (s) and “Ym-2” (s) [Radim Tonse, Czech Republic] | 
4695 | 51 | 1 | 51 | 1 | Figure 2.21: top two Figures y-scales should be identical to better understand how the investment change. [Ville Tikuit, Finland] | Editoral
6690 | 51 | 1 | 51 | 2 | “The average investments in nuclear 1 are estimated to be similar,” based on Fig 2.21 this claim is false, as the investments in nuclear in 1.5C scenarios is approx. double of the investment in 2C scenarios. [Ville Tikuit, Finland] | Taken into account - New data has been added, so this comment no longer applies.
5580 | 51 | 12 | 51 | 15 | Figure 2.21 is misleading, Investment 2010 to 2030 – the year of writing is 2017, year of planned publication is around 2020. So the presented data is neither a projection, nor is it correct. Request: Delete figures and update data to 2015 or 2016 data (available) [Sven Teske, Australia] | Taken into account - A new figure has been added, and the base-year data discussion has been updated.
5913 | 51 | 12 | 51 | 29 | The investment for CO2 transport and storage (CCS T&D) is shown in the figure. Does this mean that the CO2 capture investment is not included? It would have been much more informative if the total cost of CO2 capture, transport and storage (CCS) could be presented instead. [Aage Stangeland, Norway] | Taken into account - the figure has been redesigned for clarity
3172 | 51 | 12 | 51 | 29 | These figures are very unclear and confusing as to what is or is not included. Also, to better understand investment totals the reader needs to know all the capital cost assumptions of the technologies included in the figures, and what is left out. And the totals seem far too low… so these need to be checked is such a figure is used again in the second draft. [Richard Rosen, Germany] | Accepted - the figure has been redesigned for clarity
17480 | 51 | 1 | 51 | 16 | “The range 49-58 is based on Rogelj et al,” which is correct, and is based on available literature to discuss these aspects. | Accepted - unfortunately no similar data is available for the demand side. We highlight the difficulties for these estimates in the text
17520 | 51 | 1 | 51 | 16 | “The range 49-58 is based on Rogelj et al,” which is correct, and is based on available literature to discuss these aspects. | Accepted - unfortunately no similar data is available for the demand side. We highlight the difficulties for these estimates in the text
5181 | 52 | 1 | 52 | 28 | The lock-in effect is certainly extremely important for the phase-out of fossil fuels later on. In that context, the author(s) must add the aspect of possible “lock-in-effects” for CCS technologies as well. New build power plants with a theoretical CCS retrofitting option, might even fast track new coal power plants. Whether or not CCS will be added is very uncertain. In the case of the coal power plant in Moomburg/Hamburg for example, the operator Vattenfall simply dropped that promise after they got the construction permit. As CCS is extremely expensive (far more than renewables), how can investors be forced to invest in CCS later on? Request: The Lock-in effect applies for CCS and needs to be discussed in this part. [Sven Teske, Australia] | Taken into account - the figure has been redesigned for clarity
3173 | 52 | 1 | 52 | 42 | The issue of carbon lock-in is very important, but this section is very unclear, almost unreadable, and far too vague. It needs to inform policy makers what actions, and by when various actions, need to be taken to avoid carbon lock-in in different sectors of the economy under different scenarios. For example, it needs to tell policy makers how fast gasoline and diesel vehicles need to be phased out given their expected usable lifetimes to achieve a 1.5 degree non-overshoot scenario. Probability, the answer to this specific question is “phase out needs to begin almost immediately at 5% or more per year” [Richard Rosen, Germany] | We agree that this would be important information, but have not found literature that would address these particular issues.
9031 | 52 | 3 | 52 | 29 | What about IEA ETP and WEO. They discuss lock in at the detailed level? Any reason they are not assessed here? Not in the scenario database? [Angelique Mentel, Norway] | Time and capacity constraints of the author team
9032 | 52 | 3 | 52 | 29 | How much is retired, at what cost? [Glen Peters, Norway] | Good questions, yet we didn’t find literature providing this information.
10442 | 52 | 3 | 52 | 3 | Less ambitious CO2 reductions in the near term imply “or less ambitious CO2 reduction in the near term implies” [Jonathan Lynn, Switzerland] | 
7315 | 52 | 3 | 52 | 7 | Delete the word “lock-in” [Frank Kliedbit, Austria] | Editoral
740 | 52 | 23 | 52 | 23 | Reads “starting from NDC levels” perhaps it would read “starting from Nationally Determined Contributions (NDC) levels” [Michele Kinn, United Kingdom (of Great Britain and Northern Ireland)] | Accepted - lock-in is a widely used term that is appropriately used here
3174 | 52 | 30 | 52 | 30 | This report does not consider at all available 1.5 degree pathways. More have to be pulled from the literature, and this report should not rely on those scenarios available in the IASA database. [Richard Rosen, Germany] | More are now available in the database. The authors are always welcoming suggestions for further literature.
6915 | 52 | 30 | 52 | 30 | A reference to the UNEP Emissions Gap Report 2016 (and 2017 which is currently being written) is needed, as this study covers all available analyses of NDC 2030 emission levels (while the UNFCCC secretariat is just one analysis). Presenting the median numbers in addition to the range is needed. [Bert Metz, Netherlands] | A dedicated NDC box with these references is included in Chapter 4
3710 | 52 | 31 | 52 | 32 | Many mitigation NDCs are specified by countries only up to 2025. You need to make clearer that modelers or authors of literature assume additional assumptions, e.g. extrapolating trends beyond 2025. “Implicit goes in this direction, but the next sentence then starts “ altogether“ and reads too definitive. Make clearer that additional assumptions are made by analysts, and separate clearly from what governments have put forward [Herbert Winkler, South Africa] | This should be made clear in the dedicated box on NDCs in Chapter 4
741 | 52 | 32 | 52 | 32 | Reads “implies by the Nationally Determined Contributions (NDCs)“ perhaps it should now read “implies by the NDCs” [Michele Kinn, United Kingdom (of Great Britain and Northern Ireland)] | Noted
9816 | 52 | 35 | 52 | 35 | The range 49-58 is based on Rogelj et al., which is correct, and is based on 10 studies, including the UNFCCC sec. 2016, but it already includes Ky et al. In line 36 it is mentioned that the range has not changed due to new studies. This is assessed each year in the UNFCCC secretariat and is based on 10 studies. [Sven Teske, Australia] | A dedicated NDC box with these references is included in Chapter 4
9817 | 52 | 35 | 52 | 35 | The range 49-58 is based on Rogelj et al., which is correct, and is based on 10 studies, including the UNFCCC sec. 2016, but it already includes Ky et al. In line 36 it is mentioned that the range has not changed due to new studies. This is assessed each year in the UNFCCC secretariat and is based on 10 studies. [Sven Teske, Australia] | A dedicated NDC box with these references is included in Chapter 4

### IPCC WGI SR15 First Order Draft Review Comments And Responses - Chapter 2

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<tr>
<td>6916</td>
<td>52</td>
<td>38</td>
<td>52</td>
<td>42</td>
<td>The finding that “the large majority of models failed to produce 1.5 compatible scenarios needs to be emphasised much stronger. There is a tendency to say that missing the 2030 emission levels compatible with the least cost scenario ‘makes it harder and more costly’ to stay below 1.5C (or 2C). And policy makers are eager to believe that they can still pull off the policies to meet the 1.5C (or 2C). This is misleading, as the results of modeling attempts show. It is time to be honest: if the 2030 emission levels consistent with 1.5C (and 2C) are not met, for all practical purposes they will not longer be possible. This message needs to figure prominently in the policy makers summary of the report. [Bart Metz, Netherlands]</td>
<td>This aspect is now also highlighted in the ES.</td>
</tr>
<tr>
<td>3175</td>
<td>52</td>
<td>46</td>
<td>52</td>
<td>65</td>
<td>Another reason why this report has to present and discuss non-overshoot scenarios is because these will involve less uncertainty than the longer term overshoot scenarios. This is because the non-overshoot scenarios will have to reach a stable temperature goal well before 2050, depending on the temperature level set as the goal. [Richard Rosen, Germany]</td>
<td>Noted - Non-overshoot scenarios have appeared in the recent literature and are now assessed.</td>
</tr>
<tr>
<td>5182</td>
<td>53</td>
<td>3</td>
<td>53</td>
<td>6</td>
<td>SSP1 contains high shares of technologies which have proven to be market values. Thus a specific renewables and energy efficiency pathway is required to assess how a climate mitigation pathway with market driven and proven technologies might look like. The current SSP1 category is insufficient. [Sven Teike, Australia]</td>
<td>Noted - The assessment is based on literature and scenarios much broader than SSP1.</td>
</tr>
<tr>
<td>5183</td>
<td>53</td>
<td>6</td>
<td>53</td>
<td>6</td>
<td>Reference required to back up this statement. Recommend to use a reference from a scientist which is not part of the IPCC author team. Definition of “high technological progress rate” missing [Sven Teike, Australia]</td>
<td>This is not clear to us which statement is meant.</td>
</tr>
<tr>
<td>3176</td>
<td>53</td>
<td>19</td>
<td>66</td>
<td>26</td>
<td>This entire section will have to be shortened and completely revised to include clear comparisons between the basic kinds of scenarios that need to be included: 1.5 degree non-overshoot scenarios, 1.5 degree overshoot scenarios, and various 2.0 degree scenarios. [Richard Rosen, Germany]</td>
<td>Noted - The section has been re-formatted and includes the requested comparison.</td>
</tr>
<tr>
<td>6917</td>
<td>53</td>
<td>21</td>
<td>53</td>
<td>22</td>
<td>Here it is said that “1.5C pathways are brought to zero between 2040 and 2060” elsewhere different texts appear, i.e. by 2050 or shortly thereafter. Make sure there is consistency throughout the chapter. This is possibly caused by the different numbers attached to 1.5 scenarios with 85% versus 65% probability; keeping these different probability levels separate can help eliminate the inconsistency. [Bart Metz, Netherlands]</td>
<td>Accepted - The chapter has been cross-checked for internal consistency.</td>
</tr>
<tr>
<td>21139</td>
<td>53</td>
<td>31</td>
<td>53</td>
<td>34</td>
<td>Would note that SOLPs are crucial in the near-term to reduce the rate of warming as well as slowing or potentially avoiding passing thresholds for climate feedbacks and tipping points if the 1.5C guardrail is passed - cite Xu and Ramathan 2017. Well Below 2C. Mitigation strategies for avoiding dangerous to catastrophic climate changes, PNAS, doi/10.1073/pnas.1618411114. Diffnoud et al., 2015. Catalogue of abrupt shifts in intergovernmental Panel on Climate change models, PNAS, doi/10.1073/pnas.1514511112 [Nathan Borgford-Panyel, Switzerland]</td>
<td>Rejected - This Special Report focuses on mitigation in the context of 1.5°C. The issues raised by the reviewer (the rate of temperature increase) is not a key assessment topic here and thus outside the scope of this Special Report. The reviewer provides no evidence that the tipping points referred to would be more affected by the rate of change than the absolute level of warming.</td>
</tr>
<tr>
<td>10663</td>
<td>53</td>
<td>31</td>
<td>53</td>
<td>34</td>
<td>Reducing SCFs is crucial in the near-term to slow the rate of warming and to stave off triggering of self-reinforcing feedbacks and surpassing irreversible tipping points that could be compromised if the 1.5°C threshold is exceeded (Xu and Ramathan 2017. Well Below 2C. Mitigation strategies for avoiding dangerous to catastrophic climate changes, PNAS, doi/10.1073/pnas.1618411114. Diffnoud et al., 2015. Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change models, PNAS, doi/10.1073/pnas.1514511112) [Kristin Campbell, United States of America]</td>
<td>Noted</td>
</tr>
<tr>
<td>2614</td>
<td>53</td>
<td>38</td>
<td>53</td>
<td>8</td>
<td>Perhaps mention the primary sources of the different gases and so subsequently how locked in they are? [Zo&quot;ha Shawoo, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Noted - CO2 emissions are attributed to sectors. We have added a discussion of CO2 commitment in Section 2.3.1. A detailed discussion of all sources for all gases is beyond the scope of this chapter and was given in AR5</td>
</tr>
<tr>
<td>21142</td>
<td>53</td>
<td>47</td>
<td></td>
<td></td>
<td>Mitigation of SOLPs could avoid 0.6°C of warming by 2050 and 1.2°C by the end of the century - cite Hu et al 2013. Mitigation of short-lived climate pollutants slows sea-level rise, Nature Climate Change doi/10.1038/nclimate1869. Xu and Ramathan 2017. Well Below 2C. Mitigation strategies for avoiding dangerous to catastrophic climate changes, PNAS, doi/10.1073/pnas.1618411114. Diffnoud et al., 2015. Catalogue of abrupt shifts in Intergovernmental Panel on Climate change models, PNAS, doi/10.1073/pnas.1514511112 [Nathan Borgford-Panyel, Switzerland]</td>
<td>Rejected - It has been an editorial decision to present mitigation measures in terms of what is consistent and required for 1.5°C pathways, rather than providing differences relative to hypothetical counterfactual baselines.</td>
</tr>
<tr>
<td>10664</td>
<td>53</td>
<td>47</td>
<td>53</td>
<td>47</td>
<td>SLCP mitigation will avoid 0.6°C of warming by 2050 and 1.2°C at 2100 (Hu et al 2013. Mitigation of short-lived climate pollutants slows sea-level rise, Nature Climate Change, doi/10.1038/nclimate1869. Xu and Ramathan 2017. Well Below 2C. Mitigation strategies for avoiding dangerous to catastrophic climate changes, PNAS, doi/10.1073/pnas.1618411114). Diffnoud et al., 2015. Catalogue of abrupt shifts in Intergovernmental Panel on Climate change models, PNAS, doi/10.1073/pnas.1514511112) [Kristin Campbell, United States of America]</td>
<td>Rejected - It has been an editorial decision to present mitigation measures in terms of what is consistent and required for 1.5°C pathways, rather than providing differences relative to hypothetical counterfactual baselines.</td>
</tr>
<tr>
<td>7445</td>
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<td>53</td>
<td>The information used here is from before the adoption of the Kigali amendment and from before any details of this amendment were considered. We think that the Kigali amendment needs to be covered in the text. Since many f-gases are included both cooling and warming species. The legend and caption have been clarified. [Bert Metz, Netherlands]</td>
<td>Accepted - Estimates of HFC projections under implementation of the Kigali Amendment have been added to the emissions overview figure in Section 2.3.1</td>
</tr>
<tr>
<td>4547</td>
<td>54</td>
<td>26</td>
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<td></td>
<td>Pg 2.22 - Add legend for bold black lines [Radim Volek, Czech Republic]</td>
<td>Added</td>
</tr>
<tr>
<td>9033</td>
<td>54</td>
<td>1</td>
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<td>Figure, why are things so similar to the top panel? [Klen Petras, Norway]</td>
<td>Because results from different models are similar for 1.5°C pathways, although some variation for CH4 and trop. C3 exist. Part of this is due to the fact that mitigation potentials are fully exploited in these scenarios.</td>
</tr>
<tr>
<td>13519</td>
<td>54</td>
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<td>54</td>
<td>1</td>
<td>The top figure is basically good. However, a figure for 2°C pathways should be also added. On the other hand, the bar charts for each scenario are not needed and they can be shown as error bars. [Toshihiko Takamura, Japan]</td>
<td>Accepted - Indirect aerosol effects are included in the overall category of aerosol effects, which includes both cooling and warming species. The legend and caption have been clarified.</td>
</tr>
<tr>
<td>7446</td>
<td>54</td>
<td>1</td>
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<td>4</td>
<td>We think that the legend box to especially the upper figure panel is somewhat inconsistent with the text in the figure caption where the substances are listed in a different way. Consider to reformulate the text in the figure caption since this may arouse many questions like: Since many f-gases are short-lived, should references be made to OTHER short-lived climate foras? Are organic and black carbon and indirect aerosol effects included under aerosols (green)? Both are organic carbon (negative RF) and black carbon (positive RF?) represented by the same bar? In addition consider to clarify what part of the text in the figure caption that relates to the lower panel. What is “other forcing” in the Y-axis in the lower panel? - is it the forcings mentioned above, including DD and D-AF? [Bert Metz, Netherlands]</td>
<td>Accepted - The table for the SLCP mitigation in 1.5°C and 2°C pathways is shown in the bottom panel.</td>
</tr>
<tr>
<td>17481</td>
<td>54</td>
<td>3</td>
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<td>E [Tom Gabriel Johansen, Norway]</td>
<td>Noted</td>
</tr>
<tr>
<td>17521</td>
<td>54</td>
<td>3</td>
<td></td>
<td></td>
<td>E [Angela Morell, Norway]</td>
<td>Noted</td>
</tr>
</tbody>
</table>
In addition to the information provided in Table 2.10, it would help to outline what the technology options to avoid these unmitigated emissions from these sectors and their availability are. It will help to compare the challenge for the CDR technologies.

I would suggest that there is a fourth question: “To what extent do current discussions of CDR at a later stage generate a “moral hazard” in terms of energy pathways for specific regions cannot describe the risks for climate mitigation if currently unproven CDR will be unsuccessful in the market. This situation has not all changed over the past decade, and the AR6 is seem to be unable to develop alternatives. (Sven Teske, Austria)

Noted. We did not elevate this to the level of framing questions, as this is beyond the scope of the sub-section, but we address it in the assessment by pointing out that the 1.5°C pathway literature does not support the notion that CDR availability would resolve the need for urgent and rapid mitigation.

There are energy pathways available which do not diminish and thus do not require CDR (Teske et al. 2015, Jacobson 2017, Byer 2016). To entirely rely on CDR, which is currently neither the market, nor close to market prices is irresponsible and scientifically flawed. I therefore urge, to implement SSPs category scenarios - all assumptions of SSPs - but without nuclear and CCS. Nuclear does not fit in high solar- and wind scenarios because of inefficiency (system-conflict). (Sven Teske, Austria)

I would be important to ensure that all statements regarding quantitative estimates are tied back to the fact that these are projections from models and not statements of fact that could otherwise be misinterpreted as such. This could be made clear, for example, by adding the phrase “under each modelled pathway” (or something equivalent) to the end of the sentence running from line 22 to line 34 on page 56. Otherwise statements here and elsewhere in the text that relate to model outputs might read as more definitive statements of established fact. (Jennifer Morgan, Netherlands)

Very complicated discussion. Needs to be simplified. Figure 2.24 that is referred to, is also way to complex to easily understand. Needs to be redesigned. Another problem is that 50% and 65% probability 1.5 scenarios are grouped, while they probably have quite different CDR characteristics. Would be important (as commented on above) to separate these classes of 1.5 scenarios. What is missing in these paragraphs is a critical discussion on the reality of huge amounts of cumulative CDR (like the 1200 Gt) in light of sustainability limitations and the need to limit the risk of betting on options that have not yet been implemented at scale. Some of that is on page 60, lines 4-10, so maybe that text can be moved here. (Bart Metz, Netherlands)

This whole section 2.4.2.1 is quite dense and needs reviewing (Jonathan Lynn, Switzerland)

*Reference to relevant sub-section of Section 4.3, which assessed the current status and development of the carbon dioxide removal (CDR) technology, should be added here. The readers, especially the policymakers, should be alerted that there is huge uncertainty about large scale deployment of the CDR technology as the assessment in Sub-sections 4.3.2.3, 4.3.6.1 - 4.3.6.3 have shown. The CDR technology is still immature as this stage, and the life cycle of power stations should also be taken into account when considering mitigation pathways. (Bai Ming Lee, China)

We need additional models as the reviewed ones do not reflect current scientific discussions and current energy market development. To entirely rely on CDR which is currently neither the market, nor close to market prices is irresponsible and scientifically flawed. I therefore urge, to implement SSPs category scenarios - all assumptions of SSPs - but without nuclear and CCS. Nuclear does not fit in high solar- and wind scenarios because of inefficiency (system-conflict). (Sven Teske, Austria)

We need to implement additional models as the reviewed ones do not reflect current scientific discussions and current energy market development. To entirely rely on CDR which is currently neither the market, nor close to market prices is irresponsible and scientifically flawed. I therefore urge, to implement SSPs category scenarios - all assumptions of SSPs - but without nuclear and CCS. Nuclear does not fit in high solar- and wind scenarios because of inefficiency (system-conflict). (Sven Teske, Austria)

Note that peak (based on the assumption that there are negative emissions). (Kenneth Möllersten, Sweden)

The oil-fired concept may be new to policymakers and so needs explained (Ieaw Jim, United Kingdom (of Great Britain and Northern Ireland))

The total amount of fossil geological and terrestrial carbon that is oxidized by human activity – is there a simpler way of expressing this? (Jonathan Lynn, Switzerland)

The integrated 1.5°C pathway literature is fully assessed and a large number of scenarios by a dozen and more models were reported in the database for the assessment.

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This is a misunderstanding. Figure 2.24 did not show fossil CCS, but total CCS comprising both bioenergy and fossil CCS. We have clarified this in the new draft.

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This is a misunderstanding. Figure 2.24 did not show fossil CCS, but total CCS comprising both bioenergy and fossil CCS. We have clarified this in the new draft.
The numbers should be GtCO2 cumulative not per year. [Jasmin Kemper, United Kingdom (of Great Britain and Northern Ireland)]

2015 59 4 59 21 perhaps mention technological barriers to CDR eg. time needed to develop the technology, effectiveness, cost, etc? [Zoha Shawoo, United Kingdom]

5187 59 4 59 9 The use of CDR to compensate for excess emissions in the past has received most attention in the literature since the Fifth Assessment Report (Fuss et al. 2014b) and was often connected to a concern that the expectation of CDR becoming available at large scale would postpone early mitigation efforts (Anderson and Peters 2016). Its importance is significantly increased in 1.5°C pathways compared to WB2C pathways, with CO2 budget drawdowns of 300-510 GtCO2 in the former compared to 80-200 GtCO2 in the latter (interquartile range from the scenarios available in the database to this assessment). To not react and simply continue with the same strategy is fundamentally scientifically flawed and irresponsible. [Sven Teske, Germany]

6226 59 12 61 4 As suggested above the discussion of CDR options need to happen earlier in the chapter (2.3.4) and be integrated with the CDR material from ch4 (to be moved to ch2). [Bert Metz, Netherlands]

Section 2.4.2.2 in total reads as too unqualified a listing of CDR-related proposals and could leave the impression that all are available and effective and that it is simply a matter of choice. In practice, some of those listed have already been studied in some considerable detail and largely discarded (see e.g. (Williams, P., & Bottle, R. (2016). Update on Climate Geoengineering in Relation to the Convention on Biological Diversity: Potential Impacts and Regulatory Framework. Technical Series No.84. Secretariat of the Convention on Biological Diversity, Montreal, 158 pages, https://www.cbd.int/publications/doc-db/hs-84-en.pdf), or even explicitly legislated against (ocean fertilisation, for example - for details of Resolutions and amendments under the London Convention and Protocol, see http://www.iom.int/en/OurWork/Environment5/CLPEmergingIssues/goe/geoengineering/Pages/default.aspx). [Kenneth Morgan, Netherlands]

While the importance of CDR is claimed to increase (see page 59), most references in this section are older than 10 years. Either update or delete this entire section. [Sven Teake, Australia]

This sentence needs at far too definitive a statement regarding availability, practicality, acceptability and effectiveness of CDR technologies. It is true to say that a number of approaches have been proposed; some of which have some research and development, but it is still not the case in any practical sense that "there are a number of approaches to actively remove carbon dioxide from the atmosphere" as stated on page 2.60. In his 2012 update of the 2009 Royal Society report, Shepard (2012) [DOI: 10.1098/rsta.2012.0189] reviewed five different CDR proposals (land-use management to protect or enhance land carbon sinks; the use of biomasses for carbon sequestration as well as a carbon neutral energy source; acceleration of natural (geological) weathering processes that remove CO2 from the atmosphere; direct engineered capture of CO2 from ambient air; and the enhancement of oceanic uptake of CO2, for example, by fertilization of the oceans with naturally scarce nutrients, or by increasing upwelling processes) and concluded that "of the CDR methods assessed, none has yet been demonstrated to be economic at a affordable cost, with acceptable side effects". This remains the case to date. If what is being conveyed in this sentence relates to approaches that have been applied as assumptions in models and projections, then this could be made more explicit. [Kenneth Morgan, Netherlands]


This information is incomplete. In addition to combustion BECCS can be based CO2 capture from gasification and fermentation. E.g., one reference that considers gasification and fermentation and which is from the same time period as the other two included isFliedt/Senken K, Yen J, Moreira JR (2003). Potential market niches for biomass energy with CO2 capture and storage - Opportunities for energy supply with negative CO2 emissions. Biomass and Bioenergy 25 (3):273-285. [Kenneth Mikkelsen, Sweden]

These references are really dated, giving no indication of progress they may have. May be better to remove from the reference list and suggest the topic be updated. These may be references for when first proposed, but it seems absurd to have them be the only references at the introduction of this idea. Other references to CDR/DAC in this paragraph seem similarly dated. [Michael MacCracken, United States of America]


This statement is too general and needs to be more specific. Not all potential CO2 utilisation products achieve sequestration of 100 years and more especially fuels, chemicals, polymers). There is currently a hot debate whether some of these options are mitigation or rather a distraction thereof (Chapter 4 seems to discuss this in more detail, so you might align/adapt from there.) [Janis Kemper, United Kingdom (of Great Britain and Northern Ireland)]

Agreed. We removed the introduction of CCU as a fifth group as it was tangential to the topic of the subsection.

What industrial products are locked away for centuries? [Glen Peters, Norway]

In chapter 2. None of these technologies are is compatible with sustainable development [Elenita Daño, Philippines]


There is a missing term after "ocean". [Serge PLANTON, France]

Comment Response

Partly accepted - Wording changed, ocean iron fertilization removed from the list, and suggested reference added in the subsection 2.3.4.2. We disagree with the notion that listed CDR measures other than OIF have already been largely discarded.

Accepted - Wording changed. See also response to comment 1564

Noted - Wording changed. CDR will be discussed on a technology by technology level in Chapter 4.

Accepted - Newer references have been added.

Accepted - Newer references have been added.

Rejected - CDR is part of 1.5°C pathways and therefore also part of the assessment of these pathways.

Rejected - CDR is part of 1.5°C pathways and therefore also part of the assessment of these pathways.

Accepted - Newer references have been added

Added

Added

Added

Addition

Addition

Addition

Addition

Added

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Added

Added

Added

Addition

Addition

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Addition

Added

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Noted - Wording changed. CDR will be discussed on a technology by technology level in Chapter 4.

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Added

Added

Added

Addition

Addition

Addition

Addition

Added

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Accepted - Wording changed. See also response to comment 1564

Noted - Wording changed. CDR will be discussed on a technology by technology level in Chapter 4.

Accepted - Newer references have been added.
<table>
<thead>
<tr>
<th>Comment No</th>
<th>From Page</th>
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<th>To Page</th>
<th>To Line</th>
<th>Comment</th>
<th>Response</th>
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<tr>
<td>6712</td>
<td>60</td>
<td>30</td>
<td>60</td>
<td>31</td>
<td>To say that &quot;some well below 2C and 1.5C pathways including additional CDR options such as Direct Air Capture are becoming available&quot; may well be true in a purely model-to-model sense (e.g. DAC can be added as a theoretical option to models), but in all practical senses, DAC is not available in a way that makes sense economically or energetically. As noted by Wilcox et al. (2017) [<a href="https://doi.org/10.1088/1748-9326/aaabfd">https://doi.org/10.1088/1748-9326/aaabfd</a>], &quot;reasonable opportunities&quot; for DAC remain limited to the production of only dilute CO2 streams with restricted applications, including enhanced oil recovery, for example. [Jennifer Morgan, Netherlands]</td>
<td>Rejected. We speak about 1.5°C pathways including DAC becoming available, not about DAC itself becoming available large-scale overnight.</td>
</tr>
<tr>
<td>916</td>
<td>60</td>
<td>31</td>
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<td>31</td>
<td>Some comment should be made on the state of development of direct air capture, its potential costs, and environmental issues. The danger is that it as seen as a convenient fix. [David Infield, United Kingdom of Great Britain and Northern Ireland]</td>
<td>Rejected. The costs, potentials and side effect discussion of CDR measures on a technology by technology basis is subject of Chapter 4. A reference to Chapter 4 is provided.</td>
</tr>
<tr>
<td>6713</td>
<td>60</td>
<td>31</td>
<td>60</td>
<td>32</td>
<td>There are clear reasons why some ocean-based CDR options have not been taken up in the literature on mitigation pathways (see comment 7 above): it is unlikely to be simply a matter of time before they are taken up in such literature. [Jennifer Morgan, Netherlands]</td>
<td>Agreed.</td>
</tr>
<tr>
<td>21160</td>
<td>60</td>
<td>35</td>
<td>60</td>
<td>36</td>
<td>why does the assessment not also cover reforestation and other ecosystem restoration? [David Cooper, Canada]</td>
<td>We have mentioned nature-based CDR in the general discussion, but cannot assess in the pathway literature as it is mostly not included in pathway modeling (except of reforestation which is included as part of afforestation). We have now noted this gap in integrated assessment modeling more clearly in Section 2.3.4. The underlying reason is the complexity of modeling the relevant processes, including nutrient cycles and soil carbon storage. The community is working on including these processes and nature-based CDR, but the work will not come in time for SR1.5.</td>
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<tr>
<td>20470</td>
<td>60</td>
<td>35</td>
<td>60</td>
<td>36</td>
<td>I think the choice to focus, and in particular the choice not to consider DAC, should be explicitly justified in the text. [Oliver Morton, United Kingdom of Great Britain and Northern Ireland]</td>
<td>Agreed. This literature is cited in Section 2.3.4.2.</td>
</tr>
<tr>
<td>16212</td>
<td>60</td>
<td>36</td>
<td>60</td>
<td>56</td>
<td>Given progress across the field, limiting the presentation to these two approaches seems far too limiting. [Michael MacCracken, United States of America]</td>
<td>Noted. Progress is being made but to date there is no robust literature on 1.5°C pathways with a whole range of CDR measures outside Afforestation / reforestation, BECCS and DAC. We will revisit this at the time of drafting the final order draft.</td>
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<tr>
<td>6714</td>
<td>60</td>
<td>47</td>
<td>60</td>
<td>50</td>
<td>Once again, these sentences read far too definitively as they are written in the context of the ‘certainty’ implied by model assumptions, and yet may come across to the reader more as statements of fact or, at least, research findings [Jennifer Morgan, Netherlands]</td>
<td>Accepted. Changed language accordingly.</td>
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<tr>
<td>9240</td>
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<td>52</td>
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<td>How does this square with Fig 2.23: co2 supply, is transformation to other fucles? GCAM, AIM are more on electricity? [Glen Peters, Norway]</td>
<td>Noted. Language has been revised to indicate uncertainties more clearly.</td>
</tr>
<tr>
<td>1850</td>
<td>60</td>
<td>8</td>
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<td></td>
<td>2.4.3 As regards the CDRs, especially the CCS, there were also other reference in subsection 2.3.4.1.2 (e.g. Riahi et al. 2017) and like there, some more careful language would be needed here by taking into account the following: Riahi et al. 2017: ‘CCS plays an important role in many of the mitigation scenarios even though its deployment is subject to large uncertainties..’ AR5-WGIII-SPM: “overshoot scenarios typically rely on the availability and widespread deployment of BECCS and afforestation in the second half of the century. The... CDR technologies and methods are, to varying degrees, associated with challenges and risks (see Section SPM 4.2) (high confidence)” [Riahi et al. 2017: “CCS plays an important role in many of the mitigation scenarios even though its deployment is subject to large uncertainties..’ AR5-WGIII-SPM: “overshoot scenarios typically rely on the availability and widespread deployment of BECCS and afforestation in the second half of the century. The... CDR technologies and methods are, to varying degrees, associated with challenges and risks (see Section SPM 4.2) (high confidence)” [Tibor Farago, Hungary]</td>
<td>Accepted. CDR section was brought into Section 2.3 and Chapter 4 has been more clearly cross-referenced.</td>
</tr>
<tr>
<td>6927</td>
<td>60</td>
<td>8</td>
<td>62</td>
<td>52</td>
<td>To be integrated with material form ch 4 to be moved to ch 2 and preferably placed earlier in the chapter (2.3.4) [Bart Metz, Netherlands]</td>
<td>Accepted. CDR section was brought into Section 2.3 and Chapter 4 has been more clearly cross-referenced.</td>
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<td>1185</td>
<td>60</td>
<td>8</td>
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<td>2</td>
<td>After reading Ch2, it is clear that Ch2 should discuss more comprehensively the SDG implications of CDR (particularly BECCS) given their prominence in M pathways consistent with the 1.5C target (section 5.4). This will require some co-ordination at LAM3. [Petra Tschakert, Australia]</td>
<td>Agreed. This literature is cited in Section 2.3.4.2.</td>
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<td>6097</td>
<td>60</td>
<td>8</td>
<td>62</td>
<td>35</td>
<td>According to Smith et al. (2016), no NET or combination of NETs ‘currently available that could be implemented to meet the less than 2 degree C target without significant impact on either land, energy, water, nutrient, almond or cost and so ‘plan A’ must be to immediately reduce GHG emissions.” <a href="http://www.nature.com/nclimate/journal/v6/n1/full/nclimate2870.html?WT.ec_id=NCLIMATE-201610&amp;spMailingID=50320407&amp;spUserID=MTI3MTU2ODk4MDgS1&amp;spJobID=823491820&amp;spReportId=ODUzMndxODw5S0">http://www.nature.com/nclimate/journal/v6/n1/full/nclimate2870.html?WT.ec_id=NCLIMATE-201610&amp;spMailingID=50320407&amp;spUserID=MTI3MTU2ODk4MDgS1&amp;spJobID=823491820&amp;spReportId=ODUzMndxODw5S0</a> [Jennifer Morgan, Netherlands]</td>
<td>Noted. This section highlights the fact that CDR is not pulling off rapid and deep near-term mitigation in 1.5C pathways.</td>
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<td>6715</td>
<td>60</td>
<td>9</td>
<td>61</td>
<td>9</td>
<td>Again, reference to a range of proposed CDR approaches as ‘options’ grants them more certainty and confidence than they should attract, given the state of knowledge on the potential effectiveness and adverse impacts of many such proposals. They may be ‘options’ in terms of selection for modeling assumptions and parameters, but the term can be interpreted very differently in terms of policy and public understanding (see comments 6 and 7 above). [Jennifer Morgan, Netherlands]</td>
<td>Accepted. Replaced options with measures.</td>
</tr>
</tbody>
</table>
Report "bioenergy crops can substantially increase agricultural water demand" but the information in the text only discuss the irritation water demand, for industrial water demand, and domestic water demand in China under changing climate is also increasing, see the paper with attachment 'Impacts of climate variability and changes on domestic water use in the Yellow River Basin of China. Modelling domestic water demand in Huaihe River Basin of China under climate change and population dynamics. Adaptation to climate change impacts on water demand. Forecasting industrial water demand in Huaihe River Basin due to environmental changes' all these papers are very important for water demand under climate change, should also be cited in the text. [Xiaojun WANG, China]

Report "bioenergy crops can substantially increase agricultural water demand" but the information in the text only discuss the irritation water demand, for industrial water demand, and domestic water demand in China under changing climate is also increasing, see the paper with attachment 'Impacts of climate variability and changes on domestic water use in the Yellow River Basin of China. Modelling domestic water demand in Huaihe River Basin of China under climate change and population dynamics. Adaptation to climate change impacts on water demand. Forecasting industrial water demand in Huaihe River Basin due to environmental changes' all these papers are very important for water demand under climate change, should also be cited in the text. [Xiaojun WANG, China]

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The sentence on risk of CO2 leakage, which cites the paper of Torvanger et al. (2012) to support a statement that risk of CO2 leakage from deep geological storage is suggested in decline over time, may be open to question, as the risk of "off" leakage and the risk arising from storage sites are two quite different things. In the context of the preceding sentence, which relates to outgassing from the oceans, the sentence as it stands appears to relate to declines in risk of leakage. Torvanger et al. (2012) appears to consider risk in a broader modeling context of relative impacts, based on specific assumptions about leakage rates. On risk of "off" leakage, for example, those authors warn that "more than marginal leakages from storage sites are possible" and that "Such leakages are not likely to be at a flat rate, and they may peak millennia from now." [Jennifer Morgan, Netherlands] See comment 1612. The draft text on hypothetical magnitude of leakage risk has been removed. In addition, both the risk of and the risk arising from leakages are now discussed.

This statement, as drafted, presents the risk of CO2 leakage from CCS operations as quite low. But this is a misleading statement. It ignores the potential risk of leakage during the injection phase, well blow outs, improper sealing of well casings and the potentially higher risk of leakage in former oil and gas fields (http://www.sciencedirect.com/science/article/pii/S1750583613000035), which are full of incompletely sealed and improperly sealed wells. What's more, the mechanism of storage for CO2 in deep geological formations are only partially understood at this point. Finally, even very low leakage rates could completely negate the climate benefits of CCS. (Aaser, C et al, 2006, Carbon Capture and Storage from Fossil Fuels and Biomass – Costs and Potential Role in Stabilising the Atmosphere, Climatic Change vol. 74, 2006, pp: 47-79.) [Jennifer Morgan, Netherlands] See comment 1612. The draft text on hypothetical magnitude of leakage risk has been removed.

The quantity of CO2 stored in CCS and BECCS is 3900 GtCO2 storage capacity worldwide." This is stated in other words in the paragraph: "found that the cumulative demand for CO2 storage arising from fossil fuels and biomass production exceeds the available capacity in the future if current deployment rates are maintained. "It's completely inappropriate to rely on the IPCC-CCS 2005 report estimates for storage capacity as those top-down assessments have been shown to wildly overestimate potential storage capacity for CCS. Bottom up assessments provide a far more accurate picture. What's more, such storage estimates don't take into account changing factors such as injection rates and co-location of sources and sinks. Such issues have a dramatic impact both of the available storage space for CO2 as well as the costs associated with such activities. See, the 2009 Greenpeace report on this: http://www.greenpeace.org/international/global-international/planet-2/report/2009/5/reality-check-on-carbon-storage.pdf. See also, https://link.springer.com/content/pdf/10.1007/s11053-016-9310-7.pdf. See also, http://nora.nerc.ac.uk/1477/1/CO2_storage.pdf. [Jennifer Morgan, Netherlands] See comment 1612. The draft text on hypothetical magnitude of leakage risk has been removed. In addition, both the risk of and the risk arising from leakages are now discussed.

The sentence, as currently written, could imply that massive soil erosion in the Amazon and bioenergy crop applications that... This paragraph summarizes recent assessments of storage capacity, to see how these estimates compare to the demand for storage in scenarios. As the reviewer notes, the IPCC 2005 assessment is now dated, and we do not rely solely on this assessment, but rather on a more recent and deeper literature that has appeared since the IPCC 2005. This section on sustainability does not address the cost of storage.

The report of Torvanger et al. (2012) to support a statement that risk of CO2 leakage from deep geological storage is suggested in decline over time, may be open to question, as the risk of “off” leakage and the risk arising from storage sites are two quite different things. In the context of the preceding sentence, which relates to outgassing from the oceans, the sentence as it stands appears to relate to declines in risk of leakage. Torvanger et al. (2012) appears to consider risk in a broader modeling context of relative impacts, based on specific assumptions about leakage rates. On risk of “off” leakage, for example, those authors warn that “more than marginal leakages from storage sites are possible” and that “Such leakages are not likely to be at a flat rate, and they may peak millennia from now.” [Jennifer Morgan, Netherlands] See comment 1612. The draft text on hypothetical magnitude of leakage risk has been removed. In addition, both the risk of and the risk arising from leakages are now discussed.

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<tr>
<td>12996</td>
<td>62</td>
<td>28</td>
<td>59</td>
<td>38</td>
<td>I suggest to mention the difficulties in the correct identification of a storage site, that have limited the growth of CCS. As an example, according to &quot;EA (2014)- CCS 2014. What lies in store for CCS?&quot; the assessment of the real storage potential in saline formation is uncertain. &quot;Available experience shows that it can take 5-10 years to qualify a new saline formation for CO2 storage, even when theoretical estimates are already available and look promising. The necessity of large up-front investment in securing storage capacity is also a critical aspect in the process of investing in CCS. The final investment decision for a large capture facility cannot be taken without a very high level of confidence that the resulting CO2 can actually be stored in the envisaged site or sites. Therefore, the whole investment framework and its various stages are either strongly influenced, or actually defined, by the development of the storage site.&quot; [Cassetti Stefano, Italy]</td>
<td>As the reviewer suggests, site characterisation is a step in developing a CO2 storage site which is part of deploying CCS which is part of, for example, transforming the electricity generation system. This section, however, is on sustainability considerations and site characterisation is now mentioned in the first paragraph in this section in the context of the risk of CO2 leakage. There is a discussion on pace in section on Pace of Change in chapter 2, and further consideration on accelerating the pace in chapter 4.</td>
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<td>6929</td>
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<td>30</td>
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<td>This discussion needs to be broadened to other , mostly lana based, CDR options. The choice is not only between BECCS and bioenergy supply; landing CDR (trees in forests, agro soils, degraded lands) can play a major role [Bert Metz, Netherlands]</td>
<td>Accepted. Introductory discussion has been broadened to point to land restoration, biochar, land and soil carbon management options, and their lack of coverage in IAMs was identified.</td>
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<td>9446</td>
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<td>32</td>
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<td>34</td>
<td>I don't understand well 'CCS deployment is mostly driven by BECCS; as CCS deployment is also driven by the need to reduce emissions from fossil and industrial plants. [Isabelle Czimochowski-Launir, France]</td>
<td>Accepted. Introductory discussion has been broadened to point to land restoration, biochar, land and soil carbon management options, and their lack of coverage in IAMs was identified.</td>
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<td>and, if available, by DACS [Ton Wildenberg, Netherlands]</td>
<td>Accepted - DACS (Tip Wildenberg, Netherlands)</td>
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<td>4984</td>
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<td>BECCS and, if available, DACS is a major driver for CCS deployment in a 1.5°C and WB2C pathways where both will be dependent on establishing and build out of a wider CCS industry. the ratio/BECCS/CCS in Fig 2.9 do not support mostly driven? [Wilfried Meel, Netherlands]</td>
<td>Accepted. Introductory discussion has been broadened to point to land restoration, biochar, land and soil carbon management options, and their lack of coverage in IAMs was identified.</td>
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<td>64</td>
<td>In discussion of energy demand in 2.4.3.1, use of &quot;liquids&quot; may be confusing for non-specialists, &quot;liquid fuels&quot; may be better [Jonathan Lynn, Switzerland]</td>
<td>Accepted. - these references have been added.</td>
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<td>The SOEs include discussion of the full-life-cycle consequences of bioenergy and the debate about its ability to be carbon neutral [Nathan Boorghart- Pamel, Switzerland]</td>
<td>Rejected. This is subject of Chapter 4.</td>
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<td>10665</td>
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<td>In the SSCS, include discussion of the full-life-cycle consequences of bioenergy and debate about its ability to be carbon neutral, especially in the near-term when the risks of exceeding 1.5°C (even if only temporarily) are greatest because of regional impacts (increased heat waves, change in precipitation patterns) and feedbacks and tipping points (Arctic sea ice, permafrost, increased ice sheet melting). [Kristin Campbell, United States of America]</td>
<td>Taken into account - the sentence stated: &quot;At the same time it is deeply uncertain which key technologies, preferences and institutions will shape the energy system 50 to 80 years out,&quot; which is hence clearly different from the point made by the reviewer about the next 20 to 30 years. Nevertheless, we included a qualification about the smaller uncertainty surrounding technologies in the near term.</td>
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<td>Least energy technologies for the next 20 to 30 years are not at all uncertain. As technology requires 20 to 30 years from first development to market entry, it is certain that all renewable energy technologies currently on the market - especially solar and wind technologies - will be used till 2050. While entirely new technologies, which are not yet under development, will most likely play a role in the energy market until 2050. Make this sentence either more precise, add references or delete entire paragraph. [Sven Teske, Australia]</td>
<td>Rejected - these references have been added.</td>
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<td>5191</td>
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<td>25</td>
<td>Include SSP 0 - new category - to reflect 100% RE pathways. [Sven Teske, Australia]</td>
<td>Rejected - SSPs are narratives which are published and clearly described in the literature.</td>
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<td>6930</td>
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<td>Are the SSP1 scenarios included in the full range of the results reported in line 34? And what are the factors that drive down energy use in the baseline and what is the contribution of policy? [Bert Metz, Netherlands]</td>
<td>Taken into account - the sentence stated: &quot;At the same time it is deeply uncertain which key technologies, preferences and institutions will shape the energy system 50 to 80 years out,&quot; which is hence clearly different from the point made by the reviewer about the next 20 to 30 years. Nevertheless, we included a qualification about the smaller uncertainty surrounding technologies in the near term.</td>
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<td>17433</td>
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<td>Along with the note: &quot;Currently defined Nationally Determined Contributions (NDCs) specified under the Paris Agreement will not be sufficient to create conditions for a 1.5°C world if it should also be highlighted that current mitigation policies in the IPCC and IMO for international transport emissions are not sufficient for a 1.5°C world. [Aki Kachi, Germany]</td>
<td>Rejected - these references have been added.</td>
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<td>953</td>
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<td>Here are a couple of references to support the claim that electrification in freight will be limited. While they do not focus on 1.5 degrees, they do compare types of transport sectors and include electrification options. These papers are: S. Carrera, T. Longden, Freight futures: The potential impact of road freight on climate policy, Transportation Research Part D: Transport and Environment, Volume 55, 2017, Pages 359-372; Platzker, R. C. Longden, T., Chen, W., Fu, S., Kröger, E., Kyba, P., &amp; Luderer, G. (2014). Long-term transport energy demand and climate policy: alternative visions on transport decarbonization in energy-economy models. Energy, 64, 95-108. [Thomas Longden, Australia]</td>
<td>Accepted. - these references have been added.</td>
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<td>3852</td>
<td>62</td>
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<td>47</td>
<td>Wind Propulsion in Shipping can offer substantial reductions. The maximum market potential for bulk carriers, tankers and container vessels is estimated to add up to around 3,700-10,700 installed systems until 2030, including both retrofit and installations on newbuilds, depending on the bunker fuel price, the speed of the vessels, and the discount rate applied. The use of these wind propulsion systems would then lead to CO2 savings of around 3.5-7 Mt CO2 in 2030. Study on the Analysis of Market Potentials &amp; Market Barriers for Wind Propulsion Technologies for Ships commissioned by European Commission DG Climate Action Dagnar Nielsen, Jasper Faber, Salha Ahadou (CE Delft), Michael Traut (Tyndall Centre) Jonathan Köhler (Fraunhofer ISI) Wengang Mao (Chalmers University), Nov 2016 – publicly available Jan 2017 <a href="http://www.cedelft.eu/publicatie/study_on_the_analysis_of_market_potentials_and_market_barriers_for_wind_propulsion_technologies_for_ships/189">http://www.cedelft.eu/publicatie/study_on_the_analysis_of_market_potentials_and_market_barriers_for_wind_propulsion_technologies_for_ships/189</a> (commissioned by European Commission DG Climate Action)</td>
<td>Accepted. - these references have been added.</td>
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<td>17435</td>
<td>63</td>
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<td>Electrification options should not be underestimated. The differences between the prospects for electrification of shipping and aviation are: Kanellis, F. D., Prousalidis, J. M., &amp; Tsekouras, G. J. (2014). Control system for fuel consumption minimization–gas emission limitation of full electric propulsion ship power systems. Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment, 238(M), 17-28. [Ali Kachi, Germany]</td>
<td>Noted - we agree that it should not be underestimated. However, this sentence speaks to what is currently assumed in the models. A detailed discussion of this would be better placed in Section 2.4</td>
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<td>6931</td>
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<td>47</td>
<td>I don't understand this sentence. Please clarify. [Bert Metz, Netherlands]</td>
<td>Taken into account - this sentence has been removed.</td>
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<td>64</td>
<td>2</td>
<td>65</td>
<td>2</td>
<td>Fig 2.28 - Black line is dashed (up) and solid (down). Why? [Radim Toláč, Czech Republic]</td>
<td>This had no specific meaning. Both lines are solid now.</td>
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C&DR and BECCS are unconvincing technologies. The costs of C&DR are minimized by capture from large, CO2 rich emissions streams such as coal-fired generation and an economic value for the stored CO2 as enhanced oil recovery. In the 1.5°C pathways the electric generation emissions sources have limited lifetimes (virtually no new plants) and the potential use for enhanced oil recovery declines sharply as CO2 consumption falls. A more realistic option is capture from ambient air and combination with H2 from electrolysis using renewable electricity to produce zero net emissions liquid fuels and chemical feedstocks. The reliance of the models on BECCS is even less convincing. Suddenly after 2050 electricity generation with carbon capture with biomass fuel becomes less costly than solar and wind generation! [Erik Hales, Canada]

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<td>CDR and BECCS are unconvincing technologies. The costs of C&amp;DR are minimized by capture from large, CO2 rich emissions streams such as coal-fired generation and an economic value for the stored CO2 as enhanced oil recovery. In the 1.5°C pathways the electric generation emissions sources have limited lifetimes (virtually no new plants) and the potential use for enhanced oil recovery declines sharply as CO2 consumption falls. A more realistic option is capture from ambient air and combination with H2 from electrolysis using renewable electricity to produce zero net emissions liquid fuels and chemical feedstocks. The reliance of the models on BECCS is even less convincing. Suddenly after 2050 electricity generation with carbon capture with biomass fuel becomes less costly than solar and wind generation! [Erik Hales, Canada]</td>
<td>Noted</td>
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Fig. 2.27 - Add explanation of “w/o” and “w/” used in legend. [Radim Tolasz, Czech Republic]

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<td>4779</td>
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<td>The energy supply mix and evolution should be also presented by region. [Eleftheria Georgopoulou, Greece]</td>
<td>Accepted - included in the legend</td>
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<td>1530</td>
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<td>What this section is missing is all of the second-order issues associated with these scenarios. Indeed that might be worth of a box. For example, there are papers showing that the water demand associated with high biomass use for energy would be, arguably, catastrophic. ( e.g. <a href="https://doi.org/10.1016/j.enpol.2018.03.014">https://doi.org/10.1016/j.enpol.2018.03.014</a> ) Other papers are looking seriously at how renewable energy systems planning could allow for high penetration of intermittent renewables, and hence avoid the need for fossil with CCS, or biomass w/ CCS (e.g. doi:10.1038/s43033-019-0038-x) and indeed suggest the need modeling paradigm to deal with this ( e.g. <a href="https://doi.org/10.1016/j.ners.2014.02.003">https://doi.org/10.1016/j.ners.2014.02.003</a> ) Of course across all of this, one needs to step outside of the IAM box, since these issues for which IAMs provide little insight, and yet are still model driven. I challenge the authors of this chapter to do so! [Anthony Palt, Switzerland]</td>
<td>Accepted - a separate section which looks at the interactions between mitigation measures and sustainable development is provided in Section 2.5.3</td>
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<td>80</td>
<td>30</td>
<td>Include references to pathways without oil- and gas CCS. [Ewen Tasek, Australia]</td>
<td>Accepted - reference included</td>
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<td>With electricity being provided primarily with solar and wind, the operation of BECCS in the system becomes problematic. Peak solar and wind</td>
<td>Noted - and agreed. However, a reference would be helpful to include this comment in the draft</td>
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<td>Fig 2.27 - Add explanation of “w/o” and “w/” used in legend. [Radim Tolasz, Czech Republic]</td>
<td>Noted - agreed</td>
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<td>6961</td>
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<td>Nuclear power plays a much smaller role in the electricity sector with large disagreement between models (Kim et al.) Some 1.5°C pathways no longer see a role for nuclear fission by the end of the century, while others still project 80 EJ yr^-1 of nuclear power in 2100. This statement is a gross misrepresentation of what that paper says! According to the last of the paper, only one model (MES-SAGE) shows no nuclear power by 2100, and that’s with no climate mitigation policies. With climate mitigation policies nuclear has a much stronger tendency to grow. This paper needs to be read and reported properly. It will be very difficult to meet our climate goals, even the 2°C, let alone the 1.5, without substantial contributions from all low carbon technologies: solar, wind, hydro and nuclear! [Jason Donev, Canada]</td>
<td>Accepted - the scenario assumption underlying some of the pathways has been made explicit</td>
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<td>Nuclear power plays a much smaller role in the electricity sector with large disagreement between models (Kim et al.) Some 1.5°C pathways no longer see a role for nuclear fission by the end of the century, while others still project 80 EJ yr^-1 of nuclear power in 2100. This statement is a gross misrepresentation of what that paper says! According to the last of the paper, only one model (MES-SAGE) shows no nuclear power by 2100, and that’s with no climate mitigation policies. With climate mitigation policies nuclear has a much stronger tendency to grow. This paper needs to be read and reported properly. It will be very difficult to meet our climate goals, even the 2°C, let alone the 1.5, without substantial contributions from all low carbon technologies: solar, wind, hydro and nuclear! [Jason Donev, Canada]</td>
<td>This statement is based both on what the paper says about 2°C pathways and what the more recent literature in line with 1.5°C says. Scenario evidence from recent studies, shows that the contribution of nuclear varies strongly between scenarios with options to limit its use to virtually zero available in the literature. We added more recent references which support this statement in context of 1.5°C pathways</td>
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<td>Year missing from Kim et al. citation [Aaron Glenn, Canada]</td>
<td>Noted</td>
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<td>(Kim et al.) should also have the year 2014. [Jessica Callen, Austria]</td>
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<td>Almost no commonly accepted energy scenario - used in the energy industry - projects beyond 2050 and non includes nuclear fission. This sentence again proves that scientists working on climate models remain in their silo and do not talk to engineers and scientists from the energy sector. Interdisciplinary development and interaction to the energy sector is urgently required as energy pathways presented in this chapter are entirely disconnected from the development in real energy markets. [Evon Teseke, Australia]</td>
<td>Noted</td>
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IPCC WGI SR15 First Order Draft Review Comments And Responses - Chapter 2

Comment
Brook, Barry W. "Could nuclear fusion energy, etc., solve the greenhouse problem? The affirmative case." Energy Policy 42 (2012): 4-8. [Jason Donev, Canada] Accepted - this statement has been revised.

12750 65 14 65 14 By the end of the century, both are... [Vassilis Daioglou, Netherlands] Noted
12756 65 19 65 19 This sentence has to be amended. It mentions that capture rates of less than 95% are "increasingly uncompetitive," however there has been no prior discussion on how capture rates differ across technologies. Furthermore, this sentence alludes to carbon taxes, without them having been mentioned so far in the report. A reference has to be made to the section in the report where these are discussed in more detail (2.5.2) [Vassilis Daioglou, Netherlands] Noted
9447 65 19 65 20 "I am surprised by this sentence. Is it well formulated? Rather say 'higher carbon prices make fossil fuel use with CCS increasingly uncompetitive'? [Isabelle Czerniawski-Loirat, France]" Noted
6933 65 19 65 21 "Interesting finding that fossil CCS use becomes unattractive in 1.5°C scenarios, due to the remaining emissions. However, this only applies if there is a high carbon price. In models this carbon price is assumed to increase sharply, as that is the way the models generate their results. But in practice such high carbon prices might not be materialised. It would be good to discuss this here and show what the implications would be of lower carbon prices for the relative use of mitigation options. [Bert Metz, Netherlands] Accepted - this sentence has been amended to clarify this
4851 65 19 65 21 "Fossil fuel use with CCS is strongly reduced in 1.5°C pathways since significantly higher carbon prices make CCS installation with capture rates below 95% increasingly uncompetitive (Rogel et al. 2017a). This is not a supported argument as capture rates of fossil CCS plants can be increased, at a marginal cost, with economic incentives (as a high carbon price will be) and - as a small amount of biomass/gas blending in the feed can make a 95-95% capture CCS operation carbon neutral. [Wilfried Maas, Netherlands]" Accepted - this assessment is part of Chapter 4
10848 65 22 65 23 "Fig. 1: It has to be mentioned in the text that all the biomas for the REMICO scenarios for 2050 and 2100 should come from - in a sustainable way. I can hardly believe that this should be possible in a sustainable way [Christian Breyer, Finland]" Noted - this assessment is part of Chapter 4
1514 65 22 65 22 "What is the blame in the right-hand side of the figure? [Ken'ichi Matsumoto, Japan]" Noted - this section has been amended to clarify this
3177 65 22 66 7 "Taken as a whole, figure 3.23 illustrates one of the major flaws of the six IAMs used for this first draft. The amounts of solar and wind power calculated for both 2050 and 2100 are far too low, even in scenarios where CDR technologies are used. The reasons for this must be researched and explained to the public if these results are to be relied on in the second draft, BUT THEY SHOULD NOT BE. One reason why the use of solar and wind is far lower in these models is because the discount rate assumed in these models is too high - about 5% real instead of a social discount rate of 2% or lower. Again, these models need all need to be re-run with a 2% discount to determine how dramatically the results for the mix of energy technologies might change!! [Richard Rosen, Germany]" Rejected - Far too low measured by what standard? Note also that different 1.5°C scenarios show very different levels of solar and wind energies.
14239 65 23 66 23 "The graph here lacks a label and seems to be missing of a stacked bar chart on the right-hand side. [Jason Donev, Canada] Corrected. The label refers to other energy sources like geothermal energy.
10849 66 2 66 2 "Fig. 2.17: EUR and AFR scenario from Greenpeace has to be added - IEA is also there and their methodology is not better than that of Greenpeace [Christian Breyer, Finland]" Rejected - inclusion of quantitative scenario information in figures requires submission of data to the report’s database. The Greenpeace scenarios were not contributed.
17486 66 3 66 3 [Carlos Donev, Canada] Noted
17526 66 3 66 3 [Angela Morelli, Norway] Noted
5233 66 4 66 4 "since here only the IEA scenario is to be cited, according to the report (Notes on Page 1), it should be cited as a IEA only (not EAVENA): Chapter 2 of Perspectives for the energy transition – investment needs for a low-carbon energy system 506CEDEIA 2017 [Baekche SHOK, TEHRAI, Japan]" Noted - the reference is IEA/REN21, but we added a reference to Chapter 2.
4553 66 6 66 6 "As? [Radam Tezaly, Czech Republic]" Corrected
13218 66 9 66 9 "Can the SSPs be used to support this point at all? [Skea Jim, United Kingdom (of Great Britain and Northern Ireland)]" Noted - the SSPs are noted mentioned in the subsection and are not part of content we wanted to convey here. The SSPs are more concerned with broad socio-economic developments. Broad technology can be well related to them, assumptions about individual break-through technologies less so.
10867 66 9 66 10 "6694 66 9 66 26 This is an extremely important paragraph that unfortunately is situated at the end of the chapter. The issues raised here (that are not well covered in the modelling studies apparently) deserve a much more prominent place and discussion: (1) further demand reduction in transport and manufacturing is definitely one of the options to consider in chapter 2. So move the material on this from ch. 4 to ch. 2 and discuss it at the appropriate place, i.e. in these sections on transport and industry; (2) the role of hydrogen needs to be discussed when discussing energy supply, as there is emerging attention to power to gas (PtG) in an energy autopoietic system with large shares of intermittent renewables; (3) Other CDR options need to be discussed in the section on CDR (we are already suggesting there, moving various parts of this paragraph to the respective paragraphs in the chapter so they can get proper attention. Important issues that are not covered in IAMs should not be banned to an afterthought paragraph. [Bert Metz, Netherlands]" Accepted - the section has moved into Section 2.3 before the discussion of energy and sector developments in pathways. Other CDR options are discussed in the CDR section. An extensive table on mitigation measures is included.
**IPCC WGI SR15 First Order Draft Review Comments And Responses - Chapter 2**

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**Comment**

- It would be great if 100% renewable scenarios could be assessed, such as the important Jacobson et al. at 2015 vs Clack et al at 2017 (both in PRAS) debate. [Sven Petras, Norway]

**Response**

Note: The literature has now been referenced and briefly discussed (Section 2.4). Accepted: Reference to Jacobson, 2017, has been added.

- The statement, "There are a number of alternative narratives of carbon neutral energy systems with less reliance on bioenergy that are currently not yet covered by global mitigation pathway modelling" may be supported by additional references from the literature that model 100% renewable energy systems with solar, wind, and only locally available sustainable bioenergy, such as "D.O. Dowlatabadi et al. [2012]; G. Krauss et al. [2017]; P. Pukiet et al. [2019]; N.Daj et al. [2020]; N. Marks et al. [2020]; 2016 Zero carbon energy system of South East Europe in 2050; Applied Energy Volume 184, 15 December 2016, Pages 1511-1528; https://doi.org/10.1016/j.apenergy.2016.03.048" [Sven Teske, Australia]

**Response**

Rejected: This section is not targeted to give an overview on renewable energy scenarios. [Sven Teske, Australia]

- Include reference to the IPCC SRREN as the content is by an order of magnitude more advanced, than the content in chapter 2 in regard to energy scenarios. [Sven Teske, Australia]

**Response**

Note: These options are now discussed in Section 2.3.4.

- What is the net effect of BECCS without permanent storage? Delayed net emissions? Or did I got it wrong? [Tuomo Kalliokoski, Finland]

**Response**

The substitution was not suggested so much based on permanence, but on a range of environmental and societal impact implications.

- This section discusses a very important issue, namely non idealised model runs (using limitations the fully least cost scenarios), also elaborating on the SSP scenarios that use very different socio economic futures as baselines. This material is too important to be left to one of the final sections of the chapter. The SSP scenarios have been incorporated in the various sections earlier in the chapter, so the SSP issues should have been introduced much earlier (possibly with an appendix to cover more details). The non-optimal model runs should also be discussed in the appropriate sections earlier in the chapter and not be left to an afterthought. [Bert Metz, Netherlands]

**Response**

Taken into account - Thanks for pointing this out. Text was revised.

- There are a number of alternative visions of carbon neutral energy systems with less reliance on bioenergy that are currently not yet covered by global mitigation pathway modelling" may be supported by additional references from the literature that model 100% renewable energy systems with solar, wind, and only locally available sustainable bioenergy, such as "D.O. Dowlatabadi et al. [2012]; G. Krauss et al. [2017]; P. Pukiet et al. [2019]; N.Daj et al. [2020]; N. Marks et al. [2020]; 2016 Zero carbon energy system of South East Europe in 2050; Applied Energy Volume 184, 15 December 2016, Pages 1511-1528; https://doi.org/10.1016/j.apenergy.2016.03.048" [Sven Teske, Australia]

**Response**

Note: The literature has now been referenced and briefly discussed (Section 2.4). Accepted: Reference to Jacobson, 2017, has been added.

- Policy discussions in 2.5.1-2.5.2 should be introduced earlier in the chapter - before the characteristics and properties of the pathways are introduced.

**Response**

Taken into account - While it is impossible to discuss all important aspects directly upfront in the chapter (non-optimal model runs only being one of these) we have now included a discussion of policy assumptions in scenarios in Section 2.3 so that this is introduced earlier.

- The substitution was not suggested so much based on permanence, but on a range of environmental and societal impact implications.

**Response**

Note: The literature has now been referenced and briefly discussed (Section 2.4). Accepted: Reference to Jacobson, 2017, has been added.

- This section discusses a very important issue, namely non idealised model runs (using limitations the fully least cost scenarios), also elaborating on the SSP scenarios that use very different socio economic futures as baselines. This material is too important to be left to one of the final sections of the chapter. The SSP scenarios have been incorporated in the various sections earlier in the chapter, so the SSP issues should have been introduced much earlier (possibly with an appendix to cover more details). The non-optimal model runs should also be discussed in the appropriate sections earlier in the chapter and not be left to an afterthought. [Bert Metz, Netherlands]

**Response**

Taken into account - Thanks for pointing this out. Text was revised.

- The statement, "There are a number of alternative visions of carbon neutral energy systems with less reliance on bioenergy that are currently not yet covered by global mitigation pathway modelling" may be supported by additional references from the literature that model 100% renewable energy systems with solar, wind, and only locally available sustainable bioenergy, such as "D.O. Dowlatabadi et al. [2012]; G. Krauss et al. [2017]; P. Pukiet et al. [2019]; N.Daj et al. [2020]; N. Marks et al. [2020]; 2016 Zero carbon energy system of South East Europe in 2050; Applied Energy Volume 184, 15 December 2016, Pages 1511-1528; https://doi.org/10.1016/j.apenergy.2016.03.048" [Sven Teske, Australia]

**Response**

Note: The literature has now been referenced and briefly discussed (Section 2.4). Accepted: Reference to Jacobson, 2017, has been added.

- One challenge for a transformative mitigation pathway is people's fear of nuclear power. The discrepancy between what people feel is dangerous (like nuclear power, small amounts of radiation etc.) and what is actually dangerous (climate change, air pollution, etc.) is creating a significant barrier to effective policies on mitigating climate change. Air pollution (indoor and outdoor combined) kills an estimated 8 million people per year, even without climate change. Nuclear power is low emissions for other pollutants too and should really be considered as part of the triple-win options. [Jason Donev, Canada]

**Response**

Noted. These options are now discussed in Section 2.3.4.

- Nuclear power is low emissions for other pollutants too and should really be considered as part of the triple-win options. [Jason Donev, Canada]

**Response**

Noted. These options are now discussed in Section 2.3.4.
I love that you include the idea of policy narratives, but I encourage you to challenge your assumption that they are locked in. As Michael Grubb's book 'Policy, Economics, Carbon Models' (Routledge, 2015) and my own (Transforming Energy, Cambridge, 2015, summarized in http://dx.doi.org/10.1016/j.2017.05.033) both suggest, when one moves from a marginalist perspective to a system transformation perspective, the underlying economic theory providing useful insights switches from an equilibrium / optimizing one to an evolutionary and / or behavioral one. And that in turn is crucial for thinking about the entire policy narratives that are at work. As these writers have shown, as well as folks within the socio-technological transitions field, is that the nature of the policy regimes and instruments may be very different. Specifically, it may sholt us over from a preference for carbon price instruments, which work well within the optimizing framework, to technology support and regulatory instruments, which work well within an evolutionary or behavioral framework.

The reasoning for not using SSP3 and SSP5 in the analysis should be reported earlier in the chapter. [Eleni Kaditi, Austria]

The distinction between (i) non-climate policies, (ii) SPAs and (iii) stabilization policies must be clarified. The reader gets confused at various instances about what the authors are actually talking. [Nico Bauer, Germany]

Please consider presenting the characteristics of SSP3 and SSP4 in a manner similar to the presentation of SSP1, 2 and 5 in Figure 2.5. This will provide concrete insights for 1.5°C scenarios and thus socio-technical and economic narratives, to support RE development.

Delete both paragraphs. Does not add anything to the level of information provided and quotes a decade old and entirely outdated papers. [Sven Schlaeff, Switzerland]

There are no globally coordinated energy policies yet. And I would doubt, that this will ever be implemented. In contrast community based and locally coordinated energy policies such as feed-in tariffs, actioning and RPS (renewable power sources) drive the change, while carbon policies have been irrelevant for the development of RE in the energy sector over the past decade. [Sven Teske, Australia]


The amount of CDR required to compensate for these emissions would not be able to scale up to infinity by 2050) result in a large CO2 budget being emitted until then. In light of all evidence, the amount of CDR required to compensate for these emissions would not be able to scale up sufficiently rapidly in the second half of the century. [Nico Bauer, Germany]


There are no globally coordinated energy policies yet. And I would doubt, that this will ever be implemented. In contrast community based and locally coordinated energy policies such as feed-in tariffs, actioning and RPS (renewable power sources) drive the change, while carbon policies have been irrelevant for the development of RE in the energy sector over the past decade. [Sven Teske, Australia]
Table 2.11: If there is to be a reduction in the use of coal and traditional biomass, what energy source will substitute? You can’t simply reduce it without replacing it. This leads me to question the claim of reducing energy demand due to efficiency and behavioural changes. In order to lift people out of poverty, they require electrification (energy) — it’s tied into economic growth, health etc. If there are over a billion people living either in energy poverty or without access to energy at all, how will behavioural changes limit energy demand when in order to meet the SDGs we need to supply energy to those people who don’t have it? Additionally, behavioural changes will not be available to some. In Northern Canada for example, it gets dark early in the winter time and there is a lot of energy required for heat; this demand will exist into the future because the amount of sunlight will not change and the temperature will not warm up dramatically that the need for heat will be eliminated. Weather and climate drive most of the energy demand. Additionally, increasing energy costs in order to drive behavioural changes will only detract from the SDGs, even in developed countries, where people will become poorer trying to pay for energy. It also goes against SDG goal 7: Affordable and Clean Energy. [Michelle Leslie, Canada]

Table 2.11: What do (F1, F2, L1, L2, L3) etc. mean? [Erika Måså, Sweden]

Table 2.11: Are indicators for each SSP consistent (see p. 75)? [Jonas Gómez Yáñez, Switzerland]

Table 2.11: Tab 2.11: row 4, col 2 - change format of US currency “1260 US$” to be consistent with the whole Report (see p. 7-19) [Radim Tolasz, Czech Republic]

Table 2.11: Tab: 2.11, F1, F2, L1, L2 should be consistent. [Hong Yang, Switzerland]

Table 2.11: In Table 2.11, F1, F2, L1, L2 need to be explained. [Hong Yang, Switzerland]

Table 2.11: Table 2.12 regarding the GCM4 line, it should be Partial Equilibrium (PE). [Alexandre Strapasson, Brazil]

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Table 2.11: Change format of US currency “1260 US$” to be consistent with Table 2.12. [Radim Tolasz, Czech Republic]

Table 2.11: The largest GHG industrial emitters - cement and steel - are conservative and slow moving. That fact should be mentioned in the summary. [Milton Nogueira da Silva, Brazil]

Table 2.11: Do we have a better way to express the role of “utility/behavior” in deciding the energy mix that can be achieved in the real world? [Roshan Seneviratne, Australia]

Table 2.11: If there is to be a reduction in the use of coal and traditional biomass, what energy source will substitute? You can’t simply reduce it without replacing it. This leads me to question the claim of reducing energy demand due to efficiency and behavioural changes. In order to lift people out of poverty, they require electrification (energy) — it’s tied into economic growth, health etc. If there are over a billion people living either in energy poverty or without access to energy at all, how will behavioural changes limit energy demand when in order to meet the SDGs we need to supply energy to those people who don’t have it? Additionally, behavioural changes will not be available to some. In Northern Canada for example, it gets dark early in the winter time and there is a lot of energy required for heat; this demand will exist into the future because the amount of sunlight will not change and the temperature will not warm up dramatically that the need for heat will be eliminated. Weather and climate drive most of the energy demand. Additionally, increasing energy costs in order to drive behavioural changes will only detract from the SDGs, even in developed countries, where people will become poorer trying to pay for energy. It also goes against SDG goal 7: Affordable and Clean Energy. [Michelle Leslie, Canada]

Table 2.11: What do (F1, F2, L1, L2, L3) etc. mean? [Erika Måså, Sweden]

Table 2.11: Tab 2.11: row 4, col 2 - change format of US currency “1260 US$” to be consistent with the whole Report (see p. 7-19) [Radim Tolasz, Czech Republic]

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Table 2.11: The largest GHG industrial emitters - cement and steel - are conservative and slow moving. That fact should be mentioned in the summary. [Milton Nogueira da Silva, Brazil]
The word "related" appears in a different font. [Olga Alcaraz, Spain] Accepted - text was revised and suggestion included.

"mode" should be "model". [Roger Bodman, Australia] Editorial - corrected.

"Comment Response" mode appears in a different font. [Roger Bodman, Australia] Editorial - corrected.

Add column to Table 2.13 on how relates to people/groups/society. [Lisa Lucero, United States of America] Rejected - Table 2.13 synthesizes quantitative sectoral-level insights in key sectors at global scale, grounded in published scenarios combined with expert judgment, including feasibility analysis signs for those transitions. For specific technologies, regional details and feasibility "practice" see Ch4.

The word "related" appears in a different font. [Olga Alcaraz, Spain] Accepted - text was revised and suggestion included.

"Comment Response" mode appears in a different font. [Roger Bodman, Australia] Editorial - corrected.

The statement, "solar photovoltaic installations and renewable energy technologies have been consistently underestimated by key experts" may be supported by additional references, including Haas, R., Lettner, G., Auer, H., Dui, N. The looming revolution: How photovoltaics will change electricity markets in Europe fundamentally, Energy, Volume 57, 2013. https://doi.org/10.1016/j.energy.2013.04.034 [Sir KUKIS, Turkey]

Suggest spelling out "Integrated Assessment Models" in the sub-section title. [Aaron Glenn, Canada] Editorial - IAM is spelled out

Add cite - Xu and Ramantahn 2017, Well below 2°C: Mitigation strategies for avoiding dangerous to catastrophic climate changes, PNAS

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The transitions on the land are not limited to afforestation... why the column in the table 2-13 is so narrowly labeled as afforestation? [Maria Jose, Spain]

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Comment | Response
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6164 | Superconducting cables in developing countries. This is far too specific a technology to deserve a place in this document. It is also mind-numbingly technical. Long-distance superconducting cables do not save energy, they still need refrigeration. Also they have to be DC not AC because superconductors don't mix well: there is an additional magnetis disruption (i.e. energy loss). Established HVDC cables of overhead 1MW pylons are best - ditch the mention of superconducting cables. (But superconducting fault current limiter as components of smart grids are an excellent technology - but for cost-benefit reasons, not energy saving) [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)]

7081 | I see that here there are some sectoral details, but not regional which are the most relevant. Also, do the authors want to comment on the likelihood of these transitions to happen? E.g. 3% annual building renovation to NZEB by 2020 is simply impossible, let alone globally. Renovation rates are rather high in Sweden, yet still at 2% and definitely not to NZEB standard, with the unavailability of workmanship - not funding - being a key limiting factor according to a recent study (Matsa et al., 2017, Dynamic modeling of renovation scenarios for the existing multifamily buildings in Gothenburg up to year 2050). [Enka Mata, Sweden]

4555 | Tab 2.13, row 4, col 5 - Add explanation of "BAU" and add "q" to "CO2e" [Radim Tolasz, Czech Republic]

4556 | Tab 2.13, row 5, col 4 - Add explanation of "EV" [Radim Tolasz, Czech Republic]

15038 | Table entries on CTPH and Mission 2020: why include these and not others [e.g. SE4ALL]? Appears policy prescriptive to hand pick short term global policy goals from non-government actors. [Farhan Akhtar, United States of America]

13465 | Does social cost of carbon estimate consider historical carbon emission responsibility/liability? [dt Nenm UDDDD, Australia]


10450 | Box 2.1: Very dense for the (non-economics) specialist [Michael Lind, Switzerland]

2787 | Box 2.1 is a long discussion of cost-benefit analysis and the social cost of carbon that is not relevant for this chapter and probably not needed for the 1.5°C Special Report. Chapter 1 concludes that cost-benefit analysis is not appropriate. The whole report and chapter 2 in particular focuses on pathways and scenarios for 1.5°C and 2°C. The relevant concept is cost effectiveness which is discussed in Box 2.3. I don't think all of that material is needed and the box or text might be better placed earlier in the chapter, for example p.7 line 13 [Erik Hale, Canada]

12757 | It is very unclear what “modelling in traditional silos” means... [Vassilis Danagouli, Netherlands]

13000 | Please consider that it is true that a correct urban planning could reduce GHG emissions, but if a city is already built, the effect of land planning is less relevant [Cesare Stefano, Italy]

1561 | This is an important message that should appear in the summary of the chapter [Roks Lecucio, Belgium]


8165 | Taken into account - The Executive Summary has gone through major revisions and more aspects are highlighted, including policy issues related to energy demand.

4920 | Change behavior to “beliefs” [Roger Bodman, Australia]

12758 | Taken into account - Text revised and changed to "modeling of individual sectors".

13685 | Note that a lot of behavioral changes are (line 9-11) dietary nHhVs towards more healthy nutrition and food waste reduction besides improved livestock management. This should have effects not only on methane emissions but also on emissions of N2O and CO2 since less area and N-fertilizer is needed to satisfy human needs for food. [Harald Leiforsen, Norway]

7749 | Add comma in line with historical experience. [Roger Bodman, Australia]

9309 | The word “keep” in “assume keep pollution emissions or control standards” should be “keeping.” [Seth Kilkis, Turkey]

4944 | and assume keep air pollution needs re-writing in some way, eg. move keep along and write as ‘are kept at some historical level’ [Roger Bodman, Australia]

4945 | Assumptions’ [Roger Bodman, Australia]

17737 | Taken into account - Text revised in line with suggestion. 

17738 | Taken into account - The studies assessed in Table 2.13 identify crucial steps in key sectors mainly at global scale, grounded in published scenarios combined with expert judgment, including feasibility analysis/ analysis for those transitions. For specific technologies, regional details and feasibility “in practice” see Ch4.

17739 | Taken into account - Table 2.13 provides no likelihood but identifies crucial steps in key sectors, grounded in published scenarios combined with expert judgment, required in the short term for a 1.5°C pathway, including feasibility analysis/ analysis for those transitions. These set of studies do not provide regional detail. For regional details and feasibility “in practice” see Ch3.
Box 2.1: This illustration is quite important because many IAMs only consider "cost minimum" criteria to choose technology which not always be the selection criteria of stakeholders. Also, it can be a bridge to SDGs. The relation with SDGs is not well mentioned in the last 14 lines. It is better to refer to some trial studies already done on relations between IAM with and SDGs (P.P. Shukla's work indicated that if all the SDGs are well attained, low-carbon world is automatically reached) [Shuiz Nishioka, Japan]

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<table>
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<th>Comment No</th>
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<tr>
<td>6371</td>
<td>77</td>
<td>17</td>
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<td></td>
<td>I’m missing some good figures and tables in this section that summarise the cost implications, including how much costs increase relative to 2 degree pathways, and the extent to which costs depend on underlying socio-economic development. The spaghetti diagram on Fig 2.28 is not helpful, not least because the scale is dominated by a single outlier and other lines are to be distinguished by socio-economic context. This will be very important information and at the moment it seems very hard to extract. Maybe that’s deliberate because the authors feel that a myopic focus on costs is inappropate, but people will want this information very clearly so it’s better if the authors present this in effective ways. [Andy Reisinger, New Zealand]</td>
<td>Taken into account - The latest carbon pricing data submitted to SR1.5C database is now presented, including a new figure and new class of scenarios. Note, however, that text that compares both 1.5 and 2°C was available in the FOD p.78, line 53, and p.79 lines 1-24].</td>
</tr>
<tr>
<td>20336</td>
<td>77</td>
<td>17</td>
<td>77</td>
<td>32</td>
<td>It seems that Box 2.1 and Box 2.2 are interchanged [Taran Fehm, Norway]</td>
<td>Editorial - corrected.</td>
</tr>
<tr>
<td>12105</td>
<td>77</td>
<td>17</td>
<td>77</td>
<td>40</td>
<td>Accept [no explanation and cost but it does not clearly add to the difference of abatement cost, such as marginal abatement cost and average abatement cost. At policy debate, I feel that there is some misleading explanation (or the way it is explained) it is intentionally done). Some additional explanation is better to be here. [Takashi Hongo, Japan]</td>
<td>Taken into account - section title slightly modified also to accommodate new sub-section on investments. Please note that discussions about social costs of carbon and avoided externalities (i.e. benefits of climate mitigation) will be treated in Ch.3. Furthermore, please also note that the performance (ex-post) of carbon prices and energy efficiency measures is addressed in Ch.4.</td>
</tr>
<tr>
<td>21311</td>
<td>77</td>
<td>17</td>
<td>80</td>
<td>1</td>
<td>Section 2.5 should not be titled “Economic implications of 1.5 degree scenarios” because while carbon prices can be an imperfect proxy for mitigation costs, they are not a useful proxy for economic impacts of mitigation. Studies consistently show that if the revenues from carbon prices are used in productive ways, the economic impact of these policies is small, and can be positive or negative. In addition, there is a broad consensus that smart actions to improve energy efficiency and to invest in technological progress can drive more rapid economic growth by overcoming existing market barriers. The current discussion will give the reader the misleading impression that higher carbon prices lead to not only larger mitigation costs but also worse economic outcomes. The caveats proposed in the text are not sufficient – this should be central to any discussion of economic impacts. [Jan Corfee-Morlot, France]</td>
<td>Taken into account - The authors can only draw upon the literature available to the assessment. We appreciate the reviewer’s call for new real-world developments to be incorporated in the models. We amended the manuscript to highlight that when real-world costs and deployment rates differ from those project in models, carbon price trajectories might differ. See section 2.5.1.2 (about limitations of IAMs in assessing policy options).</td>
</tr>
<tr>
<td>6938</td>
<td>77</td>
<td>17</td>
<td>80</td>
<td>22</td>
<td>I miss a through discussion of the macro-economic impacts of 1.5°C scenarios. That would be much more relevant than the tangency discussion on carbon prices (a result of the way models work and irrelevant for actual policy making). When it comes to discussing carbon pricing as a real world policy instrument (as in the paragraphs from page 79, line 53 to page 80, line 22) then that material should be moved to chapter 4, where all policy instruments will be discussed in an integrated way [see also my comments on the structure of the entire report] [Bert Metz, Netherlands]</td>
<td>Taken into account - A discussion of macro-economic impacts beyond Box 2.2 will be re-considered for the Third Order Draft when the literature for 1.5°C pathways has consolidated. The range of carbon prices for 1.5°C vs. 2°C scenarios provides important policy-relevant information despite the large uncertainty across models. Carbon prices were also reported in previous IPCC reports, e.g. AR5 (Clarke et al., 2014).</td>
</tr>
<tr>
<td>5202</td>
<td>77</td>
<td>17</td>
<td>80</td>
<td>40</td>
<td>The cited models overestimated the costs for renewables and underestimated the costs for FF and nuclear. Thus, the results do not reflect the economic reality. RE expansion is driven through economic advantages of RE. This needs to be reflected in the models. The current state of this section is outdated and incomplete. [Brian Tissie, Australia]</td>
<td>Taken into account - A box on national case studies is under development. Depending on available literature, different countries will be included to the possible extent. Hopefully the distinction can be made.</td>
</tr>
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<td>539</td>
<td>77</td>
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<td>An estimate of the worldwide social cost (direct + external cost, where external costs include health and climate costs of going to 100% clean, renewable energy, with 80% by 2030 and 100% by 2050, which will limit global warming to 1.5°C. [Mark Jacobson, United States of America]</td>
<td>Taken into account - A box on national case studies is under development. Depending on available literature, different countries will be included to the possible extent. Hopefully the distinction can be made.</td>
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<tr>
<td>1188</td>
<td>77</td>
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<td>80</td>
<td>22</td>
<td>The emphasis on economic is justified here. At LAMs, we can discuss whether Ch4 and/or 5 want to have a parallel argument re the social implications of stringent M pathways, esp. regarding justice. On p.79, it would be good to flag some differential impacts between low- and high-income countries. [Petra Tschakert, Australia]</td>
<td>Taken into account - The latest carbon pricing data submitted to SR1.5C database is now</td>
</tr>
<tr>
<td>6497</td>
<td>77</td>
<td>26</td>
<td>77</td>
<td>26</td>
<td>The ‘Cross-Chapter Box’ is Box 2.1 (Roger Bodman, Australia)</td>
<td>Editorial - revised.</td>
</tr>
<tr>
<td>14328</td>
<td>77</td>
<td>26</td>
<td>77</td>
<td>26</td>
<td>The references to Box 2.1 could be simplified (see Box 2.1) and the reference to Box 2.1 on line 32 should be replaced by a reference to Box 2.1. [Eloi PLANTEUX, France]</td>
<td>Editorial - revised.</td>
</tr>
<tr>
<td>16213</td>
<td>77</td>
<td>28</td>
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<td>28</td>
<td>There should somewhere be a discussion of the implications (and shortcomings) of using GWP=100 versus what the models really calculate and versus using different periods for GWP and how GWP=100 can hide and mislead about possible approaches to reducing overall radiative forcing over various time periods. [Michael MacCracken, United States of America]</td>
<td>Taken into account - Please note that there is such a discussion, in the box on metrics in Ch1 that is referred to at the end of this sentence.</td>
</tr>
<tr>
<td>9556</td>
<td>77</td>
<td>45</td>
<td>78</td>
<td>52</td>
<td>This box is also valuable as an example of assessment by SDGs [Shuzo Nishioka, Japan]</td>
<td>Noted</td>
</tr>
<tr>
<td>9583</td>
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<td>45</td>
<td>78</td>
<td>52</td>
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<td>Noted</td>
</tr>
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<td>3181</td>
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<td>45</td>
<td>78</td>
<td>52</td>
<td>box 2.2 should also be eliminated. This discussed of costs and benefits, and how they relate to GDP is highly biased and controversial, yet these important issues are omitted from the box. My Climate Change Economics, vol 7, no. 1, 2016 paper provides extensive discussion issues. But this Special Report is not used to deal with these issues such as the proper interpretation of increases or decreases in GDP. It is a diversion from the main focus the report needs to have. More importantly, this report needs to address other important macro-economic implications of the scenarios discussed in it. Namely, this report should have a more detailed discussion of one of the main benefits to the world economy and unemployment that a 1.5 degree non-overshoot scenario would have compared with a 1.5 degree overshoot scenario. Namely, as in the investment build-up during the early years of World War II, the additional investment requirements of a non-overshoot scenario in the first 10-15 years of its deployment, would very likely drive economic growth, carbon neutrality and happiness. [Richard Rosen, Germany]</td>
<td>Taken into account - The latest carbon pricing data submitted to SR1.5C database is now</td>
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<td>6498</td>
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<td>Also Box referred to here is Box 2.1 (Roger Bodman, Australia)</td>
<td>Editorial - corrected.</td>
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<td>9555</td>
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<td>Insert Gross National Happiness (GNH) of Bhutan as a well known typical national specific goal [Shuzo Nishioka, Japan]</td>
<td>Reported - This aspect is explicitly treated in Ch4, Box 4.1: Case Study: Bhutan - mutually enforcing economic growth, carbon neutrality and happiness.</td>
</tr>
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<tr>
<td>17330</td>
<td>77</td>
<td>7</td>
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<td>It can be useful to use the concept of opportunity cost to explain macro-economic mitigation costs. [Young-Hee Ahn, Republic of Korea]</td>
<td>Noted</td>
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Somewhere here, that the choice of the "climate goal" against which to optimize is very important and must be chosen carefully. For example, in an RCP case prepared around the time of the Copenhagen (2009) meeting, the climate goal was anything like 2 °C (2 W/m²) in 2100. This led, for example, to there being no attempt to choose the likely carbon emissions until 2050 in that IPCC's atmospheric lifetime is less than 2 weeks, so there was no reason to start controlling it until the latest possible and to then discount the cost of doing so over most of the century. The climate effect of this was to allow BC to contribute to global warming for essentially a century and yet this was still consistent with the goal. There was a similar problem with mathews, and some models even allowed overshoots. This was not really caught until some presentations of the comparison study were done, giving some quite misleading implications for policy to speak about. While it can sometimes be mathematically challenging to implement a goal that minimizes climate change and impacts, but this cannot be resolved by choosing a "climate goal" that does not really capture the implications of climate change, sea level rise, ocean acidification, etc. [Michael MacCracken, United States of America]

Noted - Please note that we do not discuss the choice of goal, but rather the choice of policies to reach it. To some extent this choice is touched upon in box 2.1, however. At all events, see Chapter 1 (section 1.2) for a detailed discussion of the 1.5°C climate goal.

I wonder how useful a range of $240-$32,000 is [Jonathan Lynn, Switzerland] Taken into account - data and resulting estimates are being updated in the database as participating modelling teams submit figures for the SODD. However, note that text comparing 1.5 and 2°C estimates was provided in FOD (see p.79, lines 53, and p.79 lines 1-24).

Taken into account - These aspects are now more clearly highlighted and they are touched upon in the Exec. Summary. More quantitative estimates and comparison between 1.5°C scenarios may be included in the next draft as more scenario design characteristics become available.

I see a very important finding and I'm puzzled why this is buried in text and not brought out more strongly. There are other important dimensions of course but this is key information that needs to be brought out clearly (including perhaps more of a discussion of where and when those costs would fall) [Andy Reisinger, New Zealand] Taken into account - yes, a 5% discount rate is used. See caption Figure.

This paragraph clearly shows the limitations of IAMs to say something useful about policies, as the main instrument used in the models is the carbon price. Showing ranges of the carbon price of 250-3,000 $/tCO₂ in 2100 makes clear that this is only relevant for internal usage in the modelling discussions, but not for real world policy. It would be very important to discuss this. It is highly questionable that models which lead to such high carbon prices as a result of limited model limitations (WITCH-GLOBIOM) should really be included in the dataset. [Bert Metz, Netherlands]

Note to editors - Carbon prices in the models are not only internal devices. They show the marginal abatement costs under the given set of assumptions, which is very relevant for assessing the implications of long-term goals. There is also an emerging literature (discussed in the Section), where carbon pricing is combined with other policies. In these cases, resulting carbon prices are the residual pricing (after application of the other policies) needed to achieve emissions goals.
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<tr>
<td>4296</td>
<td>80</td>
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<td>I am not an expert on scenarios, but Figure 2.28 is very, very odd. Discussing on CO2 prices up to 38000 $/tCO2 may be just an indication of something seriously wrong in the model... if there is no error, and you want to maintain the figure, at least plot the same figure with the y-axis going only up to 5000 $, with some of the lines (like the current green line) going &quot;out of scale&quot; soon after 2050. By doing this, the figure will gain quality and resolution on the scenarios that seem more reasonable (i.e., those predicting &quot;feasable&quot; prices of CO2). [Abanades Carlos, Spain]</td>
<td>Noted - Please note that this was the latest data set being reported by participating modelling groups. New data and resulting figures are being updated in the database for the SOD.</td>
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<td>2786</td>
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<td>Figure 2.28 Break the vertical scale so that the one outlier does not obscure the results for all of the other cases. [Erik Haites, Canada]</td>
<td>Taken into account - data and resulting estimates are being updated in the database as participating modelling teams submit figures for the SOD.</td>
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<td>5205</td>
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<td>12</td>
<td>This is simply wrong. RPS only exists in the USA. Feed-in tariffs shoulder the overall majority of RE development over the past decade. The references are both old (almost 10 years) and incomplete. Use new references (see REN21 Global Status Report, IEA World Energy Outlook, IRENA policy analysis). [Sven Teske, Australia]</td>
<td>Taken into account - text revised and expanded (e.g., tradable green certificate schemes, FiT, etc.). Note however that specific policy instruments addressing RET are assessed from an ex-post perspective in Ch4. Links to Ch4 are provided.</td>
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<td>13002</td>
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<td>22</td>
<td>This sentence is not relevant and quite obvious (what does it mean &quot;politically feasible&quot;?). Suggest deleting it. [Cesareni Stefano, Italy]</td>
<td>Rejected - political feasibility is an important element of the &quot;feasibility&quot; dimensions elaborated in Ch1. See e.g. Box 1.3, Table 1 (social and institutional dimension).</td>
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<td>9243</td>
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<td>If the SPA’s are all fragmented, how are global C prices estimated? How do the C prices vary by region? That would be extremely useful information to show... [Glen Peters, Norway]</td>
<td>Taken into account - The SR1.5C database keeps being updated and resulting figures improved. TSU is supporting the design of figures to deliver key message(s).</td>
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<td>17487</td>
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<td>A [Tom Gabriel Johansen, Norway]</td>
<td>Retrieved - political feasibility is an important element of the &quot;feasibility&quot; dimensions elaborated in Ch1. See e.g. Box 1.3, Table 1 (social and institutional dimension).</td>
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<tr>
<td>17527</td>
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<td>A [Angela Morelli, Norway]</td>
<td>Retrieved - political feasibility is an important element of the &quot;feasibility&quot; dimensions elaborated in Ch1. See e.g. Box 1.3, Table 1 (social and institutional dimension).</td>
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<td>7066</td>
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<td>Is the sociotechnical literature expected to be specific of the 1.5°C pathways as compared to the 2°C? No specific challenges have been identified. [Erika Mata, Sweden]</td>
<td>Section 2.6.3 made more specific on sociotechnical literature to 1.5°C.</td>
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<td>6939</td>
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<td>More this section to chapter 5, where the sustainable development implications of 1.5 adaptation and mitigation pathways are discussed. (see also my comments on the structure of the entire report). [Bert Metz, Netherlands]</td>
<td>Rejected - The purpose of this subsection is to set a first order rank of the sustainability profile of different portfolios of mitigation measures found in 1.5°C pathways in this chapter (Section 2.3.4). This mapping allows to better understand the different implications for sustainable development of alternative mitigation pathways (not individual measures) towards the same 1.5°C objective. This will serve as a transition of the storyline in Ch5, where a full assessment of the synergies and trade-offs of individual mitigation measures and sustainable development goals across relevant SDGs’ outcomes is carried out.</td>
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<td>Well done! Something Ch5 can build on - to be further discussed at LAM3, esp. this (table 41-42). [Petra Tschakert, Australia]</td>
<td>Noted</td>
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<td>6166</td>
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<td>delete &quot;, for example,&quot; as you have already said &quot;includes&quot; so this is pointless repetition. [Philip Sargent, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Editorial - corrected.</td>
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IPCC WGI SR15 First Order Draft Review Comments And Responses - Chapter 2
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4208 | 81 | 7 | 81 | 8 | The wording of this sentence indicates there is the possibility of bias against nuclear energy, without fair consideration of the associated hazards and expected trade-offs for renewable energy technologies. As a general comment, it is noted that none of the authors or editors listed appear to have a background in nuclear science or engineering and yet this technology is mentioned several times in the report, although it is noted that this chapter is not oriented to assessing nuclear technology, the absence of a scientist from this field could question the report’s authority and ability to present all energy technologies in a balanced manner. It’s also unclear from the text what risks are being referred to with regard to nuclear energy and the basis for this statement (p.81, line 7). However, please note and give consideration to the following:

- The largest ionizing radiation doses to the public per unit of electricity generated are from coal and possibly geothermal energy. At the individual level, except for some rare and unusual cases, most of the exposure to ionizing radiation to the global public in the life cycle of electricity-generating technologies would all be below the levels at which health effects would be observed (UNSCEAR 2000, 2011, 2017). This latest report from UNSCEAR (2017), that assesses ionizing radiation exposure from electricity generation might be a useful reference to consider.

- Two accidents at nuclear power plants have taken place in the past approx. 40 years of operation. An accident with similar consequences as Chernobyl is no longer considered possible (GRS 1996: p.133 and WNA 2016) and the accident at the Fukushima Daiichi plant is not expected to result in a discernible increased incidence of radiation-related health effects (UNSCEAR 2014).

- The hazardous chemicals required for solar panel manufacturing combined with an absence of many PV companies addressing appropriate recycling, highlights the need for appropriate policies in place to manage this aspect of the life cycle to limit any impact it may have on health or the environment (ILO 2012; SVTC 2014a; SVTC 2014b).

- The highest number of fatalities per TWh for energy sources may be from rooftop solar due to the hazards from falling during installation and the relative high frequency of fatalities from falls (US Department of Labor 2016; 2017; Wang 2008).

- A recent report by the World Bank (2017) states that renewable technologies such as wind, solar, hydrogen and electricity systems are actually more material intensive in their composition than fossil-fuel-based energy supply systems. It notes that a new set of challenges related to the sustainable development of minerals and resources is likely to result from the increased use of renewable technologies. The report warns that it will be necessary to develop appropriate policies and measures that help ensure that the transition to low carbon is managed so that it will not negatively impact sustainable development priorities, from environmental and other material impact issues to supporting continued economic and equitable growth, in developing countries. A lack of data and the need for further research and studies on this issue was also noted.

- Following a survey of photovoltaic module manufacturers, none were able to provide documentation to verify that their supply chains do not contain conflict minerals based on the due diligence guidelines set by the OECD. Thus the companies may contribute, directly or indirectly, to armed conflict, infringements of human rights and impedes economic and social development in the countries. The report mentions the increasing need for transparency and accountability in this area.

*Taken into account - the last section of the chapter is meant to address and highlight all relevant sustainability implications of the 1.5 pathways assessed along the chapter. The order of the sections does not reflect any level of importance but respond to a logical storyline along the chapter.

- There is no reference to risks of large scale deployment nuclear power. According to various life cycle analyses nuclear power externalities are low compared to other energy sources. However, a recent study by the Swedish Environmental Research Institute (2015), which takes into account the nuclear waste management, concluded that nuclear energy has a higher life cycle impact than fossil fuels. It is important to consider the potential risks and trade-offs of individual technologies and their contribution to sustainable development.

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### Comment Response

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<tr>
<td>21112</td>
<td>81</td>
<td>17</td>
<td>81</td>
<td>21</td>
<td>This way of framing the synergies between climate and the other SDGs seems limited: in this sentence the sole reason to look for &quot;aligned&quot; policies is to accept high costs of climate policy - but sustainable development can also be a way to reduce the costs, as for example in relation with the differences between SSP1 and SSP5 baselines. [Philippe Martineau, Belgium]</td>
<td>Accepted - I - get revised. The synergies between climate policies and other societal goals are to be better framed.</td>
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<td>4780</td>
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<td>45</td>
<td>Section 2.6 would be better placed in the beginning of the chapter. In addition, their capabilities and weaknesses for dealing with the 1.5°C question should be also discussed. [Elena Georgoupiou, Greece]</td>
<td>We decided to keep section 2.6 where it is as it is more technical and already covered in parts of AR5. However, we have added to provide better signposting and also further discussion of IAMs for 1.5°C.</td>
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<td>2511</td>
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<td>The placement of this methodological chapter at the end of the chapter, after resulting using the methodological tools are assessed, seems a bit odd. [Robert Krippu, United States of America]</td>
<td>We decided to keep section 2.6 where it is as it is more technical and already covered in parts of AR5. However, we have added to provide better signposting from the other sections.</td>
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<td>7062</td>
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<td>broad range of tools. Well, there is a clear focus on IAMs and, if any of references used other modelling approaches, this was generally not stated. So would disagree with the statement. [Erika Mata, Sweden]</td>
<td>Agrees, text reordered to say tools rather than broad tools.</td>
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<td>14184</td>
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<td>6</td>
<td>82</td>
<td>6</td>
<td>See also the Global Calculator model (<a href="http://www.globalcalculator.org">www.globalcalculator.org</a>), which is a system dynamics model for carbon, energy and land use change (including changes in soil carbon). There is a large number of national 2050 calculators already available as well (see full list of calculators at <a href="http://www.2050.org.uk/calculators">www.2050.org.uk/calculators</a>). Some countries have used their own calculators for preparing their INDCs, and therefore these models have already been used in practice to assist policy making. [Alexandre Strashan, Brazil]</td>
<td>Rejected. We think that calculator pathways are not generally published and are not necessarily consistently interval when adjusted, therefore we do not think it is appropriate to assess here the AR5.</td>
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<td>What is missing here is the fact that there is a new generation of energy models, and data to support such models, that address the question of how to get an energy system to actually function if the penetration of intermittent renewables is particularly high. The feature of these models is that they use extremely high resolution data on the energy system, and on the drivers of intermittency (wind, speed temperature, snow cover) to identify the features of least cost that surpass particular reliability thresholds. See doi:10.1038/nclimate3358, <a href="https://doi.org/10.1016/j.enpol.2014.02.003">https://doi.org/10.1016/j.enpol.2014.02.003</a>, doi:10.1161/energy.2017.07.007, doi:10.1016/j.apener.2017.03.061, doi:10.1016/j.energy.2016.08.068. There are also models coming online that examines issues such as demand response, a tool to match load with intermittent output. See <a href="https://doi.org/10.1016/j.enpol.2017.07.034">https://doi.org/10.1016/j.enpol.2017.07.034</a>. [Anthony Pratt, Switzerland]</td>
<td>We agree with this comment and have added further details of sector specific models. We also point to chapter 4, where they are used as part of implementation strategy.</td>
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<td>it should not abolish one important sector, become: energy-economy-land-ocean-climate system, so that the IAMs would be a comprehensive model for mitigation pathway [Erlina Erlana, Indonesia]</td>
<td>IAMs in the literature couple energy-economy-land-ocean-climate systems to cover the largest sources of anthropogenic GHG emissions sources and drivers. Oceans are captured as part of the climate module, with a focus on their role in shaping the climate response to anthropogenic emissions.</td>
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<td>17429</td>
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<td>Do I get it right that practically one model was applied here? Uncertainty due to that should be open up more clearly at the beginning of CH2. [Tuomo Kalliekari, Finland]</td>
<td>It is not clear what text this refers to. We use MAGICC, consistently calibrated to AR5, this is more clearly explained in Section 2.2 and 2.6.2.</td>
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<td>7063</td>
<td>82</td>
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<td>I do not find accurate sector-specific models have been used, when only two references are given. In particular, Lucron et al (AR5 actually), is at least 5 yr old and the other one 1.5 yr. I understand not all sectoral models yet, so maybe one could simply point at the need. Additionally, the capabilities of sectoral models are not identified, in particular in EU, existing dynamic partial equilibrium models (such as TIMES, TIMES which is nowadays used in many MS and even regions) can explore a range of relevant questions, in combination with a multitude of sectoral bottom-up or hybrid national models (typically combining simulation and optimization). [Erika Mata, Sweden]</td>
<td>The references given here refer to the sector chapters of the AR5 as overviews on the individual sectors. The comparison of integrated pathways with sector-specific model results is presented in Section 2.4 (SOD, formerly Section 2.3, FOD) for example comparisons with IEA models. For a discussion of the capabilities of sector-specific models, the reader is referred to the AR5.</td>
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<td>3182</td>
<td>82</td>
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<td>This sentence confirms that no estimates of climate change caused damages to either the world economy, or to ecosystems, have been included in the IAMs run to produce the scenarios reported in this first draft. Yet, the avoided damages due to more aggressive and quicker mitigation of climate change in non-business as usual scenarios may be one of the biggest benefits, if not the biggest benefit, of aggressively pursuing a 1.5°C degree non-overshoot scenario, starting now. I repeat - this is one of many reasons why the six IAMs used for this first draft should not be used for the next second draft of this Special Report. Also see the model weaknesses described on page 84, lines 9-25. Sometimes modelers claim that their models must be used for certain kind of analyses because they are &quot;good enough&quot;. Unfortunately, the six IAMs used here are not &quot;good enough&quot; to justify their use here, especially given the lack of crucial documentation of both model structures (equations and constraints), and input assumptions such as all of the key technologies. [Richard Rosen, Germany]</td>
<td>The profile of the emission scenarios is determined by the climate goal formulation (which can be chosen to explicitly exclude overshoot although models may no longer solve) and the assumed emissions drivers and mitigation potentials in the IAMs. We have added a sentence to Section 2.6.1 to clarify this. We have cited a new study in Section 2.6.4 (on knowledge gaps) that shows near term emissions reductions can be higher if new estimates of climate damages are taken into account. The benefit of avoiding overshoot is assessed in Chapter 3. The assessment of pathways in Chapter 2 is based on more than six IAMs, and fully covers the available literature on 1.5°C pathways. References to extensive model documentation are provided.</td>
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<td>82</td>
<td>33</td>
<td>In line with the comment above on sectoral modelling, the authors may consider making an effort to summarize the sectoral and regional assumptions of ADVANCE project (specifically since they appear as the core new modelling work of this SR), to facilitate further use in other studies. [Erika Mata, Sweden]</td>
<td>We have now elaborated the advances in IAM modelling since AR5 in greater detail, including the work of ADVANCE.</td>
</tr>
<tr>
<td>9244</td>
<td>82</td>
<td>30</td>
<td>82</td>
<td>54</td>
<td>Well, are they suitable for the task? Why are they not assessed themselves? The models are assumed perfect? I would expect a more thorough assessment at the front of the report? Or is there a reason to not assess the IAMs that are the foundation of the entire chapter? [Olen Petersen, Norway]</td>
<td>We decided to keep section 2.6 as it is more technical and already covered in parts of AR5. However, we have added to provide better signposting from the other sections. We have added more specific discussion of IAMs and their relevance. See also the discussion on knowledge gaps (Section 2.6.4), including a discussion of IAM limitations.</td>
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<td>5207</td>
<td>82</td>
<td>30</td>
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<td>54</td>
<td>The fact that the AR5 assessment and transformation pathways are not different from AR5 is deeply concerning. The data and assumptions reflect the energy technologies and costs from at least 4 years ago. The input data is most likely even older, and the technology choices are outdated. In the past 5 years, solar photovoltaics alone reduced its costs by 80%. Request: Update categories of pathways and adjust scenarios so they reflect the market reality. [Even Teske, Australia]</td>
<td>IAMs have been updated since AR5. We have now provided more detailed discussion of these updates and advances. The reference to AR5 aims to direct the reader to an overview on IAMs, including their basic structure and types. This is not repeated in the Chapter.</td>
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<tr>
<td>12826</td>
<td>82</td>
<td>37</td>
<td>82</td>
<td>37</td>
<td>Since TAR IPCC has been distinguishing three classes of models within the hierarchy that is used for projections: (i) the comprehensive Earth System Models (AOGCMs plus Carbon Cycle components); (ii) Earth System Models of Intermediate Complexity (EMICs), and (iii) Simple Climate Models. In WGI (ii) and (iii) were evaluated and used for projections. Projections with these models were also compared to MAGICC, the model used in WGI5 in WGI Chapter 12 (12.4.2.1 and 12.4.8). The text here suggests that there are only two classes of models, and that MAGICC and EMICs belong to the same class. This is incorrect and could create confusion to earlier reports in which most models with some dynamics are EMICs, while emulators and MAGICC clearly belong to the class of Simple Climate Models. This is not a comment on model quality but an call for transparency in terminology. It is therefore recommended to keep to the terminology for the members of the model hierarchy. [Thomas Stocker, Switzerland]</td>
<td>We agree and have added EMICs accordingly.</td>
</tr>
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IPCC WGI SR15 First Order Draft Review Comments And Responses - Chapter 2

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<thead>
<tr>
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<tr>
<td>1515</td>
<td>82</td>
<td>37</td>
<td>82</td>
<td>40</td>
<td>Not only full GCM/ESM and simple models, but also ESM with medium complexity should be referred to here. [Kerenchi Matsumoto, Japan]</td>
<td>WE agree and have added EMs accordingly</td>
</tr>
<tr>
<td>2928</td>
<td>83</td>
<td>1</td>
<td></td>
<td></td>
<td>1.5 K should be &quot;1.5°C&quot;. [MacDougall Andrew, Canada]</td>
<td>Editorial issue</td>
</tr>
<tr>
<td>6499</td>
<td>83</td>
<td>1</td>
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<td>1</td>
<td>MAGICC's tuning to GAGP may also underestimate the range of uncertainty in its carbon cycle response - calibration against CO2 observations suggests a wider range. [Bodman et al, 2013] [Roger Bodman, Australia]</td>
<td>Accepted: We add further discussion of the veracity of MAGICC and its carbon cycle response</td>
</tr>
<tr>
<td>4346</td>
<td>83</td>
<td>8</td>
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<td>16</td>
<td>In addition to hydropower in the carbon cycle, it may be important to point out that some components of the climate system may not be reversible even if carbon is removed from the atmosphere (e.g. irreversible sea level rise despite CDR). [Tokarska &amp; Zickfeld, 2015] [Jones et al, 2016] References: [Jones, C. D. et al. Simulating the Earth system response to negative emissions. Environ. Res. Lett. 11, 95012 (2016).] Tokarska, K. B. &amp; Zickfeld, K. The effectiveness of net negative carbon dioxide emissions on reversing anthropogenic climate change. Environ. Res. Lett. 10, 1–11 (2015) [Katarzyna B Tokarska, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Accepted: We agree and have added discussion of these papers to the revised section</td>
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<tr>
<td>21113</td>
<td>83</td>
<td>23</td>
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<td>Section 2.6.3: this section is limited to a general description of literature availability. Could you provide more specific information on how what this literature says, if anything, about the feasibility of the kind of transitions needed in 1.5 pathways, their enabling factors, etc.? [Philippe Marbaix, Belgium]</td>
<td>Taken into account: We have made the section for focussed on the needs of our chapter. See also response to comment 10992. We have added a new paragraph in 2.5.1 on insights from socio-technical literature, whereas this section 2.6.3 focuses on existing conceptual/methods and knowledge gaps</td>
</tr>
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<td>10992</td>
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<td>25</td>
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<td>25</td>
<td>Not sure whether this should be in a catch-all section like 2.6. This has turned into WGI III ARS Chapter 61b. To be discussed. [Steeve Jim, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Taken into account: We have made the section for focussed on the needs of our chapter. Clarification: It is important to highlight that socio-technical issues are treated as far as clear/explicit links are identified with the pathways literature. Aspects beyond this are elaborated in ch4 in 2.6.3 we now additionally refer to behavioral literature because its insights have been mentioned in several parts of 2.3, but not 2.6.3. In Section 2.5.1, there is now also a new paragraph on socio-technical literature, which links to Section 2.6.3 to the rest of Chapter 2. The section on initiative-based learning has been excluded from 2.6.3 as this is the territory of Chapter 4.</td>
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<td>7065</td>
<td>83</td>
<td>27</td>
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<td></td>
<td>What about technology? Technology development is clearly underrepresented in IAMs and ESMS (as technology is assumed and broadly described), and barely mentioned in this sociotechnical literature (again implicitly assumed mixed with other drivers, the latter in focus). I do not mean technology should be in focus, but it is as important as geophysical and sectoral equilibrium (addressed in sections 2.6.1.2), and socio-economic forces (addressed in section 2.6.3). It is somehow assumed in this SR that there is sufficient knowledge on the current situation or baseline (the latter of the baseline is mentions in relation to IAMs but no further link is made to a need to improve the mapping of all quantifiable parameters in our studies) as well as [Erikka Mata, Sweden]</td>
<td>Clarification: Technology per se is mentioned (e.g. line 28, 31). All aspects, technology narratives encompassed by SSPs are contained in section 2.3. Limitations associated with IAMs can be found: e.g. in sections 2.1.3, 2.6.1</td>
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<td>743</td>
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<td>37</td>
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<td>41</td>
<td>Kern, H. (2016) [An Analysis of the Sociotechnical Transition Process from the Existing Centralised Alternating Current Voltage Electrical System in the UK to One Where Distributed Direct Current Voltage is Used to Meet The Energy Needs of the Built Environment (PhD). The University of Salford, Manchester ] does give a detailed future transition to a low powered electricity system. In fact the EMerge Alliance in the USA, the IEEE [home standard and the IE’s Code of practice, provide a move in the direction of the use of low voltage electricity systems for the home and office environment, a system that uses less electricity then that of alternating current voltage (Moshe Kern, United Kingdom (of Great Britain and Northern Ireland)]</td>
<td>Technology literature is now assessed. However, note that socio-technical issues are treated as far as clear/explicit links are identified with the pathways literature and this work has been cited for its methodological relevance in Chapter 2.6.3.</td>
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<tr>
<td>9103</td>
<td>83</td>
<td>43</td>
<td>83</td>
<td>47</td>
<td>In addition to the emphasis on initiative-based learning in local studies, the use of participatory learning objectives that are integrated with local needs, opportunities, and solutions may be emphasized based on the related literature. In addition, goal-oriented approach to foster strategic thinking is deemed to be the most critical strategy for mobilizing the capacity to shift the trends of development away from business-as usual scenarios as underlined by [Kropina, H., (2015) Sustainability in environmental education: new strategic thinking. Environ. Dev. Sus. 17 (15), 987-1002.] In addition to this reference, uses of applied learning, action research, and envisioning are also among the tools that have a pivotal role in engaging students in real-world contexts based on [Timely, D., 2011: Education for Sustainable Development: an Expert Review of Processes and Learning. UNESCO, Paris.” A recent example of integrating principles of circular economy into an education model is given by [given by [Kemkani, B.; Kems, B.,. Integrated circular economy and education model to address aspects of an energy-water-food nexus in a dairy facility and local contexts, Journal of Cleaner Production 107 (2017) 1094-1098 <a href="https://doi.org/10.1016/j.jclepro.2017.03.179">https://doi.org/10.1016/j.jclepro.2017.03.179</a>] [Bos KLXIS, Turkey]</td>
<td>Clarification: Socio-technical aspects related to implementation are treated in ch4. In addition, aspects related to sustainability (e.g. beyond IAMs studies) are developed in ch5.</td>
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<td>6073</td>
<td>84</td>
<td>7</td>
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<td>I feel this section needs to be expanded to cover the treatment of technology in IAMs, and their currently large inability to consider endogenous technological change. Also (but not necessarily in this section), where is a discussion of the choice of discount rates and the extent (whether different choices would change any of the model-based conclusions fundamentally (both about timing of options and fundamental feasibility - within the different meanings of this term) [Andy Reisinger, New Zealand]</td>
<td>We have added a discussion of the role of discount rate to Section 2.6.1 and added technology availability as a knowledge gap (among others) in Section 2.6.4. We have clarified (in Section 2.6.1) that there exist a wide range of IAMs, including models with and without endogenous technological change.</td>
</tr>
<tr>
<td>15217</td>
<td>84</td>
<td>9</td>
<td>84</td>
<td>10</td>
<td>This is not a sentence. [Michael MacCracken, United States of America]</td>
<td>Taken into account, text reworded</td>
</tr>
<tr>
<td>5208</td>
<td>84</td>
<td>9</td>
<td>84</td>
<td>34</td>
<td>Add ‘100% RE assessments’ to knowledge gaps [Sven Teske, Australia]</td>
<td>The 100% RE literature has now been referenced in Section 2.6.1.</td>
</tr>
<tr>
<td>6500</td>
<td>84</td>
<td>9</td>
<td>84</td>
<td>9</td>
<td>Delete &quot;attempt&quot;, not &quot;attempting&quot; [Roger Bodman, Australia]</td>
<td>Accepted</td>
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<tr>
<td>10851</td>
<td>84</td>
<td>9</td>
<td>84</td>
<td>28</td>
<td>as mentioned earlier in this review, 60 peer-reviewed articles on 100% RE have been fully ignored, this is a massive knowledge gap. Since 80% of the GHG emissions are from the energy sector, it is not acceptable that more detailed and more progressive energy sector research is fully ignored. Much more references are needed here and the leading research teams should be referenced, such as Lund et al., Blakers et al., Jacobson et al. and Breyer et al., - a good overview on some articles can be found here (<a href="http://atanford.io/2Z6VgRT">http://atanford.io/2Z6VgRT</a>). A most recent article on a full energy transition study for the power sector for the world in 145 regions in full hourly resolution has been accepted in ‘Progress in Photovoltaics’ from the team of Breyer et al. [accepted manuscript can be provided, upon request] [Christian Breyer, Finland]</td>
<td>A discussion of 100% RE scenarios from energy sector models has been added in Section 2.4. The literature has now also been acknowledged in Section 2.6.1.</td>
</tr>
<tr>
<td>6410</td>
<td>84</td>
<td>10</td>
<td>84</td>
<td>10</td>
<td>It is better to include Marine and Fisheries sector (coastal/ocean system) [Efufia Efufia, Indonesia]</td>
<td>Accepted, ocean added</td>
</tr>
<tr>
<td>6501</td>
<td>84</td>
<td>12</td>
<td>84</td>
<td>12</td>
<td>Delete &quot;what&quot; [Roger Bodman, Australia]</td>
<td>Accepted</td>
</tr>
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<td>10581</td>
<td>84</td>
<td>13</td>
<td>84</td>
<td>28</td>
<td>Regional mitigation and adaptation changes can also affect the emission reduction scenarios, and uncoordinated land use type for a region can shift the production scheme, changing projections within a short period. [Esmer Briceno-Elizondo, Costa Rica]</td>
<td>The three systems energy, economy, land are given as examples, they are the core societal subsystems covered by IAMs.</td>
</tr>
</tbody>
</table>
The reader can follow the logic here; you jump from carbon budget numbers, which are poorly explained to statement about policies: Start the topic.

This sentence doesn’t quite make the important point: replace the second half of the sentence to say: “indicating that during the second half of the century active removal of CO2 from the atmosphere into long-term storage has to exceed any remaining emissions of GHGs.” Otherwise the reader would incorrectly assume that removing some small amounts of CO2 would suffice to achieve a net reduction of atmospheric GHG concentration levels and that before 2050 no negative emissions would be needed. [Matthias Henning, Germany]

This entire section describes scenarios of their carbon budgets respectively that presume reaching a net negative emissions flow at several billions tons of CO2 annually. Statements on mid-century carbon neutrality thus need to be appropriately prefaced to say: “presuming the corresponding quantities of NETA will annually be removed from the atmosphere in the second half of the century, many scenarios quantify carbon budgets available by mid-century carbon neutrality at...” [Matthias Henning, Germany]

This term “carbon neutrality” should be properly introduced and defined. It is here used to mean “reaching net zero emissions i.e. a balance of sources and sinks of GHGs”. [Matthias Henning, Germany]

This sentence doesn’t quite make the important point: replace the second half of the sentence to say: “indicating that during the second half of the century active removal of CO2 from the atmosphere into long-term storage has to exceed any remaining emissions of GHGs.” Otherwise the reader would incorrectly assume that removing some small amounts of CO2 would suffice to achieve a net reduction of atmospheric GHG concentration levels and that before 2050 no negative emissions would be needed. [Matthias Henning, Germany]

This term “carbon neutrality” should be properly introduced and defined. It is here used to mean “reaching net zero emissions i.e. a balance of sources and sinks of GHGs”. [Matthias Henning, Germany]

This text is no longer included in the chapter (all SRM material is in the cross-chapter box on this topic).

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<tr>
<td>15620</td>
<td>43192</td>
<td>53</td>
<td>43192</td>
<td>53</td>
<td>Add: “and given uncertainties around the climate response at elevated temperature levels as well as socio-economic uncertainties around the deployment of negative emissions technologies, a greater risk of exceeding 1.5 °C by 2100” [Matthias Honegger, Germany]</td>
<td>Agreed, text revised.</td>
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<tr>
<td>15621</td>
<td>43222</td>
<td>5</td>
<td>43222</td>
<td>5</td>
<td>Add: “with major milestones being reached 10-20 years earlier than in case of 2 degree compatible pathways” [Matthias Honegger, Germany]</td>
<td>Agreed, done.</td>
</tr>
<tr>
<td>15622</td>
<td>43222</td>
<td>26</td>
<td>43222</td>
<td>27</td>
<td>It would be beneficial to add a percentage range of those bioenergy plants that are typically equipped with CCS in these scenarios by 2050 (or before) [Matthias Honegger, Germany]</td>
<td>Rejected - this information could be made available in the chapter body, yet space constraints do not warrant this inclusion.</td>
</tr>
<tr>
<td>15623</td>
<td>43222</td>
<td>50</td>
<td>43222</td>
<td>55</td>
<td>This paragraph is highly problematic as has been pointed out by an increasing number of scholars that are researching the topic of behaviour changes and their role for mitigating climate change. The way it is framed suggests, that consumption patterns and in particular dietary choices are independent of policies. This is clearly not the case as food choices are known to respond to the pricing of various food categories especially but not exclusively in developing countries. This paragraph should be reformulated to highlight the central point which is that food choices are important as the mentioned numbers indicate and that many scenarios have disregarded mitigation policies that aim to influence food choices. While it is understandable to an insider of IPCC scenario development i.e. the basis being the SSPs that it is not the intended meaning, the executive summary should not require such an analytical reading, but rather allow for the key insight to be conveyed in the most straightforward manner. [Matthias Honegger, Germany]</td>
<td>Agreed. These aspects are now highlighted as measures rather than scenario assumptions.</td>
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<tr>
<td>15624</td>
<td>43253</td>
<td>6</td>
<td>43222</td>
<td>6</td>
<td>Add: “and atmospheric GHG concentrations” [Matthias Honegger, Germany]</td>
<td>Rejected - we consider it not necessary to further specify this here.</td>
</tr>
<tr>
<td>15625</td>
<td>43253</td>
<td>8</td>
<td>43222</td>
<td>8</td>
<td>Suggest to add the typical range of annual removals i.e. “with annual removals amounting to between 5 and 15GtCO2 in the second half of the century” [Matthias Honegger, Germany]</td>
<td>Rejected - Unless figures are assessed in the chapter body, they cannot be highlighted in the ES.</td>
</tr>
<tr>
<td>15626</td>
<td>43253</td>
<td>13</td>
<td>43253</td>
<td>15</td>
<td>These two sentences are somewhat incompatible with each other. Are there other CDR options in some scenarios (if so which ones) or are there none? Do some scenarios not include afforestation (otherwise the first sentence is wrong)? [Matthias Honegger, Germany]</td>
<td>Rejected - They are actually compatible. There are other CDR options in some scenarios (like DMC), and some scenarios do not include afforestation.</td>
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<td>15627</td>
<td>43253</td>
<td>20</td>
<td>43253</td>
<td>21</td>
<td>Is this true? What constitutes a marked difference? Seeing the difference in both pace and cumulative volume of NETs required for 1.5°C to 2°C this statement seems debatable to say the least. [Matthias Honegger, Germany]</td>
<td>Accepted - we have changed this to “land-use change dynamics” and included the 2°C value further below.</td>
</tr>
<tr>
<td>15628</td>
<td>43253</td>
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<td>23</td>
<td>We would strongly suggest to insert a percentage figure (the share of global agriculturally productive land) i.e. roughly 13% of global agricultural land [Matthias Honegger, Germany]</td>
<td>Accepted - we have changed this to “land-use change dynamics” and included the 2°C value further below.</td>
</tr>
<tr>
<td>15629</td>
<td>43253</td>
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<td>We would suggest to insert another subheader before this paragraph. The first three paragraphs are clearly describing the need for CDR, whereas the following sections are distinctly focussed on interrelations and challenges in adequate scenario development and thus those paragraphs should have their own subheader. [Matthias Honegger, Germany]</td>
<td>Noted. The ES was restructured in a way the authors deemed most appropriate.</td>
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<tr>
<td>15630</td>
<td>43253</td>
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<td>43253</td>
<td>45</td>
<td>Add: Furthermore, socio-political feasibility (as opposed to technical and economical feasibility) remains exogenous from scenario production and integrated assessment modeling. [Matthias Honegger, Germany]</td>
<td>Rejected - it is debatable whether socio-political feasibility remaining exogenous is a limitation rather than a strength.</td>
</tr>
</tbody>
</table>