

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
12955	0	0	0	0	Introduction of this new chapter in IPCC Report is a welcome move. The chapter would benefit from a discussion on comparison and contrasts in Business innovation and R&D innovation.	Taken into account. This is a good point. We have focussed more on the R&D innovation literature as that is most policy-relevant (rather than mostly academic).	Prashant Goswami	Institute of Frontier Science and Application	India
1925	0				It is important to include a chapter on technology in the AR6 and I suggest that the chapter draw on some quantitative information to better underpin the importance of innovation particularly from the private sector. Two references that I think are helpful are 1) the IEA TCEP which show that 7 out of 45 technologies are not on pace with its SDS scenario, and 2) OECD R&D statistics (global statistics would be even better) that show the dominance of private R&D spending on technology. The chapter currently contains a long list of potential issues innovation; these sets of data could provide a framework to better assess which are priority issues, and which efforts may be productive or counterproductive.	Accept, thank you for those suggestions. The sources would need to be complemented with information with more of a developing-world perspective, including innovation capabilities, which has also been included. Much of what this comment asks for is already in chapter 2.	Haroon Khesghi	ExxonMobil Research and Engineering Company	United States of America
3299	0				Congratulations and thanks to the authors - a clear and helpful chapter.	Thank you.	Klaus Radunsky	retired from Umweltbundesamt	Austria
3309	0				It is suggested to better link chapters 16 and 15. Rapid and strong mitigation needs both: technology and finance but also capacity. As capacity/capacity building has not been given space in a chapter of its own it should be addressed more prominently in oth, chapter 15 and chapter 16.	Accept. We consider capacity as part of our chapter, in particular in section 16.6 (which has been strengthened in that respect).	Klaus Radunsky	retired from Umweltbundesamt	Austria
17545	0				This seems to me a very mixed chapter, with some good material, but overall I fear it lacks either (a) real coherence or a clear message contributing either to overall narrative of WGIII, or (b) to more specific policy and analytic issues. A surprisingly large proportion of the references are very dated, clearly AR5 or earlier - possibly justifiable given the absence of such chapter before, but much modern literature is missing. I believe the authors need to step back and think about what fundamental messages are conveyed in the literature. I believe these include the facts that Innovation: - is not neutral: it has good or bad consequences, largely dependent upon public policy on how innovation is fostered and the consequences are regulated – in the language of Chapter 1, it involves tradeoffs and synergies - is an evolutionary process which inherently involves a combination of push and pull forces, with the transition from push/public-dominated to pull/market (or other user) – dominated, being the most crucial and difficult step - is about much more than just technology, but concerns the wider economic, policy and institutional environmental – not just as barriers but enablers, so that the innovation journey overall includes evolution in a wide range of non-technology factors relating to industrial structure, consumers, finance, regulation, institutions and infrastructure. - has shown huge transformative potential, often underestimated, when pursued at scale (eg. the PV, Wind and battery revolutions); these transformations have all involved this shift over time from tech push to market pull at sale largely driven by public policy - is, in aggregate, positive for economic development, but .. - is very poorly represented in most modeling and as such, models have often misled us about the costs or potential for change, and about dynamically optimal policies Also notable is that the major emitting sectors – energy, materials, etc – are	Noted, points very well taken and acknowledged. We are working with other chapters, including your own, to align the contribution to the narrative, thank you for that. A couple of responses. The older literature is partly a deliberate choice because this is the first time in IPCC that a full chapter is addressing innovation. The good and bad consequences of innovation are indeed important, including rebounds and spillovers, and the dependence on policy. We thank you for the time you have taken to share those valuable insights that give the chapter a good steer.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
25445	1		60		Do not use undefined terms such as "dirty industry".	Accept. Term will be removed.	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
18511	1		64		overall comments (1) the chapter reviews hard and soft technologies. there is one in between which may deserve attention: urban spatial designing. when a city is compact, the infrastructure will require lower carbon intensive materials as compared to spread city form. spatially when functional areas are mixed, i.e. residential quarters and workplaces are nearby, limited or no transport will be needed but transport will be a big challenge when they are apart or far away from one another. (2) appropriate technology. example a building. we have technologies that can construct a building 1000 metres tall. but it can be high energy and carbon demanding as compared to one 100 meters high buildings. that means that some technologies there is no need to go unlimited. (3) some negative technologies. example: oil extracting technologies that can drain the last drop of oil or at a very fast rate. such technologies will accelerate the process of resource depletion. such technologies do not necessarily supportive of lower carbon.	Taken into account. These points will be discussed in the chapter team and included, if there is literature and if there is an appropriate place, through the chapter.	Jiahua Pan	Chinese Academy of Social Science	China
34841	1		64		Chapter 16 looks interesting from the executive summary to the end ... however, it needs better reconstruction by adding global implications and robust dataset to understand the role of technology in climate emergence in the society.	Taken into account. The chapter will be extensively restructured in the SOD. The comment on a robust dataset and climate emergence/y (?) is not clear.	Onema Adojoh	Missouri University of Science and Technology, Rolla, USA	United States of America
9869	1	1	71	59	Avery innovation has limitation because of its relative advantage, therefore one area must be designed with special Innovation.	Noted. That innovations have limitations is something that we aim to address more in the chapter. The remainder of the comment is not clear.	Taufiq Ramdani Karim	University of Mataram	Indonesia
11067	1	1	82	40	It seems that you have disregarded some relevant research, particularly on assessment criteria, policy mixes and interactions.	Noted. We assessed policy mixes in section 16.5. There is also a task division with chapter 13. It would be helpful if the missed literature for this chapter in particular would be indicated.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
14411	1	1	82	40	UNFCCC/UN Climate had some specific initiatives including Nairobi Work Programme or formation of SBSTA to specifically contribute to enhancement of technology and innovation either for climate change mitigation as well as adaptation. So, the comment in Page 5, line 33-34 as "The UNFCCC mechanisms for technology development and transfer have been insufficiently fulfilling the needs of low-emission technologies, in particular in developing countries" may be a bit harsh and undermining their effort. A number of technical reports were published accordingly by them. For developing country, there had been a discussion to relax patent right for technologies, which can be identified as related to climate change mitigation. Even in section 16-6 there is rather insufficient discussion on the effort of UNFCCC/UN Climate and the patent issue for developing countries. Need to emphasize and elaborate this section.	Accept. Section 16.6 in the FOD was indeed incomplete and will be elaborated more in the SOD. However, there is ample literature indicating that the technology needs of developing countries well exceed what international institutions, including the UNFCCC despite its best efforts, provide. This is not intended as undermining those efforts as the need for international cooperation is clear - but as signalling that current efforts are not sufficient.	Md. Sirajul Islam	Department of Civil and Environmental Engineering, North South University, Bashundhara, Dhaka	Bangladesh
2511	1	1	82	47	The chapter needs a more careful use of the English language.	Noted.	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)

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2531	1	1	82	47	I'm afraid figures sources should be placed below them, as a different caption, not in the title. Some figures lack source.	Noted.	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
2535	1	1	82	47	It would probably be good to have a clear definition of the concepts of diffusion and deployment. These two concepts are used throughout the chapter as synonyms at times, and with different meanings at others. At first, deployment seems to be used as early efforts and diffusion as actually becoming widespread. As in: "... includes R&D expenditure (see above) but also investments in demonstration, early deployment, and diffusion" - page 15 table 16.1. Or in: "Although empirical data in energy technologies supports the negative correlation between cumulative deployment of and costs, the size of this correlation is not sufficient to estimate the causal effect of increase in deployment on cost reduction (Nemet 2006)." - Page 19 line 1 The chapter roughly defines diffusion in page 22 line 31: "Market penetration (or technology diffusion) has been shown to proceed non-linearly in a characteristic logistic (S shaped) curve used in the diffusion and technology substitution literature (Gruebler 1996)." But then uses deployment in what would be coherent to use diffusion: "For instance, to increase the chance attaining stringent climate targets such as 2°C or 1.5°C, economic growth should decouple from GHG emissions as soon as possible through the deployment of low-carbon technologies." - page 34 line 10. Or page 35 line 10: "... we note that 2°C degrees climate scenarios characterized by delayed action the forecate particularly steep declines of emissions in the second half of the century. To achieve this, they rely on large-scale deployment of carbon dioxide removal (CDR) technologies, which raise major concern not only in terms of technical feasibility but also, and most importantly, in terms of sustainability." But also uses diffusion with the same meaning: "Technological innovation and diffusion are the major drivers of emissions reductions in mitigation pathways which allow to achieving such large-scale, deep energy transition." - Page 31 line	Accept. We will take this useful and sharp comment into account. The first version in the comment on the difference between deployment and diffusion is the version that we adopted. We should use the term consistently and will see to it that this is done in the SOD.	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
42179	3				might be a good idea to look up O'Brien 2018 ALSO see chapter 17, page 8 lines 21-43 for broader view of innovation	Noted. We are looking up that reference and will see what it says about broadening our innovation view. On first sight O'Brien is about transformations, which indeed has an innovation component.	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
37709	4	7	4	7	"hassles" is very informal, and underplays the real challenges of implementation; suggest "challenges" instead	Accepted: text revised	Michiel Schaeffer	Climate Analytics	Netherlands
40349	4	9	4	9	See below. May create social, economical and environmental impacts	Accepted: text revised	Gunta Kalvane	University of Latvia	Latvia
6289	4	14	4	15	I suggest adding the Storage facilities on the impact of technological change. It has greater impacts on production and marketing processes.	Taken into account: there will be a whole new version of the ES	Brown Gwambene	Marian University College	United Republic of Tanzania
37711	4	16	4	16	"These unintended effects require a better understanding" should be rephrased to, "A better (more thorough) understanding of these unintended effects is required"...	Taken into account: there will be a whole new version of the ES.	Michiel Schaeffer	Climate Analytics	Netherlands
11895	4	18	4	22	Please consider adding a sentence on the importance of policy in avoiding undesired rebound-effects (f.ex. from line 30-33 on p. 9)	Taken into account: there will be a whole new version of the ES	Maria Malene Kvalevåg	Norwegian Environment Agency	Norway

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2503	4	18	4	28	How do the ideas from these two paragraphs relate? Also, the rebound effect has been widely known since before AR5, so any new insight on the rebound effect?	Accepted: the text will be revised for the new version of the ES	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
37713	4	21	4	21	the "likely" here is a hedging word that interrupts the flow of the sentence. it should be omitted, unless it is IPCC's "uncertainty language". If so it should go after the sentence. If neither of these options is applicable, "likely" should linguistically go before the word "eroded". it depends on where and whether the hedging is required / intended.	Taken into account: there will be a whole new version of the ES	Michiel Schaeffer	Climate Analytics	Netherlands
6521	4	22	4	23	The logical flow between paragraphs is not smooth.	Taken into account: there will be a whole new version of the ES	Yeong Jae Kim	RFF-CMCC European Institute on Economics and the Environment	Italy
26031	4	23	4	24	The authors do a fantastic job of expanding innovation insights from the Technology Innovation Systems (TIS) literature. However, TIS is only one of several ways to understand technology innovation processes. It forms part of a broader family of theories, i.e. socio-technical transitions or sustainability transitions. It would be good if the authors could review insights from sustainability transition theories such as Transitions Management (see Loorbach et al, Kern et al, Rotmans et al), Strategic Niche Management (see Rob Raven's coverage of the SNM literature), the Multi-level Perspective (Franck Geels'), for example. This would provide a more nuanced view of theoretical insights that could be applied to the IPCC reporting. This would particularly make sense given that it is the first time that a chapter is dedicated to cover innovation, technology development and transfer within IPCC reports. This would set the tone for subsequent Assessment Reports to give a more representative picture of insights from transitions studies.	Taken into account: there will be a whole new version of the ES. Innovation studies approaches beyond TIS will be an inherent part of the revision.	Zyaad Boodoo	Government of Mauritius	Mauritius
6523	4	23	4	25	When I read 'innovation process' - I immediately think of processes as defined in the innovation systems literature. So I think it would be good to add a couple of innovation system literature to define the term used throughout the report. E.g. Technology innovation system, Functional innovation system, and Energy Technology Innovation System literature.	Taken into account: there will be a whole new version of the ES. This point will be taken up in the chapter text of the SOD.	Yeong Jae Kim	RFF-CMCC European Institute on Economics and the Environment	Italy
37715	4	31	4	31	"legal framework" - should be plural, all the others are in plural form	Editorial: the sentence will be revised in the new version of the ES	Michiel Schaeffer	Climate Analytics	Netherlands
37717	4	32	4	33	the word "depends" is confusing here. Does the 'key driver' depend on the market and institutional factors, OR does the development of the particular technology depend on the market and institutional factors?	Taken into account: there will be a whole new version of the ES	Michiel Schaeffer	Climate Analytics	Netherlands
1935	4	37	4	41	This paragraph seems out of place in a chapter on innovation. Suggest deleting	Accepted: the text will be revised for the new version of the ES. Decision-making is an inherent part of the innovation science literature, so will be retained, but the emphasis will be made more appropriate.	Haroon Kheshgi	ExxonMobil Research and Engineering Company	United States of America
2505	4	37	4	41	Like the rebound effect, discounting has been widely discussed long before AR5. What is new?	Accept, text will be revised.	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)

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11141	4	40	4	41	Section 16.2.1.11 takes three types of cognitive barriers, as well as organizational and political barrier. These barriers should be treated equally in the Executive Summary, and should not take only one example. In addition, those that happening already (species extinction and the melting of polar ice caps), and that can be described stochastically (leaking of uranium - is this mean nuclear power accident or atomic bomb explosion?), and that may or may not happen (failure to deal with hazardous waste) are totally different issue in its nature and shall not be taken into one basket.	Taken into account, in particular in section 16.2. We intend to also speak more about enablers.	Midori Sasaki	Industrial organization	Japan
17555	4	42	4	44	Might want to clarify what means by infrastructure – more than just long lived stock? And to note that infrastructure is a part of the system which may either frustrate or facilitate low carbon innovation (eg. “piggybacking” of new techs on established infrastructure until it can develop its own	Taken into account: there will be a whole new version of the ES. A section with emphasis on infrastructure will not be included anymore.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
37719	4	43	4	43	“is worth mentioning” is rather informal and undermines the importance of carbon lock-in	Editorial: the sentence will be revised in the new version of the ES	Michiel Schaeffer	Climate Analytics	Netherlands
6519	4		4		The overall impression is that the literature is skewed towards mitigation. If you include more of adaptation related stories, that would be balanced.	Noted. It is a fair point that there is more literature on mitigation but this report is on mitigation.	Yeong Jae Kim	RFF-CMCC European Institute on Economics and the Environment	Italy
18231	4	1	5	43	This executive summary must be completely redrafted. The current version does not reflect key findings from sections properly but only pick up minor findings in biased manner. Each section has to be summarized concisely and must be reflected in the executive summary.	Taken into account: there will be a whole new version of the ES	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
6537	4		5		The executive summary should be rewritten in a holistic way. It is currently written in a bit by bit way. In particular, authors should highlight the importance of this chapter explicitly as this is the first time in the history of the IPCC assessment report to include this chapter. Why is this chapter crucial?	Taken into account: there will be a whole new version of the ES	Yeong Jae Kim	RFF-CMCC European Institute on Economics and the Environment	Italy
35589	4		5		The Executive Summary is quite poor. It highlights issues that are peripheral to the chapter, such as the rebound effect and starts with obvious statements about technology. It does not do justice to the chapter and it certainly does not do justice to the subject matter.	Taken into account: there will be a whole new version of the ES. However, rebounds and other unintended consequences of innovation will still play a role as it is both relevant and well documented in the literature.	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)
34749	4	1	64	6	Please include a description to cover the following areas for a more comprehensive report: 1. Economies of scale in technology transfer 2. Redundancy of technology transfer 3. Factors determining the need for technology transfer 4. Investments in R&D for developing technology 5. Benefits to countries by transfer of technology - the giver and the receiver 6. Improvements in the quality of life, economy of the recipient nation, trade benefits 7. Poverty reduction by technology transfer 8. Human resource development, training needs, education and advancement. 9. Management of intellectual property and ownership rights. 10 Possible effects due to exploitation and plagiarism of intellectual property.	Taken into account: there will be a whole new version of the ES, in which these suggestions (to the extent clear and documented in the literature) are taken on board.	Rabiz Foda	Hydro One Networks Inc.	Canada

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35591	4		65		Ch 16 needs a thorough restructure and needs to be much more clearly focused. It needs to get to the point about understanding innovation and be clear about the role of policy. It needs a better discussion of timelines for development of wholly new technologies and therefore the role of innovation policy over the short and long term. the simple presentation provided in https://doi.org/10.1016/j.enpol.2018.08.061 would be a very useful addition.	Accept. We have revised the structure of chapter 16 based on several comments.	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)
42141	4	1			This is a general comment on the whole chapter. (1) I am unclear what the focus of this chapter is meant to be. The title is innovation, technology development and transfer. Does this mean that this chapter is only about technological innovation - because this is how it is written. If it is meant to be any more than this then it is lacking. I would have liked there to be a more clearly orientated innovation chapter and then include the necessary innovation of roles - for example, government roles or institutional rules; also the need for innovation in institutions; innovation in mind set about climate mitigation and the ways of tackling it; innovation in the way people are connected in with climate mitigation issues - including new ways of communicating etc. So as an innovation chapter i feel it is poor. If it is only about technological innovation, then it still is very narrow. (2) the chapter as it stands - has a focus on technological innovation but it is also very economic. There is then a huge overlap with the policy chapter 13 - one section of our chapter is very similar in content to the whole of chapter 16. Chapter 13 and 16 really need to work out boundaries. (3) The refs are pretty old throughout the chapter (4) there is not enough on solutions for innovation. (5) people and society seen absent from this chapter.	Taken into account: the chapter is about technological innvation as well technology development and transfer, and the context in which this happens. Coordination with the respective other chapters will be pursued! The references will be updated.	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
35565	4	3		4	what disruptive innovations have taken place in the last 5 years and in what sense is digitisation the driver? This is waffle	Noted. Text will be revised.	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)
17547	4	3			In energy, not so obvious – yes for DSR and aspects of PV cells, but I’d think the changes in wider solar tech, wind, and batteries are at least as important as digital for climate change	Taken into account: there will be a whole new version of the ES where this will be addressed.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
35567	4	7			hassles'?	Editorial: the sentence will be revised in th enew version of the ES	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)
42143	4	7			hassles' should be replaced	Editorial: the sentence will be revised in th enew version of the ES	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
17549	4	10			It would be nice to also align terminology here with Chapter 1, and as used in some parts of this chapter, re “synergies and tradeoffs” with the multiple goals of societies and sustainable development	Taken into account: there will be a whole new version of the ES, and alignment with chapter 1 will be sought.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
35569	4	12			technological development is both a source and remedy of environmental damage - what does this mean?	Rejected: the sentence is self explanatory	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)

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35571	4	15			why would improving soil yield be an unintended consequence? Or indeed improved productivity, or wealth	Noted, will be revised (editorial)	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)
35573	4	17			Why is the rebound effect singled out in this way? It is not a good example of an unintended consequence and what will a reader take from this? It reads as if it undermines the case for energy efficiency, which it does not	Taken into account: there will be a whole new version of the ES with this point better addressed	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)
17551	4	19			Rebound is a key difference between energy efficiency vs energy supply techs, but is there something specific around innovation to say that is new since AR5? And surely this should cross-refer to chapter 5? The following sentence is too strong – the literature on rebound indicates more context-dependent, and also influenced by policy package – (see later)	Taken into account: the language on rebounds will be improved and the cross-references will be introduced.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
35575	4	23			why 'must' we use TIS to understand anything?	Accept, will be revised.	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)
17553	4	31			Maybe here the place to emphasize that innovation is about much more than just technology – see my overview comments (see comment to 16.3.2 on 'multiple journeys' and associate literature)	Noted: even though innovation is much more than technology, the chapter focuses on technological innovation	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
35577	4	32			starts 'one of the key' and then lists at least 4 items	Editorial: the sentence will be revised in the new version of the ES	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)
35579	4	37		41	Oh good grief. What is the fact base for any of this?	Noted. We will look into this again and make sure the SOD takes care of this.	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)
3301	5	2	5	2	Insert "of" after existence.	Editorial: the sentence will be revised in the new version of the ES	Klaus Radunsky	retired from Umweltbundesamt	Austria
2507	5	3	5	5	This statement should probably relate to the transition framework Chapter 1 presents in 1.5.4	Taken into account: this reference will be introduced in the chapter. (We're not supposed to reference other chapters in our ES.)	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
3303	5	7	5	7	Delete "a" after reaching.	Editorial: the sentence will be revised in the new version of the ES	Klaus Radunsky	retired from Umweltbundesamt	Austria
17559	5	13	5	15	Reads oddly. The literature in general distinguishes 'horizontal' innovation associated with general purpose, vs 'vertical' innovation focused upon particularly sectors and improved ways of delivering specific sectoral services. See eg. OECD references in: Grubb M.J., W.McDowell and P.Drummond (2017), On order and complexity in innovations systems: Conceptual frameworks for policy mixes in sustainability, transitions, Energy Research and Social Sciences, Vol.33:pp21-34	Taken into account: thank you for pointing out this way of distinguishing and the reference.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)

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37721	5	17	5	17	What is understood by "optimistic"? Cost-optimal modeling is just what it is: assessment of trade-offs of mitigation options in terms of costs and then balancing those options along the time axis to minimize overall costs. This type of modeling does not include trade-offs between other time-dependent elements such as those barriers mentioned. The modeling is therefore not too "optimistic", but literally agnostic about those barriers. The models simply provide a balance of options which need to be implemented to reach pre-defined low emissions levels in cost-optimal ways, they don't tell us anything about how difficult it is to actually implement them, and thus are not optimistic, nor pessimistic.	Taken into account: there will be a whole new version of the ES, and this language will be revised. Thank you for spotting this.	Michiel Schaeffer	Climate Analytics	Netherlands
17561	5	17	5	18	I don't understand what this means. Insofar as it seems to say that "cost-optimal" models as applied historically are too optimistic, the chapter itself notes precisely the opposite with respect to PV, and similarly wind.	Taken into account: there will be a whole new version of the ES and this part will be revised strongly.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
43739	5	17	5	20	Minor point, this sounds like 'stranded assets' have to be 'overcome' (as a barrier) before deployment of 'zero and low carbon innovation'. Suggest re-wording as stranded assets may be a barrier to cost optimisation in a theoretical modelling context but stranded assets are not, per se, a barrier to innovation.	Taken into account: there will be a whole new version of the ES and this paragraph will be revised strongly.	Kirsty Hamilton	Chatham House (Associate Fellow, unpaid)	United Kingdom (of Great Britain and Northern Ireland)
11145	5	19	5	20	replace the word "stranded assets" to "carbon lock-ins (technologies)". the word "carbon lock in" is better to use in this context.	Accept, thank you for the suggestion.	Midori Sasaki	industrial organization	Japan
37723	5	24	5	26	"Establishing national innovation systems ... development of a country" This sentence seems like a non sequitur to me	Taken into account: there will be a whole new version of the ES and this sentence will be removed.	Michiel Schaeffer	Climate Analytics	Netherlands
43741	5	27	5	32	To be most useful for policy-makers, it may help for authors to read across between chapters to check how 'policy' or 'policy instruments' are categorised and referred to. I made a comment on Ch6 (Energy Systems) about removing/rewording reference to 'command and control' as a category of policies. Here you have three primary categorisations. Although this chapter is about innovation and technology, many of the same policies are covered within the chapter as Ch6 (and actually Ch15 as well) e.g. the use of FITs for renewables.	Taken into account: this will be done in coordination with chapter 13.	Kirsty Hamilton	Chatham House (Associate Fellow, unpaid)	United Kingdom (of Great Britain and Northern Ireland)
10721	5	33	5	34	It is described that "The UNFCCC mechanisms for technology development and transfer have been insufficiently fulfilling the needs of low-emission technologies, in particular in developing countries" in Executive Summary, but there is no argument to support it in the text of this chapter. Therefore this sentence should be removed.	Taken into account: the literature actually does support such a statement but the current section does need to be strengthened.	Deguchi Tetsuya	Research Institute of Innovative Technology for the Earth	Japan
18243	5	33	5	34	It is argued that "The UNFCCC mechanisms for technology development and transfer have been insufficiently fulfilling the needs of low-emission technologies, in particular in developing countries" but there is no discussion to support this sentence in the report. Therefore this sentence should be deleted.	Taken into account: the literature actually does support such a statement but the current section does need to be strengthened.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
37725	5	33	5	34	In what sense have UNFCCC mechanisms been "insufficiently fulfilling" the needs? The ES must first summarize/define what these needs are, otherwise this is not a meaningful statement. The text preceding this para does not do a good job clearly explaining what those needs are	Taken into account: the literature actually does support such a statement but the current phrasing does need to be strengthened.	Michiel Schaeffer	Climate Analytics	Netherlands
37727	5	33	5	34	mechanisms don't have agency, so I'd suggest "insufficiently facilitated" instead of "fulfilling" and then "the needs of" can be deleted.	Taken into account: thank you for the suggestion.	Michiel Schaeffer	Climate Analytics	Netherlands

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11023	5	36	5	38	These are rather instruments for international cooperation rather than outcomes of the cooperation process.	taken into account, text will be revised.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
8621	5	39	5	41	Duplicates with Line 17-19 on p.16-5.	Editorial: the sentence will be removed in the new version of the ES	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
11897	5	39	5	41	Please consider removing this paragraph as it is already stated in the introduction, where it is more conveniently placed in my opinion	Editorial: the sentence will be removed in the new version of the ES	Maria Malene Kvalevåg	Norwegian Environment Agency	Norway
3305	5	41	5	41	Delete "the" after further.	Editorial: thank you	Klaus Radunsky	retired from Umweltbundesamt	Austria
17557	5	6			It seems to me this would be a stronger place to start the Exec Sum – I'd see the logical order being to start by emphasising that innovation is central, but complex, and build out the other messages from there It would also be useful to flag here the functions of innovation systems (Hekkert et al 2014)	Taken into account: suggestion will be taken into account in the new version	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
35477	5	17		20	The phrase "optimistic in terms of timing of action" is ambiguous or unclear. I'm not sure I agree that there is a robust evidence and high agreement that cost optimal models are too optimistic in terms of technology availability, because in the past I have seen models with very high cost for low-carbon technologies and underestimated (pessimistic) technological progress rates.	Taken into account: there will be a whole new version of the ES and in particular this paragraph	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
43611	5	21			While 16.5.2 substantiates this conclusion, the other direction is also true: early adopters, and niche groups outside of mainstream markets play a key role in pushing new technologies. See for example Nemets book on Solar, and also Creutzig et al 2017 in Nature Energy. Also Rehdanz published on people happy to pay a premium for a clean technology thus helping to make it market ready. So I suggest to add a new point that points to the constructive role of adopters of technologies helping to make it market ready. Also it could point out that technologies must have an end-user perspective to make them attractive. this explains the difference between CCS (doesn't get off the ground, as there is no end-use business case here) and solar (attractive for some even when it was expensive, as it was also a status symbol on the roof, etc.). In chapter 5 there is discussion of the demand-side of technologies. Ch. 5 and Ch. 16 can crosslink here.	Accept, this will be taken into account. This point will also be strengthened in the chapter itself.	Felix Creutzig	MCC Berlin	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
17563	5	28			<p>This mixes up two different dimensions – policy instruments, and the processes they aim to influence.</p> <p>There are various different classification systems of instruments. The “reg, econ and soft” classification misses out R&D, infrastructure, etc ...</p> <p>In terms of the core “3 domain” of economic process (ie. falling sort of existing tech frontier; reallocation of resources around existing tech frontier; and moving the frontier), both regulatory and soft instruments would tend to reflect the “standards and engagement”, respectively, of corresponding First pillar instruments. Whilst R&D & infrastructure are third pillar, acting directly on innovation & strategic development of the technology frontier;</p> <p>[Grubb M. with J.C.Hourcade and K.Neuhoﬀ, Planetary Economics: Energy, Climate Change and the Three Domains of Sustainable Development (Routledge, 2014); Grubb, M., J-C Hourcade, K.Neuhoﬀ (2015), The Three Domains structure of energy-climate transitions. Technological Forecasting and Social Change, 98, 290-302.doi:10.1016 /j.techfore.2015.05.009]</p>	Taken into account: there will be a whole new version of the ES	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
17565	5	31			What are these (indirect policy instruments)? PLEASE strive for consistent use of clearly defined terms.	Taken into account: there will be a whole new version of the ES	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
17567	5	32			<p>One important thing I feel is missing from the Exec Sum is the evidence that the sectors most relevant tend to have low rates of innovation, which</p> <p>(a) Increases the case for public policy and</p> <p>(b) Increases the potential for economic gain from accelerating innovation in those sectors</p> <p>In general, it feels like the chapter is a bit abstract, partly because it says very little about specific sectoral transformations</p>	Taken into account: there will be a whole new version of the ES	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
18245	6	1	6	19	Reference to 5.3.2 must be made as "digitalization, with appropriate policy and planning to avoid rebound effects in place, offers opportunity to drastically cut GHG emissions while meeting economic growth and SDGs goals "	Taken into account. A cross-chapter box on digitalisation will be co-led with chapter 5 and will be placed in chapter 16. Where there's literature, this point will be taken into account.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
18247	6	1	6	19	Refer to 8.3.5.12 and discuss the ICT enabled technological - societal innovation.	See answer to comment 18245.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
18249	6	1	6	19	Refer to 9.4 for a range of technological progress used in building sector. They are essential in cutting GHGs in the building sector.	Taken into account: there will be a whole new version of Section 16.1 in the SOD which will put chapter 16 more in the context of other chapters.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
18251	6	1	6	19	Refer to 10.3 for a range of technologies in the transport sector. They are essential in cutting GHGs in the sector .	See answer to comment 18249	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
18253	6	1	6	19	Refer to 11.3 for a range of mitigation technologies in the industrial sector. Many of them require drastic technological innovation.	See answer to comment 18249	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
18255	6	1	6	19	Refer to 12.6.1.3 for detailed massive GHGs cut potential of general purpose technologies such as ICT and advanced plastics.	See answer to comment 18249, and 18245.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
18257	6	1	6	19	Refer to 6.4 for a range of technology and innovation those are necessary in the energy systems.	See answer to comment 18249	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
18259	6	1	6	19	Refer to 2.6 regarding technological change as the drivers of mitigation.	See answer to comment 18249	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
18261	6	1	6	19	Refer to 1.4.3 for latest progress of technology in general.	Taken into account: the consistency with chapter 1's framing will be improved.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
40353	6	1	6	20	considering that, this chapter is for the first time in IPCC report, additional information is needed, for example the definition for technologies themselves, green technology, digital technology etc. in the text green technology is used as synonym to technology. Providing examples to each of them - digital, green technology - will be useful	Accepted. This will be done more explicitly, though not only in the introduction.	Gunta Kalvane	University of Latvia	Latvia
40351	6	2	6	5	in my opinion, the first paragraph, is redundant. It repeats too many times in the whole document	Accepted; text to be removed	Gunta Kalvane	University of Latvia	Latvia
2499	6	6	6	9	This paragraph mentions only the disruptive technological innovation originated by digital technology and the impacts of that trend on the employment. First, it is necessary to provide some references for the description. Secondly, the deployment of new and renewables would be mentioned after AR5 and explain more complicated impacts on the employment based on the information in 16.2.1.	Partially accepted. Second part -- reviewer comment referring to AR5 is not clear.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2509	6	6	6	9	1. What about renewables steeply falling costs? 2. There is no consensus in the literature that employment impacts of green technologies are necessarily negative. Thus employment impacts can also be positive, in which case it is the opposite of a problem.	Accepted. Will be rewritten to present a more balanced statement on employment impacts.	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
42145	6	6	6	9	this says that digital technology is the major driver of disruptive technological innovations - without a reference - but I would question this.	Noted. References will be provided pointing to the increasing role of digital technologies including artificial intelligence as drivers of innovations, e.g. significant progress is being made in the use of AI to model and test innovative plasma containment solutions fusion reactors.	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
18263	6	21	6	43	This section sounds overly negative towards technology. I suggest, 1st paragraph must highlight more about the positive side of technology, enabler of economic growth and sustainable development. Any statistics show technology leads the progress of human welfare over time. Cite Pinker 2019 "Enlightenment Now" for example. That is why all nations are keen to acquire technology. Then, in the 2nd separate paragraph, highlight the negative side and remedy.	Taken into account. The point of these two paragraphs is that the trajectory of technological development is shaped by the overarching concept of development. The suggested content can be incorporated into a revision of these paragraphs, but the original content probably needs to stay.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
46315	6	21	6	45	I also revised Ch17 (on transitions in the context of sustainable development) so this opening section is duplicative (and superficial) - I would suggest deleting it.	Accepted. Removed.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
40355	6	22	6	23	In my opinion, the first sentence, is redundant.	Accepted. Removed.	Gunta Kalvane	University of Latvia	Latvia
2513	6	23	6	23	How is the 'good life' defined? Any reference?	Taken into account. Source of the phrase in the context of development discourse will be included in SOD.	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
17571	6	33	6	45	Not clear that the 'conventional development model' has any particular prescriptions regarding technology and innovation which need to be 'abandoned'. ? I couldnt really follow the substantive links here What I think SD does imply is a deeper concern about the DIRECTION of innovation	Partially accepted. Literature describing prescriptions exists and will be included in SOD. The content will be modified to emphasize the influence of Devt and SD on the direction of innovation.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
42147	6	33	6	45	unclear paragraph which needs to be rewritten	Noted. The paragraph will be clarified.	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
8623	6	42	6	43	It is difficult to understand without further explanation in the overall context. It should further explain the background theory of Geels (2004) or describe it in a more general way.	Accepted. Elaboration utilizing Geels and related literature will be done.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
2515	6	43	6	43	When talking about niche, regime and landscape I believe you should cite Frank Geels even if you have before, and refer to the framework from Chapter 1.	Accepted. Absolutely. Frank's seminal work will provide a central strand of reference in synthesizing this work.	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
20253	6		7		There is only one sub-section 16.2.1. Consequences of technological change: co-benefits, synergies and trade-offs under Section 16.2 . Should it be another sub-section under 16.2?	Accepted. It will be revised and made a separate subsection.	Thi Lan Huong Huynh	Viet Nam Institute of Meteorology, Hydrology and Climate change	Vietnam
5775	6	21	13	47	Starting this chapter with a section on the potentially negative consequences of innovation in this chapter is a bad idea and could color many readers' view of the entire chapter. The chapter will be stronger if it can start with the necessity of innovation within mitigation and adaptation pathways - at a minimum, providing clear linkages to the discussion of these pathways in prior chapters. In almost all cases of the major phenomena discussed in this section, the answer as to whether the consequences of innovation will be negative or positive is "it depends." Yet, the section dwells more heavily on the negative consequences, for instance for employment. This issue is particularly pertinent to the rebound effect. The rebound effect may limit the impact of energy efficiency in developed countries but in developing countries it is a desired consequence that allows previously-deprived people the chance to utilize vital energy services more fully.	Noted. The chapter is being restructured to emphasize the necessity of innovation, recognizing the need to anticipate and address any unintended consequences.	DAVID HART	GEORGE MASON UNIVERSITY	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
8625	6	21	13	47	[16.2. Restructure the context to associate with sustainable technology innovation] ◦ The discussion in this section should be approached by addressing the major issues that emerge in the process of promoting sustainable innovation in response to climate change. The title should also be revised based on the various issues associated with sustainable technological innovation, not just based on the results of technological change. ◦ The composition and contents of the sub-title should be reconstructed, too. Currently, the contents of different levels and categories are being discussed in parallel. They should be reorganized and categorized accordingly in order to ensure a smooth development of discussion.	Noted. Recent work on factors that influence adoption of innovations in general and sustainable technological innovation in particular will be revisited in revising this subsection. The sub-titles will be streamlined as well to support a clearer storyline.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
6517	6		13		A couple of sub-sections are irrelevant to the key theme of the 16.2. tech changes in the context of sustainable development. I would strongly recommend to reorganise the entire section 16.2. Alternatively, you could re-write up the introduction of the section 16.2 (page 6 two paragraphs).	Partially accepted. In view of previous comments, the alternative suggestion to rewrite introduction will be considered upon discussion within Ch.16.	Yeong Jae Kim	RFF-CMCC European Institute on Economics and the Environment	Italy
18233	6	21	16	48	16.2 is overly focused on negative side of innovation and technology and different from other sections. Article 10 of the Paris Agreement clearly says the importance of technology, innovation and technology transfer for achieving the long-term goals of the PA. I suggest you discuss at first more about the positive side of technology with other lead authors. Any statistics show technology leads the progress of human welfare of the globe over time. Cite Pinker 2019. "Enlightenment Now" for example.	Taken into consideration. This comment is similar to that of David Hart and will be similarly addressed. Pinker 2019 is particularly appreciated.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
8619	6	1	64	3	<p>[Overall, the frame of chapter 16 must be defined more clearly]</p> <ul style="list-style-type: none"> - The direction of technology innovation takes precedence over the amount and speed of technology innovation when responding to climate change. Technology innovation heading into the wrong direction may exacerbate the climate crisis. The focus should be on developing "sustainable" technology innovation, not technology innovation. - Therefore, the contents of the section should also focus on identifying the questions about how to promote innovation in response to climate change, reflecting ways to form a sustainable technology trajectory and innovation system in a larger technology and innovation system that deepens the climate crisis. - Approaches are needed to assess the current situation in terms of R&D investment, technology learning and diffusion, infrastructure building, law and system improvement, demand generation, and ecosystem composition to promote sustainable and green technologies for climate change. - The structure of the article tends to become unclear as it discusses about technology innovation for climate change after discussing general technology innovation and policies. - The current situation requires discussing about expanding R&D and public purchases to promote the development of climate change-responsive technologies in situations in which competition exists between two kinds of technology and innovation systems, one that worsens the climate crisis and one that does not. In the general context of technology innovation, the discussion about innovative purchases and R&D investments being accelerators of innovation does not provide meaningful information because they are applicable to both kinds of technologies. - The title of the chapter could be revised to "Innovation, Technological Development and Transfer for Addressing the Climate Crisis." 	<p>Taken into account. These are useful framings which we will carefully consider. Other reviewers have suggested references that can be used to make some of these points.</p>	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
8683	6	1	64	3	<p>[In conclusion, perspectives on climate change-worsening technology and innovation systems vs. climate change-responsive technology and innovation systems must be suggested first and discussion points for the latter should be developed]</p> <p>- To achieve this, it is necessary to clarify that technological change can evolve in various directions, not on a single-track basis, depending on the direction of the development. In addition, we need to clarify the view that current climate change is a phenomenon evolved through technology and innovation systems that threaten sustainability, and that we need to develop sustainable technologies and innovation systems to overcome its challenges. This is also the perspective of the "Transformative Innovation Policy," which has recently emerged as a new paradigm.</p>	<p>Noted. See response to 8619.</p>	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
35479	6	1	82		<p>The report does require substantial English editing, and a better organization to avoid the repetition of arguments</p>	<p>Noted.</p>	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
36351	6	10		11	<p>What "In the context of sustainable development" means?</p>	<p>Noted. Used in relation to technological development, this phrase is an attempt to point out the influence of SD thinking and policy on the trajectory of technological R&D."</p>	Youba Sokona	South Centre	Switzerland

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
17569	6	13			The chapter does not clearly distinguish deployment, diffusion and transfer. The chapter has 35 references to deployment and 65 to diffusion but it is not clear if these are in fact differentiated, or simply considered interchangeable. There was an IPCC Author email exchange with Chapter 1 which indicated a useful distinction between deployment and diffusion with proposed definitions, and chapter 16 would seem the logical place to clarify this, and ensure also definitions in the Glossary. The distinction is significant in the large Systematic Review of Evidence on Induced Innovation (Grubb and 13 other authors, invited submission to Environmental Research Letters).	Accepted: Section 16.1 will be fully revised in the SOD	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
36353	6	44			Could you please define what sustainable technology means?	Accepted. To be specified as sustainable ENERGY technology.	Youba Sokona	South Centre	Switzerland
2519	7	2	7	17	16.2.1.1 is drawing conclusions from a very specific cut of available literature with the argument that there is no further literature, which does not hold true. A quick search for the keywords "economic impacts green technologies" in Web of Science results 1,038 papers and a quick look allows me to see case studies including employment impacts in China, Brazil, Germany, Sweden and EU in general. Searching for "employment impacts green technologies" resulted in 68 papers including again cases of China, Germany, India and others.	Accepted. This is a fair critique. We are aware of this limited coverage and are reviewing additional papers -- incidentally already using the Bibliometrix R package on WoW to conduct a more thorough search.	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
46317	7	2	7	43	This is standard text on environmental policy and regulation, but this chapter is supposed to be about innovation and technological change (more specifically).	Accepted. This text will be replaced with innovation and technological change focused content and references.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
44989	7	2	7	46	There is no discussion of the relationship of technological innovation and economic growth in general. Since emissions have historically been driven by GDP growth, this is a curious omission.	Partially accepted. The section attempts to establish this relationship by comparing the conventional view of development (= economic growth) to its alternative, SD.	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
42151	7	3	7	17	this seems a very thin paragraph - what about 'just' transitions and efforts in relation to employment = certainly Scotland and Germany	Accepted. Will be expanded based on the approach outlined in response to Comments 44989 and 2519.	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
42149	7	3	7	43	needs far more refs for the statements	Accept. This will be improved in SOD.	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
40357	7	4	7	4	the explanation about green technology would be useful as well some specific and real example	Taken into account. Following the this initial drafting, we currently question the validity of labelling a class of technologies as "green." We expect to resolve this issue in the next draft.	Gunta Kalvane	University of Latvia	Latvia
2517	7	4	7	5	This does not seem to be true. There is a large number of papers studying employment impacts in China mostly, but several other countries as well.	Accepted. Yes, the current text was treated primarily as a 'place-holder.' The next draft will present more diverse (as in global) findings about employment impacts.	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
25433	7	4	7	17	Analysis to also consider national circumstances and capabilities in developing countries.	Noted. The geopolitical scope of the analysis will be expanded to through much needed light on the situation in developing countries.	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
44985	7	4	7	17	This paragraph is largely about the impact on the labour market of policy-induced technological change, and this is not currently made clear. There can also be significant labour market implications of technological change that is not directly policy-induced - see for example instances in which technological innovation in coal mining threatened jobs.	Taken into account. The intension of the paragraph is to highlight the labor market impacts of technological change as such. For this standpoint, direct and indirect effects would seem to be beside the point. Further review of the literature is indeed warranted to address this question.	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
18265	7	8	7	11	The economic impact of stricter environmental policy depends on how green policy is implemented. For example, if poicy increase energy costs and lmiit energy access, it has negative consequence. Citing Vona 2019 alone is very misleading.	Accept. The literature base will be improved in the SOD.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
8629	7	9	7	9	The phrase "At the aggregate level" is mentioned twice in the sentence.	Accept. The duplicate text will be removed.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
8631	7	20	7	20	[16.2.1 Reword the title] - The title is written as "Competitiveness and Trade." However, the actual contents mean "competitiveness in terms of efficiency and trade." In other words, it is explaining the impacts on the probabilities and trade in order to explain the impacts on the competitiveness.	Noted. Title will be modified to align better with the content.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
44987	7	21	7	43	As with the previous paragraph, this largely addresses the impact of technological change induced by policy. If this is indeed the aim, it needs to be rather clearer. Perhaps the heading for 16.2.1. should be "Consequences of technological change induced by climate change policies: co-benefits, synergies and trade-offs"	Accepted. The heading will be updated and content revised along the lines already mentioned in response to previous comment.	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
18267	7	22	7	22	Elaborate more what Kozluk and Zipperer found. Methodological weakness are raised in their paper. This has to be mentioned here.	Accepted. Very much appreciated. Will review the suggested reference and update accordingly.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
8633	7	25	7	26	[16.2.1.2 Provide the solution for enhancing productivity] - The preceding sentence includes an explanation about based on what mechanisms environmental regulations reduce productivity, but this sentence does not provide any explanations about mechanism bases that allow environmental regulations to increase productivity. Some explanations are provided in the latter sentences, but they provide explanations that may or may not increase productivity depending on the circumstances of the entity. Therefore, a description of the mechanism for increasing productivity should be provided after sentences 25-26.	Accepted. Additional summary of current work covering mechanisms for increasing productivity will be included in the SOD.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
26033	7	42	7	43	There seems to be missing references on those "empirical analyses" referred to.	Accepted. References will be included.	Zyaad Boodoo	Government of Mauritius	Mauritius
45115	7	6	8	33	The presence of rebound effects could also be used to make a connection with the need for transdisciplinary research, including the social sciences, in the scope of this chapter for R&D and innovation policy.	Accepted. Some promising transdisciplinary research has been uncovered since this draft. Examples: Santarius (2018), Sorrell, Gaterskeben & Druckman, 2020). These and others will inform revision of this section in the SOD.	Siir Kilkis	The Scientific and Technological Research Council of Turkey	Turkey
8635	7	46	8	4	[16.2.1.3. Not matched with title and contents] The title and contents of "Distribution of Wealth" are not clearly linked. In addition, the contents are more about challenges rather than about "co-benefits," "synergies," or trade-offs.	Accepted. Content will be removed.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
2521	7	2	13	47	I have difficulties in understanding why 16.2.1 comes first in Chapter 16. Chapter 16 is about innovation and technology and broad impacts on sustainable development are being discussed before innovation and technology themselves.	Partially accepted. The attempt here was the outline the effect of development & SD policies on the direction of innovation and technology. This section will be revised to better reflect the storyline of the entire chapter with a view to putting SD front and center.	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
8627	7	2	13	48	[16.2. Necessary for additional information, and clarify the words] - There is only one subsection, 16.2.1, in 16.2 and it seems necessary to group the contents and create a section for greater details. The title says "co-benefits," "synergies," and "trade-offs," but "co-benefits" should be defined more clearly and the difference between "co-benefits" and "synergies" should be clarified, too. The contents are consisted largely of "benefit," "rebound effect," "cost and challenge" (or "expected results," "unexpected results," and "challenges").	Accepted. We will look at the subsections. Other comments will be taken into account	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
35581	7		14		suggest that the whole of section 16.2.1. is moved to later in the chapter so that the chapter starts by explaining technological innovation and diffusion as the reader would expect. This first section is fragmented and weak and need re-writing. Sect 16.3 is far better and more substantive and the right place for the chapter to start.	Taken into account. Sections 16.2 and 16.3 will not be swapped. Instead, the introduction will explain the concepts of technology innovation briefly, as indeed can be expected.	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)
17573	7	3			TBH this seems a very odd place to start. AND, whilst synergies and tradeoffs are in the title (as requested by governments, and as used as part of the Chapter 1 framework), the terms are mostly confined to one main subsection (16.2.1.6)	Accepted. This will be relocated (possibly to 16.2.1.6 or other location) based on the overall restructuring of the chapter.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
17575	7	20			This is a strange section. It is supposed to be reviewing literature since AR5, but there is only one such reference. It seems to entirely overlook the modern literature evaluating the Porter Hypothesis which is centrally about this (e.g Ambec, S., Cohen, M. A., Elgie, S., & Lanoie, P. (2013). The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness? Review of Environmental Economics and Policy, 7(1), 2–22. https://doi.org/10.1093/reep/res016 and Cohen, F., Glachant, M., & Soderberg, M. (2017). The impact of energy prices on product innovation: Evidence from the UK refrigerator market. ENERGY ECONOMICS, 68(1), 81–88. https://doi.org/10.1016/j.eneco.2017.10.020). It confuses substitution effects on trade, with the dynamic impacts of innovation and diffusion. The core point is that there is a competition between short term losses from substitution effects (though the evidence for this is limited in practice), against the national and potentially global gains from innovation. The section needs a fundamental rewrite based on knowledge of the field and clarity about the question.	Accepted. As was the case with other sections, the text here is a place-holder pending more indepth and comprehensive reviews. The suggested literature is much appreciated and will be taken into consideration in revising the section.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
35481	7	46			16.2.1.3 does not contain any reference to back up the claims being made	Accepted. 16.2.1.3 is mostly place-holder text. Additional references have since been found and will inform the revision.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
46319	8	1	8	4	This is the weirdest example to pluck out of nowhere: MaaS has significantly lower barriers to entry for elderly and disabled users than owning and driving a car ... which is highly exclusionary (and by far the dominant mode of transport). And that's it for an entire section on distribution of wealth?!	Accepted. This is indeed a huge topic and will be substantially revised to capture the scope of work on distribution.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
1059	8	22	8	35	These three paragraphs contain some good examples of rebound effects on the "household" end use side (direct energy use in the household and for personal transportation).	Noted	Harry Saunders	Carnegie Institution for Science	United States of America
15465	8	33	8	35	This paragraph is repeated at p. 10 lines 1-3	Noted. Paragraph will be removed.	Simone D'Alessandro	University of Pisa	Italy
6291	8	34	8	38	The two paragraphs should be merged as their conveying the related message in the same perspective and conceptual	Accepted. Paragraphs will be revised to convey a single message.	Brown Gwambene	Marian University College	United Republic of Tanzania
1061	8	36	8	38	The studies by Barker et al. are fundamentally aimed at the production side -- production output of the entire economy (often taken as GDP/GNP). These are the end-use goods and services supplied to households by producers, and contain "embedded energy" from the production processes used to supply them.	Noted. This reference was used in error. Revision of this text will be informed by more relevant work -- including: Du, Shao & Yan (2020); Thomas & Rosenow (2020); Uidir et al (2020).	Harry Saunders	Carnegie Institution for Science	United States of America
1063	8	6	9	33	Other examples of the macro approach to production, which also show large "economy-wide" rebounds like Barker et al.include Fouquet and Stern. Fouquet and Pearson [1] found that rebound effects were greater than 100% in the second half of the nineteenth century in the UK - precisely when Jevons (1865) was writing. Stern [3,4,5] estimates very large rebounds economy-wide:	Taken into account. Suggested references very much appreciated and will be taken into account in the SOD.	Harry Saunders	Carnegie Institution for Science	United States of America
1065	8	6	9	33	It is not too surprising that rebounds would be different as between households and producers as they each use different metrics -- in economist-speak, households maximize utility while producers maximize profit.	Accepted. The distinction (between households and producers) will be made more explicitly in the revision of this section -- reflecting different drivers.	Harry Saunders	Carnegie Institution for Science	United States of America
1067	8	6	9	33	Somewhere in this section should be reference to seminal work of Roy [1] on rebound effects.	Accepted. The Roy work will be captured. However, the section will cite relevant new work post-Roy. 2000.	Harry Saunders	Carnegie Institution for Science	United States of America
1069	8	6	9	33	1.Roy J. 2000. The rebound effect: some empirical evidence from India. Energy Policy 28(6-7): 433-38	Accepted. Please see response to Comment 1067.	Harry Saunders	Carnegie Institution for Science	United States of America
1089	8	6	9	33	Other examples of the macro approach to production, which also show large "economy-wide" rebounds like Barker et al.include Fouquet and Stern. Fouquet and Pearson [*] found that rebound effects were greater than 100% in the second half of the nineteenth century in the UK - precisely when Jevons (1865) was writing. Stern [***, ****, *****] estimates very large rebounds economy-wide:	Accepted. But please note this comment is actually a repetition (most likely accidental) of Comment 1063. In any case, the response already given above applies.	Harry Saunders	Carnegie Institution for Science	United States of America
1091	8	6	9	33	* mRoy J. 2000. The rebound effect: some empirical evidence from India. Energy Policy 28(6-7): 433-38	Accepted. Please see response to Comment 1067.	Harry Saunders	Carnegie Institution for Science	United States of America
1347	8	6	9	33	* Roy J. 2000. The rebound effect: some empirical evidence from India. Energy Policy 28(6-7): 433-38	Accepted. Please see response to Comment 1067.	Harry Saunders	Carnegie Institution for Science	United States of America
17577	8	6	9	33	Surely the rebound effect is covered in Chapter 5? And again, many of he references here are old	Accepted. Rewrite text making reference(s) to Chapter 5. To that end, authors of said Chapter will be consulted about task division.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
8637	8	39	9	3	Duplicates with p.16-10 in box 16.1	Editorial	Soonuk Yoon	Green Technology Center Korea	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
2523	8	6	10	32	Although it is the first time there is a chapter dedicated to innovation and technology in ARs, the concept of rebound effect is quite widespread, has been mentioned before and therefore references from before AR5 (1999, 2007, 2009 and so on) should probably be used with caution.	Accepted. We appreciate this important observation and will exercise the necessary caution in the revision, focusing on material covering the post-AR5 literature (that too, with caution!).	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
4951	8	6	10	32	There is quite a lot of overlap and even identical text in these two subsections - consider merging and simplifying	Accepted. Paragraphs will be revised to convey a single message.	David Stern	Australian National University	Australia
4953	8	6	10	32	These sections could be improved to more clearly differentiate between direct rebound and total or macro rebound and which studies refer to which.	Accepted. Yes, the suggested improvements emphasizing the differences will be developed in SOD.	David Stern	Australian National University	Australia
4955	8	6	10	32	Though you correctly say that measuring macro rebound is harder than direct rebound you should give some examples of the range of results found, which tend to be larger in most cases than the direct rebound. Several lines of evidence point to rebound near 100% in the long run economy wide. I would be happy to send references or my unpublished survey paper (commissioned by Energy Policy and already submitted but not on web as a working paper) on this topic: "How Large is the Economy-Wide Rebound Effect?". Your main reference for economy-wide rebound is Barker et al. (2009) - there has been research since then, though some is formally unpublished as yet.	Accepted. The importance of making this distinction is acknowledged. By all means please send us the unpublished material. Thank you so much!	David Stern	Australian National University	Australia
29045	8	6	10	32	Check for content overlap. Sections could be merged	Accepted. Sections will be merged	Priyadarshi Shukla	Ahmedabad University	India
42153	8	6	10	32	Chapter 5 has a large section related to the rebound effect - and given it is demand one can see that it fits there. This is a boundary issues which needs to be dealt with. IF there is a section in chapter 16, then it needs to be refocused on innovation as opposed to rebound effect in general	Accepted. Please see response to Comment 17577	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
46321	8	7	10	32	This long section on the rebound effect is generic and dated (and the box is repeated in the main text). I thought the point of the IPCC assessments was (mainly) to synthesise new insights since the previous assessment. Rebound can be introduced in a short paragraph, and then any new evidence on rebound should be synthesised.	Noted. That is indeed the point. A thorough review of the literature is underway and will inform the revision of the text along the lines you suggest.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
1057	8	6	13	47	This section discussing rebound effects seems to me missing an important distinction that may possibly improve the narrative, namely the distinction between the consumer end-use side of the equation and the productive side of the economy. These display different rebound effects and different magnitudes.	Accepted. Please see response to similar Comment 4955. The revision of this section will emphasize the distinctions clearly.	Harry Saunders	Carnegie Institution for Science	United States of America
35483	8	6			16.2.1.4 is a discussion of the important rebound effect, however it would benefit from being more critical, because there are substantial issues with causality in this literature. It is possible that the number of cars, for instance, would have kept growing even if efficiency had not increased, and it is possible that efficiency improvements are a direct or indirect result of increased car production. I am not saying that this is the case, but it is important to acknowledge that the evidence is mostly correlational, report it as such, and if possible find studies where causal evidence has been plausibly demonstrated.	Taken into account. Yes indeed, we will be careful in revising this section to highlight studies of causal as distinct from correlational analyses. This is a much appreciated reminder.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
35485	8	22			Please define what the numbers 5-30% refer to exactly (e.g. as in lines 33-35), since this is the first reference.	Accepted. References were omitted in error. Will be provided in SOD.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
8639	9	7	9	16	Duplicates with p.16-10 in box 16.1	Noted. Duplicates will be removed.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
8643	9	8	9	8	ICT --> ICTs	Noted. Care will be taken to use this and other acronyms correctly in context e.g. ICTs instead of ICT, etc.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
19267	9	13	9	16	The Swiss mobile phone example is not one of the rebound effect, I believe. The mobile phone demand increased not because of weight reduction but thanks to new services provided by new kinds of phone. Or the definition of the rebound effect used here should be clarified.	Accepted. This appears to have been added in error. The literature does not suggest a definition that would consider increased variety of services provided on the same device as an example of the rebound effect -- unless it can be shown that the additional services significantly increase phone energy usage (and hence battery repletion rate).	Masahiro Sugiyama	University of Tokyo	Japan
8641	9	35	9	42	[16.2.1.5. Clarify the words] - The terms "short-term," "long-term effects," "direct effects," "micro-level," and "macro-level effects" are being used, but the text does not clearly explain what they are and how they are connected. It is assumed that "direct effects" are being created at a "micro-level" in "short-term" and that "long-term effects" should reflect "indirect effects" that are created at a "micro-level."	Noted. The terms will be clarified. We observe, though, that the reviewer intended to write "macro-level" and not "micro-level" in the last word of the comment?	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
35487	9	43	10	32	repeats from previous page	Accepted. Will be deleted.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
17639	9	35			I'm sorry but I just don't understand the focus on rebound - an issue largely around social and economic responses to enhanced energy efficiency and energy service cost reductions - upfront in a chapter which is about innovation, and in which most scenarios (see ch.3) emphasise supply side substitution, along with a dedicated chapter (Ch.5) on demand and services.	Accepted. As already responded to Comment 17577, we recognize the need to consult with authors of Chapter 5 with a view to ensuring better placement and flow of the narrative; avoidance of duplication.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
6293	10	11	10	32	The 'Box 16.1 Selected Cases of Direct Rebound Effects' should come immediately after line 3 as it cited in that paragraph.	Accepted. This (and other boxes) will be relocated as part of a general and ongoing re-organization of the chapter.	Brown Gwambene	Marian University College	United Republic of Tanzania
26035	10	11	10	32	This box seems redundant given that the text is already covered on pages 8 and 9	Accepted. To be removed.	Zyaad Boodoo	Government of Mauritius	Mauritius
8645	10	33	10	33	[16.2.1.6. Clarify the words] - It is unclear what the title means and how the contents are related to the impacts of technological changes.	Noted. The SOD will revisit the title and content to ensure better consistency in the message delivered.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
13497	10	40	10	41	Tradeoffs also exist with respect to climate mitigation and air pollution. If climate mitigation almost systematically offer co-benefit, air pollution control tends to result in a slight warming (see WG1 chapter 6, executive summary, and section 6.6 in the SOD)	Taken into account. The suggested references will be consulted to inform the content of this section.	Sophie Szopa	Commissariat à l'Énergie Atomique et aux Énergies Alternatives	France
46323	10	34	11	9	This is quite superficial, and duplicative of Ch17 - I would suggest deleting the section.	Accepted. Removed.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
18269	10	42	11	8	It is important to highlight these tradeoff, in particular that of mitigation and energy access. Enrich further these arguments.	Accepted. Further elaboration is certainly needed and will be delivered in the SOD.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
17579	10	10			I really think the authors need to sit down with Chapter 5, discuss what goes where, and the fundamentals of the rebound effect in relation specifically to innovation and welfare. Notably, positive rebound due to innovation is almost always welfare-enhancing - it means people benefit from using more of the associated service	Accepted. As in our response to Comment 17577, we recognize the need to consult with authors of Chapter 5 with a view to ensuring better placement and flow of the narrative; avoidance of duplication.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
26037	11	3	11	6	There seems to be missing references on both bullets.	Noted. References were accidentally omitted. Will be restored.	Zyaad Boodoo	Government of Mauritius	Mauritius
8647	11	3	11	8	[16.2.1.6. Provide more detailed information] - A more detailed explanation or specific title is needed. For example, in the "Climate and Increasing Energy Access," the contents explain about how climate mitigation hinders the transition to clean energy by increasing energy prices (by hindering access to clean energy) but the title indicates climate mitigation facilitates energy access.	Taken into account. The later title was crafted with a view to identifying literature explaining on the extent to which mitigation facilitates access to energy access along a low carbon path. A clearer explanation will be offered in the SOD.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
8649	11	9	11	9	[16.2.1.6. Provide more detailed information] - A brief explanation about how "trade-off" and "synergies" differ in developed and developing countries should be added.	Accepted. This distinction is needed to inform the ongoing and future negotiations between both groups of countries.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
8651	11	11	11	21	[16.2.1.7 Provide more detailed information] - It can be explained together from the "rebound effect" perspective described in 16.2.1.4 and 16.2.1.5. The "rebound effect" itself seems to be "unintended effects."	Accepted. The need for detailed information will be resolved during discussions with authors of Chapter 5 (see responses to Comments 17,577 & 42153). The level of detail to provide will be discussed and agreed in that process.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
44991	11	11	11	21	This paragraph repeats points made previously about the rebound effect, but overlooks other important forms of unintended consequences. The example of the European policy support for diesel is a useful example (see e.g. Cames, M., Helmets, E. Critical evaluation of the European diesel car boom - global comparison, environmental effects and various national strategies. Environ Sci Eur 25, 15 (2013). https://doi.org/10.1186/2190-4715-25-15). A broader point can be made by referring to the European Environment Agency's classic 2001 report "Late Lessons from Early Warnings", which deals with a series of cases in which technological innovation generated unintended effects.	Accepted. We will re-write this and related contents under a new sub-section titled "Unintended consequences." Rebound effects will be mentioned therein, but the reader will be referred to Chapter 5 for more details.	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
26039	11	14	11	16	It would be more convincing if the authors could provide an empirical example to contextualise the point of consumption rebound effect	Accepted. Empirical examples will indeed be sought and synthesized here.	Zyaad Boodoo	Government of Mauritius	Mauritius
6525	11	23	11	23	The sub-section does not belong to the section 16.2.1. Consequences of technological change: co-benefits, synergies and trade-offs.	Noted. Will be removed.	Yeong Jae Kim	RFF-CMCC European Institute on Economics and the Environment	Italy
18271	11	28	11	36	Jakob and Steckel 's argument is very robust across many countries in different development status. On the other hand Du 2015 applies to limited context of strong emerging economy with limited penetration of costly technology. Modify the text accordingly.	Accepted. The text will be updated to capture the work of Du (2015) and relevant later studies.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
44993	11	42	11	46	This section appears to conflate social innovation with the importance of social inclusion in innovation processes. Both are important, but they are clearly not the same. A thorough section might be expected to include reference to "Responsible Research and Innovation" (see Stilgoe, Jack, Richard Owen, and Phil Macnaghten. "Developing a framework for responsible innovation." Research policy 42.9 (2013): 1568-1580.), the older work of Guston & Sarewitz on technology assessment, and work exploring the benefits and limits of wider participation in technological decision-making (e.g. Stirling, Andy. "'Opening up" and "closing down" power, participation, and pluralism in the social appraisal of technology." Science, Technology, & Human Values 33.2 (2008): 262-294.)	Taken into account. This suggested references are highly appreciated and will inform revision of the section with a view to establishing a distinction between the two (preferably supported by empirical studies).	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
46325	11	11	12	34	I struggled to find any discernible narrative through these sections, or even why they were included in a chapter on innovation and technological change. They're quite generic, not always clearly relevant to climate change mitigation, and not a synthesis of recent literature.	Partially accepted. Synthesis of recent literature needs to be better developed. However, the reviewer's suggestion that a discussion of unintended effects should not be covered in a chapter dealing with innovation and technological change needs further clarification. And this clarification should include what he means by "...discernible narrative through these sections..." Which part of these sections, specifically?	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
37901	11	42	12	11	The content of this section doesn't match the title. This text is difficult to understand, isn't a assessment o the literature and doesn't hav confidence statements.	Noted. Rewriting in progress.	margot Hurlbert	University of Regina	Canada
36355	11	9			Developing countries are not homogeneous and there are huge differences among them and less differences between emerging economies and developed countruiies. Could you give some exemples?	Noted. This content will be revised with examples. We are exploring more recent literature following the categorizations and examples proposed by Bradshaw (2013).	Youba Sokona	South Centre	Switzerland
35489	11	16			repeats from the previous section. It would be helpful to regroup and structure all the comments on the rebound effect	Accepted. It is intended to thoroughly revisit this topic in consultation with authors of sections dealing the the rebound issue.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
17581	11	23			There is of course much wider literature around this, but I would think a central reference should the the World Bank study (2018/19) 'The innovation paradox' [Ciera, X., & Maloney, W. (2017). The Innovation Paradox.]	Noted. The suggested reference is much appreciated and will be consulted to inform revisions.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
25435	12	6	12	11	Refer to sustainable consumption and production patterns rather than to "green" production and consumption	Noted. This is exactly in line with our intended response to Kalvane's comment above.	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
8653	12	13	12	13	[16.2.1.10 Provide more detailed information] - 16.2.1.10 only describes general effects of ICT. There is a lack of explanation about the impact of ICT on climate change mitigation and adaptations.	Accepted. The current text will be significantly expanded to capture recent studies.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
40365	12	22	12	22	ICT also change and improve communication process between individuals and scientists. ITC significantly increases the capabilities of citizen science	Noted. We have found interesting strands of scholarly work on the potential and actual achievements of citizen science, including developments in open source knowledge platforms. Some of these will be captured in this section.	Gunta Kalvane	University of Latvia	Latvia
37949	12	28	12	28	"Inequities" would probably be more accurate here than "inequalities".	Accepted. "Inequities" replace "Inequalities."	Patricia Perkins	York University	Canada

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
11025	12	44	12	44	This is not a barrier, but a restriction ("a given"). We all discount the future. The barrier is when extremely high discount rates are used	Partially accepted. It will be helpful to define what "extremely high" would be in this case.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
17641	12	36	13	46	The topic of this section is broad, and covered by a large literature. This entire section - over a full page - only uses one reference, something which indeed was from well before AR5 and does not comprise subsequent literature (Bazerman 2009). The title refers to 'organisational and political barriers'. In the 3-level framework introduced in the Frameworks chapter, these are essentially the meso-level barriers associated with existing market structures and incumbent interests and vested thinking and regulatory structures and regulatory capture. If you want to write about barriers to innovation, diffusion and transformation, please review that literature and /or sit down with the relevant experts eg. from chapters 1, 4, 5, and 13. This entire section, like rebound, needs either deletion, coordination with relevant other chapters, or a fundamental rewrite by someone familiar with the literature	Accepted. This was initially a place holder around which a review of much more diverse literature was to have been done. Suggested references will be included in the re-write for SOD.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
35491	12	36	13	47	16.2.1.9 could be absorbed into 16.2.1.11, which is more analytical and insightful. Also, 16.2.1.11 is based on references that I could not find in the bibliography, and generally speaking, on too few references (and of unknown quality). Some statements, for instance on the negative effects of governmental organizational silos and special interests groups, are plausible and intuitive but need a much stronger empirical evidence to be convincing, or at least evidence of a broad consensus amongst researchers.	Noted. The missing references actually exist and will be provided in the next draft. Will also introduce in the narrative (and possibly boxes, space permitting) relevant empirical evidence.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
46327	12	36	13	47	With respect, this is not a synthesis nor an assessment of literature. This is a 1.5 page summary of one article from 11 years ago in a field which has been phenomenally productive and dynamic over that same period (yielding at least 2 Nobel Prizes for Kahneman and Thaler into the bargain!). I think Section 6.2 as it currently stands should be deleted in its entirety.	Rejected. The entire section should not be deleted in its entirety. Like some of the preceding sections, this is largely a placeholder (which should admittedly have been mentioned in a footnote). In anycase, this section is being substantially re-written. The suggestions to incorporate Kahneman and Thaler will be included in the rewrite.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
18273	12	36	13	48	This section cites only 1 paper, Bazerman 2009, and the argument is very single sided. Delete or rewrite in more balance manner. There are still heavy cost concern and energy access concern in global society. Strong climate policy will conflict with energy policy.	Accepted. See previous reason for the "1-paper" problem, and the solution that will be deployed.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
44995	12	36	13	48	This section is exclusively based on a single reference, which does not appear in the reference list. As I'm sure the authors are aware, there is a rich literature behind each of 'cognitive', 'organisational' and 'political' barriers to deployment, and this section thus needs considerable further development.	Noted. We will implement this recommendation along the lines similar to the response to Lafond above.	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
1937	12	44	13	48	This section seem to attribute a range of social ills to discounting based on a single reference (Bazerman) which I could not find in the reference list. Suggest discussing issues related to discounting relevant to innovation rather than rhetoric arguing that peoples' behavior regarding rate of time preference is wrong. Other factors may be more relevant here such as global commons issues, risk of investment, rule of law, property rights, and private vs societal return on innovation investments. Furthermore since there are rational reasons for decisions made in the marketplace, and since technology innovation is dominated by market-driven efforts, it is important to understand these reasons (rather than argue with them) to understand/assess how policy might change the current trend of innovation investments.	Partially accepted. The missing reference will be included in a rewrite of this subsection.	Haroon Kheshgi	ExxonMobil Research and Engineering Company	United States of America
17583	12	36			Here I think the focus on innovation is getting lost - it seems to be more general discourse.	Accepted. The revised text will sharpen the focus on innovation.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
11143	13	2	13	4	Those that happening already (species extinction and the melting of polar ice caps), and that can be described stochastically (leaking of uranium - is this mean nuclear power accident or atomic bomb explosion?), and that may or may not happen (failure to deal with hazardous waste) are totally different issue in its nature and shall not be taken into one basket. Quotation from "Ackerman and Heinerling" should be deleted or modified.	Accepted. Nuclear accidents were intended. In any case, this section has been removed altogether.	Midori Sasaki	industrial organization	Japan
42155	13	6	13	47	this entire page is based on one 2009 reference	Noted. References will be added.	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
10931	13	6	13	48	This section relies too heavily on one or two sources than are inaccurately described as recent (2009). Given the complexity of the topic of cognitive, organisational and political barriers to the accelerated deployment of climate-friendly technologies, one would expect insights from a wider range of more recent work to be included, even in a summary section.	Noted. We are aware of this issue -- the section will be rewritten to capture synthesis from a much wider body of literature.	Ian Bailey	University of Plymouth	United Kingdom (of Great Britain and Northern Ireland)
26041	13	12	13	14	The delusion of contron or positive illusion manifests also within the climate change domains within project implementation, especially through donor programs, through logical framework (LFA) based project design. Such LFAs are based on the assumption that the logic of scientific rationality framed at the start of a project will remain over the course of project implementation. Years of empirical examples have shown that this is not the case. for example see the article by Boodoo et al 2018 (The implications of how climate funds conceptualize transformational change in developing countries) https://doi.org/10.1080/17565529.2018.1442788	Noted. See response to Comment 10931	Zyaad Boodoo	Government of Mauritius	Mauritius
26043	13	22	13	35	Transitions literature, especially Transition Management refer to such barriers as a reflexivity deficit that prevent transitions to occur. See work done by Loorbach, Rotmans and others.	Noted. Reviews of Loorbach and other work is underway and will be captured in the revision.	Zyaad Boodoo	Government of Mauritius	Mauritius

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
5777	13	36	13	47	This passage over-emphasizes the role of money in US politics. While campaign contributions certainly play a role in shaping the climate debate, there are many other influences that are equally if not more powerful. Regional and cultural interests, for instance, are more fundamental in my view. Even within the frame of federal politics, lobbying is probably more significant as an instrument of corporate power than campaign contributions. The reader receives a very simplistic understanding of the policy process here.	Partially accept. Though the paragraph reflects the paper cited, the section is too one-sidedly based on one paper and will be revised to reflect a more robust literature base.	DAVID HART	GEORGE MASON UNIVERSITY	United States of America
35583	14		10		innovation 'can' be understood using TIS, not 'must', there are other lenses.	Accepted. Thank you for the comment. You are indeed correct. The revised version of Chapter 16 will include two sections. 16.3 will present the economic theories of innovation, including barriers and enablers. Section 16.4 will on the other hand discuss those approaches (lenses, as you say) which revolve around the idea of innovation systems, and related theories	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)
11027	14	5	14	5	This definition of innovation is not sufficiently general. It is circumscribed to technological innovation. Why don't you use the well-known, widely accepted Schumpeter's definition?	Accepted. This is a very good and important point. The revised version of the chapter will include a broader definition of innovation, based on the widely accepted definition of Schumpeter, although other definitions may also be discussed, if needed	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
26045	14	10	14	10	The use of "must" is overly assertive, given that there are many other ways to understand the processes of technological innovation (see first comment on other insights that can be obtained from sustainability transition theories.	Accepted. You rightly notice that "must" is not the correct word, also considerin that IPCC ARs cannot use prescriptive language. The use of prescriptive language will be avoided in the next draft.	Zyaad Boodoo	Government of Mauritius	Mauritius
26047	14	10	14	18	See comment 1 on providing a more nuanced review of other theories of sustainable transitions rather than focussing on TIS mainly.	Accepted. Thank you. See response to comment 35583	Zyaad Boodoo	Government of Mauritius	Mauritius
35493	14	37	14	38	The date "since 1997" must be incorrect since the first Frascati manual dates back 1963	Accepted. The sentence will be modified, as it was written in poor English. The correct meaning was that the OECD collected data on innovatoin metrics (most of which is freely available at aggregate level). Statistics are available starting from the mid-1990s for a reasonable set of countries.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
42157	14	2	17		this is quantitative metrics of innovation - where are non quantitative?	Noted. First, let me note that the SOD referred to "quantitative metrics" which is redundant, given that metric (i.e. a noun, indicating a system or standard of measurement) by definition has to be measurable (i.e. quantitative). The comment is not completely clear to me. Could you please provide examples of metrics that are non-quantitative? A metric (i.e. a noun, indicating a system or standard of measurement) by definition has to be measurable (i.e. quantitative). It would be helpful to have a literature reference to clarify what "non-quantitative metrics" are. Conversely, if you refer to non-quantitative outputs of innovation (i.e. not-easily measurable, such as for instance improved quality of a given product), I fully agree that those should be better described in the section, and we will do so in the SOD	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
46329	14	1	22	36	I recognise that some background 'primer' on innovation fundamentals is necessary, but I think this section 16.3 is too much like a generic primer and not enough about what we have learnt in the last 6 years since AR5 which is relevant for climate change mitigation. Most sections rely heavily on theory, normative assumptions, or normative modelling (i.e., codifying economic theory without necessarily worrying about calibration to real world conditions, imperfections ... realities!). Other sections are quite descriptive. I think the emphasis should rather be on what we have learnt empirically about innovation and technological change which is relevant for climate change mitigation - surely this should be the purpose of this chapter? What an economic model tells us should happen under stylised assumptions is much less relevant than what we have observed to happen over the past 20+ years of climate policy, and the past 40+ years of energy innovation and technology policy.	Taken into account. Thank you for highlighting this problem. Indeed, FOD of this section devoted too much space to discussion of assumptions of selected stylized models (e.g. endogenous growth models). In SOD we deleted all parts which were not relevant for policy discussion. We are also careful about the balance between empirical and theoretical works. There is no doubt that references to empirical literature are necessary to verify and quantify processes underpinning innovations; at the same time we cannot ignore theoretical contributions which are essential for framing policy discussion. We hope that the balance in SOD is a reasonable compromise	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
8655	14	1	30	32	[16.3. Confused structure with parallel descriptions of the general and sustainable innovation] - Sustainable technologies are being discussed after a general discussion about innovation theory and policy. However, it is advised to first identify problems associated with the development and diffusion of sustainable technologies and improvement of legislation and governance system, followed by the description of issues and cases of general sustainable technological innovation. This is because sustainable technological innovation designed to ameliorate the effects of climate change and innovative systems that buttress these technologies are more important than just technology innovation per se.	Partly accepted. Thank you for point this out. We agree that the chapter should be focused on sustainable technologies. In SOD we expanded parts related to sustainable innovations (see e.g. the section on technological change and sustainable development). Due to space constraints we also deleted number of references related to general innovation theories (e.g. all discussion of endogenous growth models). However, we left some key references (e.g. Romer 1990 and Arrow 1962), which help readers to understand the key processes underpinning innovations.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
18235	14	1	30	32	16.3 provides policy relevant basis for considering innovation policy. Very useful. Keep, elaborate further, summarize nicely and reflect it to the executive summary.	Noted. Thank you. We tried to improve the section further in SOD.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
45001	14	1	38	21	I find it confusing that the section on "frameworks for studying the determinants of technological innovation" is found in a separate section from the one discussing 'processes underpinning innovation'. The first half of the text in 16.5.1 (up to page 38 line 21) would seem a better fit earlier on, since it deals with conceptual frameworks that help give structure to thinking about the underpinning processes	Taken into account. Thank you for noting this. Indeed, the structure in FOD was not clear. For this reason we decided to restructure the chapter. In SOD, section 16.3 discusses the innovation process (its drivers and obstacles) from the perspective of standard economic theory. Section 16.4 extends this discussion by presenting the perspective of systemic approaches. Section 16.5 builds on these two perspective to discuss policies.	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
17585	14	1			This section seems to have surprisingly little coverage of the innovation systems literature ... eg. the long heritage of literature from Freeman and the SPRU networks ? Additionally - this seems to me the natural starting point for this chapter	Taken into account. Thank you for noting this. Indeed, the presentation of innovation systems perspective was not consistent in FOD. The new structure of SOD allows us to expose this approach. In the new structure, section 16.3 discusses the innovation process (its drivers and obstacles) from the perspective of standard economic theory. Section 16.4 extends this discussion by presenting the perspective of systemic approaches. Section 16.5 builds on these two perspective to discuss policies.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
8657	15	4	15	4	"Patent forward positions" seems to be the correct expression, instead of "patent citations."	Rejected. The correct wording in the economic literature is "patent citations" -- either as "forward citations" or as "backward citations" (see for instance Popp D, 2002, Induced Innovation and Energy Prices, American Economic Review). "Positions" is not the appropriate terminology in the field of innovation studies. However, we will be sure to fully describe the term in the next version of the Chapter	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
8659	15	4	15	15	[16.3. Provide more detailed information] - Of the "inputs," "outputs" and "outcomes metrics" of "innovation metrics," only a description of the "outputs" is provided. In addition, patent information is frequently used because it is provided in a highly accessible and structured form.	Taken into account. Table 16.1 in the FOD includes a list (and description) of "Commonly used quantitative innovation metrics, organized by inputs, outputs and outcomes.: Listing all possible inputs, outputs and outcomes is beyond the scope of the chapter. Nonetheless, in the revision towards the SOD this table (and the accompanying text in the chapter) will be thoroughly revised to ensure that no major input, output and outcome has been overlooked	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
44997	15	4	15	15	The references here are all rather dated, and the state-of-the-art in using patents has shifted somewhat, particularly in relation to the availability of data, and the international comparability of patents. Work at the OECD might be useful here: Hašič, I. and M. Migotto (2015), "Measuring environmental innovation using patent data", OECD Environment Working Papers, No. 89, OECD Publishing, Paris, https://doi.org/10.1787/5js009kf48xw-en . The OECD patent statistics manual may also be useful, and De Rassenfosse, Gaëtan, et al. "The worldwide count of priority patents: A new indicator of inventive activity." Research Policy 42.3 (2013): 720-737.	Taken into account. This is a good point. The two references you list will be considered for inclusion in the revision of the chapter. The two papers you mention take forward the debate on patents as indicators of innovation activities. The first one is relevant specifically for environmentally related innovation, while the second one applies to using patents in all fields. Yet, the shortcomings we note about patent indicators were well documented decades ago (as testified by the citations). Adding the proposed citations will help make the point that much research effort has been made to make sure that an imperfect indicator is used in the best possible way.	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
18275	15	11	15	15	It is important to discuss the limit of patent analyses. Keep the good sentences here.	Accepted. Indeed, also given the fact that any publication using patents as input necessarily contains a disclaimer pointing to the limitation of this indicator of innovation. A disclaimer to this end will be added in the SOD	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
44999	15	16	15	20	Relevant references here include: Kemp, René, and Serena Pontoglio. "The innovation effects of environmental policy instruments—A typical case of the blind men and the elephant?." Ecological economics 72 (2011): 28-36. For a recent large review and manual on measuring innovation, see Kemp et al (2019). The Maastricht Manual: Measuring Eco-Innovation for a Green Economy. INNO4SD, Maastricht. https://www.zew.de/en/publikationen/maastricht-manual-on-measuring-eco-innovation-for-a-green-economy/ ;	Taken-into-account. The papers listed in the lines commented by the reviewers are those on which the table has drawn upon. We will consider the two citations provided and include them in the list of papers if they determine a change in the table. Nonetheless, the two references may be relevant (hence, to be cited) in the text of the paragraph, rather than in the note to the table.	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
8661	15	25	15	25	[Table 16.1. Provide more detailed information] - It is not clear why "Data on public R&D expenditure typically available" is an "issue." If it is about the availability of data on public R&D expenditure, it should be more clearly explained (it overlaps with the sentences below). In addition, the cell title "issues" should be revised to "characteristics" for a more accurate delivery of its meaning.	Partly accepted. Regarding the first part of the comment, indeed the original writing was not specific enough: the problem lies in the fact that ONLY public R&D is available, i.e. data on private/business R&D is lacking. This is a limitation because the available statistics do not allow to gauge the full amount of R&D investment, and they underestimate this specific input in the innovation process. We will rephrase the commented sentence to give all these details. Regarding the second part of the comment, You are correct in noting that "Issues" is not the correct word to use. Yet, we believe that the word you suggest ("characteristics") is not the correct heading either, because it would imply that we need to describe all the characteristics of the given metric, which in fact is beyond the scope of the table, and of the IPCC AR. A different suggestion, which I believe goes towards addressing your comment, is to name the column "main shortcomings".	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
18277	15	22	17	1	Very informative table. Keep it.	Noted. The table will be improved upon and revised in the SOD. At the moment, we plan to keep it, but we may have to take a different course of action should any issue, for instance length, arise	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
45117	15	22	17	2	Recently, more mission-oriented innovation systems are now focusing on outcomes over outputs. The outcomes include reductions in CO2 emissions, improvements in air quality and the SDGs. Related discussions with references can be inserted in and in the discussions that are based on Table 16.1. Other references may include < http://www.oecd.org/naec/events/mission-oriented-research-and-innovation-in-the-european-union.htm >	Taken into account. You make an important point, yet the reference you provide (a document by M.Mazzucato) is not the best reference; referencing the book published by the same author is more in line with the guidelines for inclusion of the literature in and IPCC assessment report. Referencing the book allows to make the point exact point you suggest. Yet, it allows doing so without only referencing a document which is intended to set a (political) vision for the future.	Siir Kilkis	The Scientific and Technological Research Council of Turkey	Turkey
18855	16		14		Novel technology is disrupting climate change mitigation and offering diverse business models in green environment	Taken into account. We certainly agree with the statement, yet the nature of the comment is not clear (for instance, it is references to pages 16 to 14). We are not sure to what specific text the comment refers to, or whether you were referring to a specific sentence.	Michael Ugom	University of Nigeria, Nsukka	Nigeria
5783	16	1	22	36	I recommend expanding the sections on R&D *16.3.1.1) and diffusion (16.3.1.5) relative to the others. They don't get as much space and attention as they warrant, given their importance to the innovation process. Possibly knowledge spillovers and even learning by doing could simply be incorporated into these sections. In addition, there is no section on demonstration, which is an important and overlooked phase of the innovation process, especially for capital-intensive energy technologies.	Taken into account. Thank you. We merged the section on R&D with the one on learning by doing. We also added a more detailed discussion on diffusion (and other stages of innovation process) and on Technology Readiness Levels in subsection 16.3.1.	DAVID HART	GEORGE MASON UNIVERSITY	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
40359	16				human resources. We also use term full-time equivalent	Rejected. While indeed full-time equivalent (FTE) is one of the way to count human resources, it is not the only one. For instance, statistics and indicators based on education level cannot be translated to (and do not measure) FTEs. FTE is a specific measure that applies to the labour force, which is not the only indicator used for human resources.	Gunta Kalvane	University of Latvia	Latvia
35495	17				The metric "learning rates" is too narrow. It should include rates of cost reduction as a function of time (percent per year), in addition to the classical "learning rates" (cost reduction of a function of experience). There may also be a metric on "technical performance", for instance based on technical records and independent of cost, e.g. efficiency for solar panels, or energy density for energy storage technologies. See for instance Koh, H., & Magee, C. L. (2008). A functional approach for studying technological progress: Extension to energy technology. <i>Technological Forecasting and Social Change</i> , 75(6), 735-758. These technical performance metrics are essential to construct quality-adjusted cost metrics.	Accepted. The wording "learning rates" has been changed to "technical performance metrics". The text now also clarified that "technical performance metrics" include cost reductions calculated either based on Wright's law or Moore's law, but also also other key metrics such as efficiency and energy density.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
44191	18	1	18	1	There is a missing sub-section in 16.3.1, on economies of scale. Several studies have identified scale as a specific factor in reducing technology costs. See for example (in addition to those already cited in the chapter): Gambhir, A., Sandwell, P., Nelson, J., 2016. The future costs of OPV – A bottom-up model of material and manufacturing costs with uncertainty analysis. <i>Sol. Energy Mater. Sol. Cells</i> 156, 49–58. https://doi.org/10.1016/j.solmat.2016.05.056 Isoard, S., Soria, A., 2001. Technical change dynamics: evidence from the emerging renewable energy technologies. <i>Energy Econ.</i> 23, 619–636. https://doi.org/10.1016/S0140-9883(01)00072-X ; Yu, C.F., van Sark, W.G.J.H.M., Alsema, E.A., 2011. Unraveling the photovoltaic technology learning curve by incorporation of input price changes and scale effects. <i>Renew. Sustain. Energy Rev.</i> 15, 324–337. https://doi.org/10.1016/j.rser.2010.09.001 Zheng, C., Kammen, D.M., 2014. An innovation-focused roadmap for a sustainable global photovoltaic industry. <i>Energy Policy</i> 67, 159–169. https://doi.org/10.1016/j.enpol.2013.12.006	Taken into account. Thank you for pointing this out. We added a paragraph that discuss economies of scale using also the references that you provided (thank you for this). Unfortunately we could not add the discussion of all those references due to space constrains.	Ajay Gambhir	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
2381	18	1	18	24	There are no description on the responsibility and role of Government. It is necessary to add up that part in the text.	Taken into account. Thank you for noting this. The responsibility and role of governments is one of the central topics of the chapter. In SOD it is discussed in section 16.5. Specifically, the narrative we adopted in SOD is as follows: section 16.3 discusses the innovation process (its drivers and obstacles) from the perspective of standard economic theory. Section 16.4 extends this discussion by presenting the perspective of systemic approaches. Section 16.5 builds on these two perspective to discuss policies.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
45007	18	1	18	24	The discussion about R&D omits a critical issue: the role of R&D in generating firm-level absorptive capacity. The classic paper is of course Cohen & Levinthal, though Zahra & George 2002 is also a useful review. R&D is undertaken to improve the capacity of the firm to learn from others.	Noted. Unfortunately, we were not able to cover this topic due to space constraints. We had to shorten the section significantly and we were not able to cover all topics suggested by the reviewers	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
11029	18	3	18	10	Bear in mind that which market structures preferably lead to innovation is an old topic in the innovation economics literature, with a debate on whether monopolistic structures rather lead to innovation or not.	Taken into account. Thank you for this note. We realized that a fair discussion of this issue would require more space. Due to space limitation, we decided to delete the reference to market structure and its discussion.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
2525	18	3	18	14	This conceptualisation of R&D does not read as an assessment of the literature. It relies heavily on Romer's early publications reflecting, again, a specific, not well justified, cut of literature. Undoubtedly Paul Romer needs to be cited, but it now reads a little as it's Romer's manual.	Partially accepted. Thank you for noting this. Due to space limitation, we decided to delete the discussion of endogenous growth models. However we left the reference to Romer where we discuss the externalities of R&D and the appropriability problem.	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
40361	18	4	18	4	new solution is also the new service not only product.	Editorial. Corrected, thank you.	Gunta Kalvane	University of Latvia	Latvia
40363	18	5	18	10	the paragraph states that technology companies are initiating innovation, but today universities are also actively involved in the innovation process and investing money in innovation.	Noted. Thank you for this comment. Please note that we deleted this part due to space constraints. Please also note that in SOD we acknowledge the role of universities in Section 16.4, which discusses the systemic perspective of innovation process	Gunta Kalvane	University of Latvia	Latvia
5779	18	11	18	14	This passage refers to "monopoly rents." I believe this term will be misinterpreted by many readers, although it may be accurate in the context of specific models and economic discourse. Corporate R&D are typically funded out of retained earnings (profits) or investments, although even loss-making firms may sometimes make such investments if they are deemed vital to the firm's strategy.	Taken into account. Thank you for this note. We realized that a fair discussion of this issue would require more space. Due to space limitation, we decided to delete the reference to market structure and its discussion.	DAVID HART	GEORGE MASON UNIVERSITY	United States of America
45005	18	11	18	14	Many technology firms finance their research not with monopoly rents, but with finance provided by others in the expectation or hope of future monopoly rents. In general, the importance of expectations - both of technological possibilities and market opportunities - is given insufficient attention in the chapter.	Partially accepted. Thank you for this note. We realized that a fair discussion of this issue would require more space. Due to space limitation, we decided to delete the reference to market structure and its discussion. We also added a paragraph on expectations in subsection 16.3.6.2 (with references to Greaker, 2018 and Aghion et al., 2014)	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
18279	18	20	18	20	Learning by searching is not widely used terminology. Use different words for showing your idea correctly.	Accepted. Thank you for noting this. We replaced the term learning-by-searching with 'research and development'. We left reference to learning by searching only in the discussion of learning curves.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
44193	18	20	18	20	It would be beneficial if the major IAMs (such as those used to produce RCPs and SSPs) were listed in a table, with a description of how they treat technological change. This could also include a description of how closely their assumptions have matched reality or other forecasts, drawing from Krey et al (2019). Looking under the hood: A comparison of techno-economic assumptions across national and global integrated assessment models, Energy, 172, 1254-1267, https://doi.org/10.1016/j.energy.2018.12.131	Taken into account. We did include a box in IAMs and how they represent technological change. While this does not fully implement your suggestion of a detailed table on major IAMs (note: how do distinguish a "major" IAM is per se an interesting question, so we decided not to go down that path), it does go into the direction of addressing your comment: clarify assumptions about the modelling of technical change. In the current box on IAMs, we specifically focus on two aspects of modelling technological change in IAMs: (1) cost reductions and (2) deployment/diffusion. We included two figures showing the range of those two variables in the IPCC Scenario Database. A more complete overview of IAMs belongs in chapter 3.	Ajay Gambhir	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
8665	18	42	18	45	[16.3.1.2 The expressions should be modified or appropriate references should be provided] - Not all entities do not want to be "first adopters." Entities pursuing "first-mover advantage" will strategically want to become "first adopters," expecting the benefits they will have in the future despite initial cost losses. In the case of climate change and sustainable development technologies, they may not necessarily want to become "first adopters" if the "first-mover advantage" is not as large as "disadvantages." An additional explanation or references should be provided to support this claim.	Accepted. Thank you for your comment. This is a good point and ideally, we would discuss it in detail. Unfortunately, we have very constrained space in this section, so we could not add lengthy discussion. We made the wording of the sentence more careful, added reference to Isoard and Soria 2001 and we added a condition: "If this disadvantage overweight overwhelms the advantages of being a first mover (see e.g. Spence, 1981, and Bhattacharya, 1984.)..."	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
8667	18	43	18	45	[16.3.1.2 A description about the "lock-in effect" should be added] - The reason why new technologies do not spread quickly in the market in the early stage is because of their lower performance and higher price compared to conventional technologies. They only describe about prices but not about performance (technology development).	Accepted, thank you for this comment. We added a reference to low-performance. Note also that in SOD we discuss lock-in in section 16.5.2.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
45003	18	1	20	19	The discussion here of R&D and learning-by-doing, and subsequently the section on spillovers, omit important forms of learning. Malerba 1992 provided a great overview of 6 mechanisms of learning, including learning by searching and learning by doing, but also learning through interacting with users and suppliers. The current framing of the this section is rather narrow.	Taken into account. The revised version of the chapter now discusses the "linear" model of innovation (so-to-say) in section 16.3 and the "systemic approach" to innovation in section 16.4. In section 16.4.1 we specifically refer to the functions of innovation. In this way, we believe we address you comment in that we provide a less narrow framing for innovation, the innovatoin system and the process of learning.	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
45009	18	1	22	28	There are a couple of processes that seem to be missing in this section: process of maturation of technologies, and the resulting technology and industry life-cycle effects; and (related to this) scaling dynamics.	Taken into account. Thank you for pointing this out. In SOD we added a more detailed discussion of stages of innovation process in section 16.3.1. Section 16.4 also presents the systemic view of innovation. , which includes the mechanisms you mentioned.	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
8663	18	2	22	37	[16.3.1. Provide more detailed information] - Overall, an explanation about the "innovation process" for the energy sector should be provided. Typical innovation models include linear models, chain linked models, etc. and require descriptions of the innovation processes of technologies related to climate change or sustainable development, such as energy technologies. (Ref: Costantini et al., Demand-pull and technology-push public support for eco-innovation: The case of the biofuels sector, Research Policy, 2015; Greco et al., Open innovation in the power & energy sector: Bringing together government policies, companies' interests, and academic essence, Energy policy, 2017) There are also several types of learning that lower costs. (Ref: Shum et al., Towards a local learning (innovation) model of solar photovoltaic deployment, Energy policy, 2008)	Taken into account. Thank you for noting this. In SOD we added a new section 16.4 which describes innovation process from the perspective of innovation systems and covers the topic you mentioned.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
2527	18	1	30	32	Although chapter 16 dedicates quite much length to conceptualisation, using early references, it does not mention Joseph Schumpeter at all. And then cites more recent conclusions of academics who have Schumpeterian economics in their basis, such as Mariana Mazzucato. Chapter 15, on the other hand cites Schumpeter 10 times, so there should probably be more consistency.	Accepted. Thank you for this note. We included the reference to Schumpeter 1934 in the introduction of the chapter.	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
35497	18	3		24	This paragraph describes the assumptions of some theoretical models, rather than results from the literature. The style is not appropriate. For instance, the assertion "investment in search...is motivated by the desire to reduce the cost of production" is really an assumption of standard economics models, not a fundamental truth. This is only one example, but there are others in this section and elsewhere. Besides making it explicit that these are assumptions from economics rather than empirical evidence, it would be useful to also document the actual empirical evidence, when it exists.	Accepted. Thank you for highlighting this problem. Indeed, FOD of this section devoted too much space to discussion of assumptions of selected stylized models (e.g. endogenous growth models). In SOD we deleted all parts which were not relevant for policy discussion. We are also more careful about the balance between empirical and theoretical works. There is no doubt that references to empirical literature are necessary to verify and quantify processes underpinning innovations. We added several references related to learning by doing (e.g. McDonald and Schratzenholzer 2001, Rubin et al. 2015 and Samadi, 2018, Klaassen et al. 2005 , Mayer, T., Kreyenberg, D., Wind, J. & Braun 2012; Bettencourt et al. 2013)	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
18281	19	6	19	8	It is important to highlight that the relation could reflect reverse causality. Keep this sentence.	Noted. Thank you for the note. We keep this sentence in SOD.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
17643	19	7	19	8	Our Systematic Review (Grubb + 12 others authors) goes into some detail on this issue of causality, and suggests the distinction between deployment and diffusion, though itself not clean-cut, is significant in this regard. The distinction is also useful in relation to the wide framework of 'Emergence, Diffusion, and Reconfiguration' in overall Systems Transition (see eg application in Victor D.G, Geels F.W, Sharpe S. (2019): Accelerating the Low Carbon Transition: The Case for Stronger, More Targeted and Coordinated International Action, Brookings/Energy Transitions Commission, http://energy-transitions.org/sites/default/files/Accelerating-The-Transitions_Report.pdf). Deployment can be considered as the final stage of emergence, before the market feedbacks of diffusion start to dominate.	Taken into account. Thank you for noting this. In SOD, and specifically section 16.3.1, we provide a more detailed discussion of the stage of the innovation process, and link them to the discussion on TRLs.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
5781	19	10	19	27	This paragraph is confusing in the context of the prior discussion of R&D as "learning by searching." It will be important to settle on a consistent set of terms and use them systematically.	Accepted. Thank you for noting this. We replaced the term learning-by-searching with 'research and development'. We left reference to learning by searching only in the discussion of learning curves.	DAVID HART	GEORGE MASON UNIVERSITY	United States of America
18283	19	10	19	27	These sentences are well balanced good summary of the current status of knowledge regarding the attribution of cost reductions to different policies and processes.	Noted. Thank for your note. We rephrased this part in SOD, but we kept the key message.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
18285	19	41	19	41	"nuclear power in OECD countries" should be change to "nuclear power in some OECD countries due to increasing safety requirement and changing market conditions". Or, it would be better to delete it and discuss nuclear cost issue in 16.3.1.4	Accepted. Thank you very much for this note. We rephrased the sentence following your suggestion	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
17649	19	41	19	42	To my knowledge these are the only two cases of 'negative learning', out of several hundred (possibly a thousand) cases.	Taken into account. Thank you for highlighting this. We changed the wording of this sentence to make it clear that negative learning is the exception rather than the rule	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
17651	19	44	19	46	Another statement with no reference, that seems to me incorrect. WITCH, E3MG, a couple of others. TIAM and MESSAGE had experimental versions with experience curves but abandoned it as too complex and unstable. Liaise with Chapter 3 about how many of the models there do have endogenous innovation in this or other form	Taken into account. Thank you for your note. SOD now contains a box on IAMS, which has been developed in coordination with chapter 3. In there, details are given with respect to how models can endogenize technical change.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
18287	19	48	20	3	It is important to highlight that the relation could reflect reverse causality. Keep this sentence.	Noted. Thank you, we keep this message in SOD.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
17645	19	10			Note that learning curves - or experience curves - are about much more than learning-by-doing. Indeed the major component cost assessments (eg. Kavlak et al) identify scale effects, and R&D (both public and private) as more important at least for renewables	Accepted. Thank you for your comment. We revised the text and added the reference to Kavla et al. Unfortunately, we were not able to add a more detailed discussion due to space constraints.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
35499	19	23			Do you really mean "cross sectional data"? Or simply time series data disaggregated by component?	Noted. Yes, you are right. Unfortunately we had to delete this sentence due to space constraints. We still refer to the role of scale effects and material costs in the other parts of the chapter	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
35503	19	28		43	The key point missing here is that technologies have different rates of progress, whether as a function of time or experience. This is not only about nuclear having increasing costs. Tidal energy and solar PV have different rates, for instance. These rates are very different across technologies, but within a given technology, are relatively stable	Accepted - text revised. Thank you. We included one paragraph that discusses uncertainty associated with learning rates (including the reference to Lafond et al. 2018) and its policy implications. We also included references on the differences in learning rates between technologies	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
35501	19	36		39	It seems that a reference is missing. In which paper is there a "systematic comparison"?	Accepted - text revised. We added the reference. Thank you.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
17647	19	40			What is the reference for this? Doesn't the evidence of renewables growth suggest precisely the opposite or have I misunderstood? The only projections that got anywhere remotely close were those using experience curves. There are probably better sources, but the paper by Grubb M, and C. Wieners (2020) includes a chart showing just how wrong cost projections have been even over the past few years. Modeling Myths: On the Need for Dynamic Realism in DICE and other Equilibrium Models of Global Climate Mitigation, Institute for New Economic Thinking, Working Paper No. 112. https://doi.org/10.36687/inetwp112	Taken into account - text revised. Thank you. We tried to make this discussion much more careful. Also, thank you for the reference. We used it in the chapter.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
17653	20	4	20	6	Isn't this stating in a different way the fact that there are feedbacks between deployment and the multiple source of innovation - Bettencourt and other have demonstrated that deployment is associated with enhanced private R&D expenditure and patenting.	Taken into account. Thank you for pointing it out. In SOD we added a subsection on stages of innovation process (16.3.1) and of the drivers of innovation (16.3.2). Section 16.4 now presents the systemic view of innovation. Section 16.3.5 specifically discusses indicators, including R&D and patenting.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
35505	20	4	20	13	The hypothesis in this paragraph is interesting but again, it should be stressed that this is a theoretical assumption, not an empirical result.	Taken into account - text revised. Thank you. We rephrased this part and we added reference to empirical evidence supporting the finding in that paper.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
18289	20	14	20	19	It is important to highlight this problem. Keep it.	Noted. Thank you	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
35507	20	14	20	19	Another solution is to acknowledge that these learning curves are noisy, and therefore create significant ex-ante uncertainty (see e.g. Lafond et al (2019) Technological Forecasting and Social Change, 128, 104-117.). This implies that there is a trade-off between investing into a single technology to push it down its learning curve as much as possible, and diversifying the portfolio of investment into multiple technologies, to reduce uncertainty, as in classical portfolio theory (Way et al (2019), Journal of Economic Dynamics and Control, 101, 211-238.)	Accepted - text revised. Thank you. We included one paragraph that discusses uncertainty associated with learnign rates (including the refernce to Lafond et al. 2018) and its policy implications.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
17655	20	17	20	19	Which is a problem for modelers, but probably reflects the real world of path dependency - see Aghion, P., C. Hepburn, A. Teytelboym, and D. Zhengelis (2019). Path dependence, innovation and the economics of climate change. Handbook on Green Growth, 67–83. https://doi.org/10.4337/9781788110686.00011	Taken into account - text revised. Thank you. We included a reference to Aghion et al. 2019 paper.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
17657	20	18	20	19	Are you really saying that a model from 27 years ago is the best approach to handling endogenous innovation? Please update the literature. A good overview study is by Gillingham et al (2008) in Energy Economics (DOI: 10.1016/j.eneco.2008.03.001) but even that is a decade ago. My INET working paper "Modelling Myths: ..." is under revision as a paper in Wiley Interdisciplinary Reviews Climate Change to extend an updated coverage of the literature	Accepted - text revised. We deleted the reference to Young (1993) in this place. However we kept a brief discussion of his model in the second paragraph of subsection 16.3.2.1. The reason is that Young's arguments have important policy implications that are relevant for supporting sustainable technologies. We do agree that the chapter should primarily focus on the newest literature and therefore there are very few references to papers written before 2000.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
25437	20	42	20	45	Delete "The spillover effect associated with innovation ... (Acemoglu et al. 2012; Aghion et al. 2016).", as this is a subjective statement, and based on undefined terms such as "dirty" technologies.	Rejected. Please note that this term is widely used in the literature.	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
11031	20	43	20	43	Do you have any evidence for this? Spillovers in dirty technologies may benefit clean technologies (common parts)	Noted. We included the reference to Aghion et al.. 2013 paper which provides empirical evidence for this result. Please also note that we rephrased this paragraph	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
18291	20	21	22	7	This section captures the characteristics of spillover quite well, that is important driver of technological progress. Keep it.	Noted. Thank you	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
42159	20	22	22	7	overlap with chapter 13	Noted - we included reference to section 13.7.2 and 13.7.3.	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
17659	20	39			To my knowledge, some; one leading reference is Leonidas Paroussos et al (2019), in Nature Climate Change (DOI: 10.1038/s41558-019-0501-1)	Accepted - text revised. We included the reference to Paroussos et al. 2019.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
10707	21	9	21	9	The term of "carbon tax" is not precise. It should be replaced by "mitigation policy". Because other policy instruments than carbon tax could be available.	Rejected. This discussion refers to the models by Gerlagh and Kuik 2014. That model considers the effect of carbon tax. Mitigation policies other than carbon tax could have different impacts. Therefore, in this case we believe that we should remain precise.	Deguchi Tetsuya	Research Institute of Innovative Technology for the Earth	Japan
18293	21	9	21	9	Replace "A carbon tax" by "A mitigation policies and measures". Direct regulation or policy instruments other than carbon tax can have same effect.	Rejected. This discussion refers to the models by Gerlagh and Kuik 2014. That model considers the effect of carbon tax. We cannot be sure that mitigation policies other than carbon tax could have different impacts. Therefore, in this case we believe that we should remain precise.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
10709	21	12	21	12	The term of "carbon tax" is not precise. It should be replaced by "mitigation policy". Because other policy instruments than carbon tax could be available.	Rejected. This discussion refers to the models by Gerlagh and Kuik 2014. That model considers the effect of carbon tax. Mitigation policies other than carbon tax could have different impacts. Therefore, in this case we believe that we should remain precise.	Deguchi Tetsuya	Research Institute of Innovative Technology for the Earth	Japan
8669	21	25	21	32	[16.3.1.3 Clarify the definition] - "Recominant innovation" is about creating new technologies by combining existing technologies, so they are not completely equal to the "knowledge spillover" perspective.	Noted Thank you, we clarified the nature of recominant innovation and how they contribute to technological progress. In our view they could be considered part of spillovers in the sense that previous innovations allow to create new innovations	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
8671	22	9	22	28	[16.3.1.4 Clarify the definition] - Among the types of spillover ("rent spillover" and "knowledge spillover"), the above-mentioned is mainly about "knowledge spillover." Because this section is about "rent spillover," explaining the overall contents from the spillover perspective would increase consistency.	Taken into account. We changed the title of subsection 16.3.3.2. Please note that we changed the content of subsection 16.3.3.3. In SOD this subsection covers: economies of scale, material costs and financing costs. These are not necessarily associated with rent spillovers.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
18295	22	9	22	28	I suggest to mention nuclear in OECD contries here as an example of increased costs due to change in safety regulation scheme and change in energy market regulation with more financial costs. (Lowering)	Rejected. Unfortunately, due to space constraints we are not able to discuss all changes in costs (such as those due to regulations). However we will describe the effects you mentioned in subsection 16.3.2.3 (see our response to your comment number 18285)	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
8673	22	30	22	36	[16.3.1.5 Provide the technologies related to climate change or sustainable development, such as energy technologies] - A description about general technology diffusion models is provided. Explanations about technologies related to climate change or sustainable development, such as energy technologies, should be provided (e.g. Rao et al., A review of technology diffusion models with special reference to renewable energy technologies, Renewable and Sustainable Energy Reviews, 2010)	Accepted. Thank you for pointing this out. In SOD we added a more detailed discussion of stages of innovation process in subsection 16.3.1, which includes a more careful discussion of technological diffusion. Technology diffusion and its drivers are also discussed in section 16.3.4 (Representation of the innovation process in modelled decarbonisation) and in sections 16.4 (with respect to innovation system approaches) and 16.5 (with respect to the role of policies in promoting innovatoin and technology diffusion.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
10933	22	30	22	36	Technological diffusion appears to be discussed only very briefly in this section. There may be further discussion later in the chapter but certainly more exhaustive discussion of the factors shaping the diffusion of technologies is needed.	Taken into account. Thank you for pointing this out. In SOD we added a more detailed discussion of stages of innovation process in subsection 16.3.1, which includes a more careful discussion of technological diffusion. Technology diffusion and its drivers are also discussed in section 16.3.4 (Representation of the innovation process in modelled decarbonisation) and in sections 16.4 (with respect to innovation system approaches) and 16.5 (with respect to the role of policies in promoting innovation and technology diffusion. Technology diffusion to developing countries, also labelled technology transfer, is discussed in 16.6	Ian Bailey	University of Plymouth	United Kingdom (of Great Britain and Northern Ireland)
35509	22	30	22	36	This subsection needs attention, it is a bit short for such an important issue. It would be helpful to know how climate change mitigation technologies differ from other technologies. This should tell us what barriers to diffusion (behavior, infrastructure, cost, etc.) are most relevant, and thus what policy is likely to be more efficient.	Accepted. Thank you for pointing this out. In SOD we added a more detailed discussion of stages of innovation process in subsection 16.3.1, which includes a more careful discussion of technological diffusion. Technology diffusion and its drivers are also discussed in section 16.3.4 (Representation of the innovation process in modelled decarbonisation) and in sections 16.4 (with respect to innovation system approaches) and 16.5 (with respect to the role of policies in promoting innovation and technology diffusion).	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
45011	22	30	22	36	The short section on diffusion surely needs to be expanded, at least to address the point that innovation continues during the diffusion process. Technologies change as they diffuse, not just in terms of technology cost, but also in terms of the services offered and other characteristics.	Accepted. Thank you for pointing this out. In SOD we added a more detailed discussion of stages of innovation process in subsection 16.3.1, which includes a more careful discussion of technological diffusion. Technology diffusion and its drivers are also discussed in section 16.3.4 (Representation of the innovation process in modelled decarbonisation) and in sections 16.4 (with respect to innovation system approaches) and 16.5 (with respect to the role of policies in promoting innovation and technology diffusion).	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
11033	22	31	22	36	I find this section too short with respect to the others. Is really nothing else you can write about diffusion? Maybe you should comment here on the feedback between different phases (chain-linked model). Although you mention this feedback at the start, I feel your discussion is in fact very linear.	Accepted. Thank you for pointing this out. In SOD we added a more detailed discussion of stages of innovation process in subsection 16.3.1, which includes a more careful discussion of technological diffusion. Technology diffusion and its drivers are also discussed in section 16.3.4 (Representation of the innovation process in modelled decarbonisation) and in sections 16.4 (with respect to innovation system approaches) and 16.5 (with respect to the role of policies in promoting innovation and technology diffusion). Please note that the SOD is structured as follows: section 16.3 presents the "linear" approach to the study of innovation and technology diffusion. Section 16.4 discusses the more systemic approaches to these topics	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
6527	22	38	22	38	It would be good to include the way to measuring environmental policy stringency. Also, the form of regulation may be as important as the stringency level, the expected future policy stringency, and the effect of policy uncertainty.	Taken into account. In SOD we added a discussion on the role of policy commitment and uncertainty in subsection 16.3.3.2. In SOD section 16.5 is dedicated to discuss the relation between environmental policy and innovations	Yeong Jae Kim	RFF-CMCC European Institute on Economics and the Environment	Italy
35585	22		25		This discussion needs to include more on the role of technology specific market creation policies such as feed in tariffs, with cross references to their discussion in other chapters, notably CH 6. As it stands the discussion is naïve and fails to address the role of policy in creating conditions that investors like (there is a discussion of risk that refers to technology but fails to address the fact that renewable technology is not what attracted investors per se, rather the low risk returns created by policies were), or the limitations of carbon pricing as a market creation option. FITs are mentioned later in the chapter but this is disjointed. It is also important to bring in the role of policy in creating low risk investment environments even once subsidy per se is no longer needed.	Noted. In SOD section 16.5 is dedicated to discuss the role of policy. Please also note that incentives for investors and FIT are discussed in chapter 15.	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)
35511	22	39	26	9	This subsection is very long and it would be helpful to split it and structure it better.	Accepted. We split the subsection into several subsections	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
45013	22	39	26	9	this section on market incentives and the direction of technological change would benefit from more empirical material. I'm surprised not to see Newell et al.'s study (Newell, Richard G., Adam B. Jaffe, and Robert N. Stavins. "The induced innovation hypothesis and energy-saving technological change." The Quarterly Journal of Economics 114.3 (1999): 941-975.), and	Accepted - we included the references that you provided.	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
46331	22	39	26	10	Same comment as before: probably 2/3 of this long section is economic theory and stylised implications from that theory. I don't think this is necessary or useful for an IPCC assessment. The paragraph beginning line 37 on page 25 represents why it is not helpful or worthwhile to regurgitate economic theory: quoting welfare theorems which require private investment or use of technology to reflect externalities. And then: "this condition is likely to fail in the case of disruptive clean technologies". Really? From an economic perspective, isn't climate change the biggest externality problem we've ever seen?	Taken into account - text revised. We shortened the reference to welfare theorem to one sentence (stressing both types of externalities). Regarding the balance between theoretical and empirical literature, please see our responses to comments number 46329 and 46333	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
17587	22	3			? There is only more more ref to synergies in the rest of the doc ?	Taken into account. We added section 16.4 which is dedicated to discuss the perspective of innovation systems.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
17661	22	3			Striking that this doesn't occur again until p.36 - and rarely thereafter	Taken into account - see our response to comment 17587	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
17589	22	9			<p>If this chapter is about the factors that lead to cost reduction in technologies, then it is striking it has not mentioned economies of scale. Indeed if R&D is separated between public and private, then the Kavlak et al (2018) study of PV identifies scale economies as substantially the most important single factor in driving down PV costs. [Kavlak, G., McNerney, J., & Trancik, J. E. (2018). Evaluating the causes of cost reduction in photovoltaic modules. Energy Policy, 123(August), 700–710. https://doi.org/10.1016/j.enpol.2018.08.015]</p> <p>This section might also consider the 'multiple journeys' [six are mapped out] that lead to cost reduction, in Grubb M.J., W.McDowell and P.Drummond (2017), On order and complexity in innovations systems: Conceptual frameworks for policy mixes in sustainability, transitions, Energy Research and Social Sciences, Vol.33:pp21-34</p>	Accepted. We added a discussion on economies of scale in subsection 16.3.2.3.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
17663	22	30			<p>It strikes me that this topic is really quite fundamental - the entwined process of demand-led innovation growths with the market, initially exponentially, reducing costs that then culmination with an S-curve substitution of new technological systems. This can lead to a fundamentally different view of both the economics and metrics of decarbonisation, which surely should be a major point of this chapter?</p> <p>for a simple illustration see See the debate of INET including my response to Papers by Semienuk et al, ans Schroder et al, as Grubb (2018) 'Conditional Optimism: Economic Perspectives on Deep Decarbonization' https://www.ineteconomics.org/perspectives/blog/growth-with-decarbonization-is-not-an-oxymoron</p> <p>There are fuller and better references and work underway, but the topic should not be confined to 6 lines in a full IPCC chapter</p>	<p>Taken into account. In SOD we added a more detailed discussion of stages of innovation process in subsection 16.3.1, which includes a more careful discussion of technological diffusion. Technology diffusion and its drivers are also discussed in section 16.3.4 (Representation of the innovation process in modelled decarbonisation) and in sections 16.4 (with respect to innovation system approaches) and 16.5 (with respect to the role of policies in promoting innovation and technology diffusion). Please note that the SOD is structured as follows: section 16.3 presents the "linear" approach to the study of innovation and technology diffusion. Section 16.4 discusses the more systemic approaches to these topics.</p>	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
17665	22	39			<p>This is an interesting section, but a slightly confusing one. It seems almost like a mini-essay within the chapter, trying to cover many things that are covered elsewhere. Including general observations on innovation, trade, leakage, directionality, inadequacy of market signals, VC and other finance, carbon pricing, stranded assets, multi-level perspectives an industrial policy. As a result, it is hard to get the message. What is the specific focus of this section, and how does it relate to rest of the chapter?</p>	<p>Taken into account. We restructured the text and shortened it significantly. The purpose of this part of the section is to discuss the determinants of direction of technological change other than climate policy.</p>	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
42161	22	39			<p>section 16.3.2 - lots of old references here</p>	<p>Noted. Indeed, at the beginning of this section we include two old references (Solow 1957 and Nelson and Phelps 1966). Please keep in mind that this is first time the ipcc report includes chapter on technology. Therefore we decided to include some references that formed fundaments for the field</p>	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
25439	23	8	23	19	<p>Do not use undefined terms such as "dirty resource".</p>	<p>Rejected. See our response to your comment number 25437</p>	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
25441	23	11	23	13	<p>Delete "This is the case of ... (Aghion et el. 2016).", as an electric car may be "dirtier" if electricity is produced using coal.</p>	<p>Rejected. See our response to your comment number 25437</p>	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
11035	23	46	23	46	What about the rebound effect?	Noted. The rebound effect does not play a major role when energy is complimentary to other factors of production. Please note that we restructured the text significantly, so now it should be more clear.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
17667	23	33			It strikes me that an important contribution of this chapter would be to note that whilst much of the economics literature still refers to it as a "hypothesis", it is both common sense and verified through innumerable lines of evidence. The econometric literature on this for example no longer talks about "whether" prices affect patenting, but measures the impact in terms of the elasticity of patent generation with respect to energy prices, and a parallel literature measures patents with respect to deployed volume. The evidence is covered in our systematic review of hundreds of papers (Grubb + 12 other authors, submitted to Environmental Research Letters, available on request).	Accepted. Text revised. We no longer refer to this as "hypothesis"	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
25443	24	3	24	7	Delete "For example, increase in the price of oil ... hamper this development.", as the level of substitution depends on various factors, including electricity price and level of fossil fuels demand.	Rejected. Please note that this is an important result described in established academic literature (see references in the text)	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
10711	24	11	24	11	The term of "carbon tax" is not precise. It should be replaced by "mitigation policy". Because other policy instruments than carbon tax could be available.	Rejected. This discussion refers to the models by Maria and Van Der Werf 2008. That model considers the effect of carbon tax. Mitigation policies other than carbon tax could have different impacts.	Deguchi Tetsuya	Research Institute of Innovative Technology for the Earth	Japan
25727	24	15	24	24	Please check linkages with Chapter 13, specifically 13.7.2 on leakage effects, which addresses channels of leakage and competitiveness from carbon pricing. Please also link to Chapter 15, page 65-66, which also address leakage	Taken into account, thank you. We included reference to section 13.7.2. Section 15 only mentions the topic of leakage and does not discuss it in detail.	Renee van Diemen	WG III TSU	United Kingdom (of Great Britain and Northern Ireland)
10713	24	16	24	16	The term of "carbon tax" is not precise. It should be replaced by "mitigation policy". Because other policy instruments than carbon tax could be available.	Rejected. See our response to your comment number 10707 In this case we refer to models by van den Bijgaart 2017, Hemous 2016 and Greaker et al. (2018)	Deguchi Tetsuya	Research Institute of Innovative Technology for the Earth	Japan
18297	24	16	24	33	Replace "A carbon tax" by "A mitigation policies and measures". Direct regulation or policy instruments other than carbon tax can have same effect.	Rejected. See our response to comment number 10713	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
10715	24	19	24	19	The term of "carbon tax" is not precise. It should be replaced by "mitigation policy". Because other policy instruments than carbon tax could be available.	Rejected. See our response to comment number 10713	Deguchi Tetsuya	Research Institute of Innovative Technology for the Earth	Japan
10717	24	33	24	33	The term of "carbon tax" is not precise. It should be replaced by "mitigation policy". Because other policy instruments than carbon tax could be available.	Rejected. See our response to comment number 10713	Deguchi Tetsuya	Research Institute of Innovative Technology for the Earth	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
43743	25	12	25	18	This paragraph is presenting a version of the ecosystem of financiers and their risk appetite and the relation to innovation (higher risk). This would benefit from cross referencing with Ch15. I'm not quite sure about the final clause of the last sentence - 'not only energy production but also the financial system in the long run'. This needs clarification. If it is the extrapolation that failure to invest in 'innovation' [as a proxy term for climate solutions] will exposure the financial sector to longer-term instability due to the risks from climate change, then I don't think that point really belongs here (refer Ch15).	Taken into account - text revised.	Kirsty Hamilton	Chatham House (Associate Fellow, unpaid)	United Kingdom (of Great Britain and Northern Ireland)
42163	25	12	25	29	overlap with chapter 15 on finance	Taken into account - we included a reference to section 15.6	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
43745	25	19	25	20	I'm not sure of the relevance of this paragraph in general. The premis of the first sentence is odd. Firstly this is renewable energy (rather than 'innovation' per se); secondly there is clear evidence that financiers (debt and equity) can invest, indeed have (and have had) the appetite to invest in renewable energy with the upswing in investment starting back in 2004. A grey literature source is the Finance Guide for Policymakers (Bloomberg New Energy Finance, Chatham House, FS UNEP Collaborating Centre, 2016) - this outlines the ecosystem of different finance actors and how the transactions process works, linked to renewable energy (see for example graphics on pages 28 and 29 for the types of financiers that invest in different stages of 'innovation' and projects. Available from: http://about.bnef.com/white-papers/finance-guide-policy-makers/	Noted. We decided to delete this part due to space constraints and because this topic is covered in chapter 15.	Kirsty Hamilton	Chatham House (Associate Fellow, unpaid)	United Kingdom (of Great Britain and Northern Ireland)
43749	25	19	25	29	Actually consider deleting this whole para as it is not really about innovation but about renewable energy. Scale deployment is in mature or maturing renewable/low carbon technologies, so the question whether this should be covered by Ch16 on Innovation versus Ch6 or Ch 15 - both of which also cover renewables deployment/investment.	Accepted. We deleted this paragraph.	Kirsty Hamilton	Chatham House (Associate Fellow, unpaid)	United Kingdom (of Great Britain and Northern Ireland)
43747	25	20	25	21	Explain what is meant by "too rapid" investment in the deployment of renewable energy? This sentence needs reworked I don't really think this is about the investment in renewable energy, rather about the increasing uptake of renewable energy in the system (yes linked to investment but then any deployment could also be called investment) can create losses for some investors often related to changes in government policy. I'm sure I can dig out sources (e.g. equity research and perhaps the Carbon Disclosure Project) that examines the impact on utility sector. However, I don't think it would be accurate to say this is due to 'too rapid' investment in renewables. [One could argue that those utilities failed to take seriously the implications of climate change on changes to energy sector policy/operation].	Noted. We decided to delete this part due to space constraints and because this topic is covered in chapter 15.	Kirsty Hamilton	Chatham House (Associate Fellow, unpaid)	United Kingdom (of Great Britain and Northern Ireland)
18299	25	30	25	36	Good discussion, keep it. However, replace "camcorders" by "portable equipment such as video camera, peronal computer and mobile phone"	Noted. We decided to delete this part due to space constraints. We left the brief discussion of the paper by Geels (2002) section 16.4	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
18301	25	37	25	47	Good discussion. Add "many countries have been investing basic R&Ds by public finance and they have been successful in providing key GPTs, that are eventually used for mitigation of GHGs. Examples are battery, internet, etc.	Taken into account. Please note that in this section we only wanted to mention that market cannot solve all problems. We leave the discussion of policies (including basic R&D by public finance) in section 16.5. Please also note that we added more careful discussion of the role of GPTs in section 16.3	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
35513	25	19		29	This paragraph gives the impression that the effects of the transition on the financial system will all be negative. Is this true?	Noted. We decided to delete this part due to space constraints and because this topic is covered in chapter 15.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
35515	25	37		41	The reference to welfare theorems is imprecise, since "best possible outcome" only refers to pareto optimum, which may not be an ethically or morally good outcome at all.	Accepted - text revised.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
5785	26	1	26	9	I think this paragraph should be cut. The prior text has discussed R&D spending as well as incentives for diffusion, both of which could be seen as "industrial policy." Without a careful discussion of this term, this paragraph is likely to be confusing.	Taken into account. We deleted the sentence, which refers to industrial policy. This section is dedicated to discuss market failures (most importantly, Nordhaus 2014 paper).	DAVID HART	GEORGE MASON UNIVERSITY	United States of America
18303	26	1	26	9	Good summary. Keep it.	Noted. Thank you.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
25729	26	12	26	20	Please refer to the IPCC glossary, which includes a definition of lock-in. It is defined as: 'a situation in which the future development of a system, including infrastructure, technologies, investments, institutions, and behavioural norms, is determined or constrained ('locked-in') by historic developments.	Accepted. Appropriate rewriting consistent with the glossary will be done.	Renee van Diemen	WG III TSU	United Kingdom (of Great Britain and Northern Ireland)
11039	26	30	26	33	No, not at all. Compared to RETs, fossil-fuel electricity plants are much more costly to operate (given that the fuel is not free and O&M costs are rather similar except for off-shore wind).	Accepted. This is most probably an unintentional oversight. Of course fossil and renewables have persistently been compared on uneven playing fields. Revision will take recent LCA and related approaches into account.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
43755	26	11	27	3	This section (16.3.2.2) has a focus on carbon lock-in. Cross reference with Energy Systems Ch6 section 6.7.3, page 111 (line 1) to page 115 (line 25)	Accepted	Kirsty Hamilton	Chatham House (Associate Fellow, unpaid)	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
18305	26	11	27	7	The discussion in this section is single sided. Existing infrastructure does not always invite lock-in to carbon intensive economy, but often serve as the infrastructure for low carbon technology. Existing power grid systems and fossil fuel power generators have been very instrumental to accommodate renewable energy by providing flexibility. In the transition process, fossil fuel power plants can be "repurposed" to accommodate renewables in the grid by providing ancillary service such as peak demand service or frequency adjustment. (see IEA World Energy Outlook 2019; Klitkou 2015). Likewise, existing roads are being repurposed from the infrastructure for combustion engine vehicle to EV. Auto makers are being repurposing themselves from combustion engine makers to EV makers. Power plant makers are shifting from fossil fired power plant maker to CCS and bio plant maker. Figure 16.1 does not reflect these changes and so very incorrect and misleading. Delete these sentences and the figure.	Accepted. This was an oversight that we missed in the rush to submission of this section. We absolutely accept this comment. The updated draft will provide a more balanced discussion.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
35517	26	11		33	lines 30-33 repeat from 15-17	Accepted. Appropriate editing to be done	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
42165	26	11			section 16.3.2.2 overlaps with chapter 13 and 15	Accepted. Appropriate editing to be done	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
2529	27	8	27	47	Please see Chapter 1 section 1.5.4 for the three level transition framework. I believe it's worth aligning this section with this framework, also used in sectoral chapters, like chapter 10.	Noted. We assume that this comment refers to 16.3.2.2 on page 26 (page 27 has only 28 lines). Please note that we restructured the chapter and we moved this text to section 16.4 which discusses barriers to innovation from systemic perspective and hence it is closer to the framework you mentioned.	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
11041	27	14	27	16	I don't see the logics of the mechanism here. This would not be the effect according to the first strand of the literature mentioned in lines 41-47 in page 23.	Noted. The two papers mentioned in page 23 of FOD did not consider international effects. It is not clear what their prediction would be in the international setup. Note that these models do not consider competition between dirty and clean technologies. Instead they consider the competition between technologies improving efficiency of energy and those that increase efficiency of other factors of production	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
10719	27	18	27	18	The term of "carbon tax" is not precise. It should be replaced by "mitigation policy". Because other policy instruments than carbon tax could be available.	Rejected. See our response to your comment number 10707 In this case we refer to models by Hemous 2016	Deguchi Tetsuya	Research Institute of Innovative Technology for the Earth	Japan
18307	27	18	27	18	Replace "A carbon tax" by "A mitigation policies and measures". Direct regulation or policy instruments other than carbon tax can have same effect.	Rejected. See our response to your comment number 10707 In this case we refer to models by Hemous 2016	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
46333	27	9	29	1	Again, this section also seems overwhelming from stylised modelling not empirics, and neither the section as a whole nor Table 16.2 are clearly directed to climate change mitigation. This should be the lens through which the literature is assessed and reviewed, no?	Noted. This subsection is dedicated to the discussion of theoretical results, which have important implications for climate policy. Some of the references explicitly discuss climate related technologies. Other references provide general discussion about theory of technological change, but their predictions are directly applicable in the context of sustainable technological change.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
35519	27				Fig 16.1: Please provide the source and all methodological details and source data. It's a nice and useful chart, but I can imagine that some methodological decisions are difficult to make, for instance evaluating the strength of the "techno institutional effects"	Accepted. Source and details will be provided.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
5787	28	1	28	14	This paragraph should be moved to the top of this section so that the concept of absorptive capacity is introduced to the reader.	Taken into account. Absorptive capacity is important, but it is not a central theme of this subsection. To avoid confusion, we changed the title of this subsection.	DAVID HART	GEORGE MASON UNIVERSITY	United States of America
45021	28	1	28	38	This section would benefit from engaging with the large literature on technology transfer that focuses on the importance of "recipient" countries' technological and innovative capabilities (see e.g. Lema, Rasmus, and Adrian Lema. "Technology transfer? The rise of China and India in green technology sectors." Innovation and Development 2.1 (2012): 23-44. and Bell, Martin, and Paulo N. Figueiredo. "Innovation capability building and learning mechanisms in latecomer firms: recent empirical contributions and implications for research." Canadian Journal of Development Studies/Revue canadienne d'études du développement 33.1 (2012): 14-40. also: Binz, Christian, and Bernhard Truffer. "Global Innovation Systems—A conceptual framework for innovation dynamics in transnational contexts." Research Policy 46.7 (2017): 1284-1298.	Noted. We decided to discuss issues related to technology transfer in section 16.6	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
11043	28	26	28	28	Confusing terminology. It is the LCOE which suffers, not the efficiency of the technology as such.	Rejected. The two models cited in the text (Basu and Weil 1998; Caselli and Coleman 2006) refer to efficiency of technology, which includes both, technology costs and its performance	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
18309	28	23	38	23	Insert "This implies energy efficiency has been improved along with productivity improvement" before "However".	Rejected. Unfortunately, we are not aware that would support this statement in the context of FDI technology transfer (which is the topic discussed in this paragraph)	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
5789	29	2	30	32	This section (16.3.3) doesn't have a clear point. What it should say is that innovation is a social process, not one that relies simply on advances in science and technology. That means that decisions about innovation should or even must involve a set of societal stakeholders as well as the technical community and senior corporate or national leadership. The paradigm of "supply push" that dominated through most of the Cold War is obsolete.	Accepted with some reservations. Innovation is not solely a 'social process.' Perhaps 'socio-technical' better characterizes it. Further review will settle this issue	DAVID HART	GEORGE MASON UNIVERSITY	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
6529	30	1	30	3	Missing citation. A recent paper published in Energy Policy demonstrates a good example of applying of the Technology Innovation System approach. If you all would agree to include the Eenergy Technology Innovation System (ETIS) approach in the text, the below paper is the first-of-its kind application of the framework. Please refer to the below citation. Kim, Y. J., & Wilson, C. (2019). Analysing Energy Innovation Portfolios from a Systemic Perspective. Energy Policy, 134 (2019) 110942	Accepted.	Yeong Jae Kim	RFF-CMCC European Institute on Economics and the Environment	Italy
46335	30	1	30	13	I liked this paragraph, but I also wondered whether any of the preceding expositions of what economic theory tells us environmental problems recognises any or all of the prescriptions of systems frameworks like TIS. Or is this section charting off into new territory from that which went before. And if so, do the chapter authors have a view on which of economic theory and innovation systems theory is most useful, insightful, novel, actionable?	Accepted. The intention was not to create/follow a new thread. However, we'll take this as a suggestion to further explore the literature with this very interesting idea in mind!	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
45019	30	11	30	12	I see this as a mis-characterisation of 'innovation system policy'. A great deal of policy recommendations from scholars and policy advocates rooted in an innovation systems perspective are mission-oriented, and are heavily informed by 'strategic priorities'. The entire 'Technological Innovation Systems' body of research, and associated work on 'systemic instruments' is very strongly guided by strategic priorities, and is strongly mission-oriented. Similarly, the Dutch policy experiment with 'Transition Management' in the 2000s was based on an innovation system perspective, and was clearly mission-oriented.	Accepted. Indeed the earliest case studies of transition management (Loorbach and others) do display a clear mission orientation operationalize via the construction of 'transition arenas' involving small groups of 'front-runners.' We will revisit the latest studies and produce a hopefully better characterization.	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
18311	30	37	30	43	Careful wording is required not to single out ceritan targets. Simply say "innovation is the key to achieve any targets".	Accepted. The sentence has been worded more carefully, yet avoiding prescriptive language. Note that the sentence has also been moved, in line with other comments (see 5791)	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
5791	30	35	34	42	This section should be moved to the top and made the introduction to the chapter. First technological innovation is essential. Second it's not well-represented in the models, and there could be large errors as a result in both pessimistic and optimistic directions. Therefore, policy makers need to take action to try to encourage the optimistic results!	Taken into account. The content of this section will appear in the Chapter introduction, in a modified version, as part of the handshake/link/contextualization with other chapters.	DAVID HART	GEORGE MASON UNIVERSITY	United States of America
46337	30	37	34	42	Mitigation pathways in IAMs - including their technological assumptions and implications - will be thoroughly covered elsewhere in WG3 report, and I think does not need covering in brief here. Figure 16.2 is very confusing (and not explained). It seems to be included to make the point that experts underestimated how rapidly PV has diffused and costs have come down. I don't think a Figure of this complexity is needed to make that point.	Accepted. The paragraph from lines 37-43 was removed from this section, hence Mitigation pathways in IAMS are not discussed here in brief. The new version of the chapter contains a box focusing on how technological change is represented in IAMs. Figure 2 was also removed following the revision of the FOD.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
18237	30	35	36	19	16.4 provides policy relevant discussions regarding the long-term pathway and innovation. Highlighting the roles and limits of IAMs are also very policy relevant. Keep, elaborate further, summarize nicely and reflect it to the exective summary.	Taken into account. The SOD contains a box focusing on how technical change is represented in IAMs, and the strenghts and limitations of this representation. An effort was made to reflect this in the Executive summary.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
42167	30	35			section 16.4 - 16.4.1 is relatively limited about models. In general I think the discussion around the merits of the different models have to come in one place. If chapter 16 wants to discuss how these models do or don't help technology transfer or innovation - then maybe there is a specific literature - it just does not come across in this section. boundaries need again to be sorted out with the relevant chapter.	Taken into account. The new version of chapter 16 includes a specific box on IAMs discussing how technological change is implemented in the models, in coordination with Chapter 3. Boundaries with other chapters have been established on a number of points: chapter 16 will include General Purpose Technologies (previously in Chapter 12) and the analysis of spillovers (previously chapter 5).	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
5793	31	23	31	24	This sentence should be put in bold and moved to the top of this chapter: "Technological innovation and diffusion are the major drivers of emissions reductions in mitigation pathways which allow to achieving such large-scale, deep energy transition"	Taken into account. The text mentioned has been moved to the introduction, amended to take into account also other comments (see comment 18313).	DAVID HART	GEORGE MASON UNIVERSITY	United States of America
18313	31	23	31	26	Good paragraph. Copy it to the executive summary.	Noted. We take the suggested relocation into account in the new outline of the chapter	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
44197	31	28	31	29	Useful to add the main papers, e.g.: - Iyer et al. (2015) - already cited in chapter - van Sluisveld et al. (2015) - already cited in chapter - Napp et al. (2017) Exploring the Feasibility of Low-Carbon Scenarios Using Historical Energy Transitions Analysis, <i>Energies</i> , 10(1), 116, https://doi.org/10.3390/en10010116 .	Accepted. Of the three references provided, two are already cited in the paragraph: they will be kept and citations in the specific lines suggested by the reviewer will be considered. The third paper (Napp et al.) was included.	Ajay Gambhir	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
18315	31	32	31	35	Good paragraph. Copy it to the executive summary.	Noted. We take the suggested relocation into account in the new outline of the chapter	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
35529	31	6	33	4	I found the title of section 16.4.1 slightly misleading. I was expecting a historical study of past periods of transformative change, perhaps the industrial revolution in 18th century Britain, or the Meiji era in Japan, or something more specific to the environment, such as changes to protect the Ozone layer after the Montreal protocol, or regulations after the great London fog, or maybe even examples of speed of change in other technologies (e.g. diffusion of smartphones). This may have been quite informative to provide a point of comparison.	Accepted. The title of the section has been changed, following a restructuring of the chapter between FOD and SOD. Note that points of comparison can be provided to the extent that such comparisons already exist in the literature, given that the AR of the IPCC is an assessment of available evidence.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
17669	31	6			I think this section needs also to align with Chapter 4 in particular?	Taken into account. Appropriate cross-chapter conversations were carried out and reflected in the SOD	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
35521	31	29		31	I would add "rate of cost reduction" or "rate of productivity growth" to the list of indicators. It may be helpful to check and harmonize with Table 16.1 on page 15.	Noted. Thank you for the well-taken comment. Note that SOD underwent a significant restructuring. It now contains a specific table with indicators used in the literature (16.4).	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
35523	31	36		37	I find the statement "technological development has increased, rather than decreased, fossil emissions" controversial. As written, it implies a clear direct causal pathway. The empirical evidence, to me, does not prove that emissions would have been lower if technological progress had been slower. I appreciate that the authors are rightly concerned with the "rebound effect", but this is a statistical regularity and it is usually not suggested that technological progress itself is responsible for more emissions, except in rare cases, e.g. coal mining technologies becoming more efficient. Technological progress in general is only responsible through its impact on lower costs and thus lower prices and thus higher consumption. This is important because the best policy will differ depending on whether technological progress is a direct on indirect causal factor.	Taken into account. This is a well taken point. However, following cross-chapter conversation, the discussion of rebound effects has been moved to Chapter XX.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
35525	31	42		44	I do not understand the statement "there is the distinct possibility that technological change in fact favours non-mitigation issues over reducing GHG emissions", even after looking at the sections referenced. I would urge the authors to avoid general statements about the effects of "technological change" being good or bad for emissions. Some technologies are mostly good, some are mostly bad, all are hard to evaluate. Particularly in a section devoted to history, it would be helpful to give examples. The draft report overall does a good job at presenting many useful and state-of-the-art theories, but I would have welcomed more applied literature to help us judge which theories are in fact pertinent for the specific cases relevant to climate change.	Taken into account. The point is well taken, thank you. The revised chapter avoids general statements about the effects of "technological change" being good or bad for emissions and better reflects the applied literature (or lack thereof) needed to judge which theories are in fact pertinent for the specific cases relevant to climate change. Note that SOD also contains specific boxes illustrating case studies.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
15467	32	1	32	1	"As shown in 2" not clear	Rejected. As the referee correctly points out, the reference should have been indeed to table 16.3. Furthermore, following the revision of the chapter, the Table will be removed	Simone D'Alessandro	University of Pisa	Italy
26049	32	1	32	1	Typo on "2"	Rejected. As the referee correctly points out, the reference should have been indeed to table 16.3. Furthermore, following the revision of the chapter, the Table will be removed	Zyaad Boodoo	Government of Mauritius	Mauritius
15469	32	12	32	14	There is no reference to Table 16.3 (p 32) until p.46. Also the caption does not help in understanding the table.	Rejected. As the referee correctly points out, the reference should have been indeed to table 16.3. Furthermore, following the revision of the chapter, the Table will be removed	Simone D'Alessandro	University of Pisa	Italy
35531	32	3		18	The caption of the table repeats from lines 3-8. Rather than repeating it may be preferable to give more technical details.	Rejected. The point is well taken, thank you. Yet, following the revision of the chapter, the table will be removed so the suggestion cannot be implemented	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
35527	32				I did not understand clearly what the Table was showing, and I had to go to the original paper. It is crucial to explain clearly what the "normalization" is, since it changes the key result.	Rejected. The point is well taken, thank you. Yet, following the revision of the chapter, the table will be removed so the suggestion cannot be implemented	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
11045	33	1	33	4	No, this analysis is misleading in my view. The stages of the two technologies are different and they cannot be compared. PV has had two decades of diffusion, which has led to reduction in its costs, in turn leading to further diffusion. This diffusion-cost-reduction cycle has not occurred for EVs. In addition, your statement that "this once more...for technology diffusion" might be right but EVs are not a good example. They are simply not yet a low-cost technology with the same service attributes as its competitors.	Taken into account. Point well taken, thank you. Following the revision of the chapter, this text has been eliminated. The new version will instead contain specific sections presenting "case studies" which will fully reflect your comment: i.e. for each technology the specific technological phase will be described, and cross technology comparisons will not be carried out lightly.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
17671	33	1	33	4	This is unreferenced and by what criteria are renewables speeding up whilst EVs are lagging? Compared to what? When I last checked, both were growing at around 30-40%/yr.	Rejected. The point is well taken. Yet, following the revision of the chapter, this text has been deleted. Please also see response to comment 11045.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
18317	33	2	33	3	EV is not cheap and that is the major barrier for diffusion. Correct.	Noted. Thank you for the comment. Indeed, other key barriers to the diffusion of EV include behavioral barriers and infrastructure barriers at present. Yet, note that this specific section has been removed. The SOD now contains boxes illustrating specific case studies on low-carbon technologies, but electric vehicles will not be included.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
18319	33	5	33	5	Figure 16.2 well summarises the broad range of expert views. Keep it.	Rejected. The point is well taken, thank you. Yet, following the revision of the chapter, the table will be removed so the suggestion cannot be implemented	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
25731	33	10	33	42	It might be helpful for readability purposes to link this section to Chapter 3 and Annex C on IAM approaches and limitations	Taken into account. SOD contains a box specifically discussing how innovation and technological change is represented in IAMs, including limitations. The box was drafted in coordination with Chapter 3.	Renee van Diemen	WG III TSU	United Kingdom (of Great Britain and Northern Ireland)
18321	33	12	33	18	This paragraph is important and should be in executive summary. And the section 16.4.2 is very important for policy makers. Elaborate further.	Taken into account. The new version of the chapter includes a box on the modelling of technical change in IAMs, which will make this point. Also, the role of non-technical barriers is extensively discussed in the chapter, including in the specific context of some "case studies" included in boxes. The role of non-technical barriers has been highlighted in the chapter submission to the executive summary.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
35533	33	2		3	I agree that low technology costs are not a sufficient condition but I do not understand how this follows from the previous sentences	Taken into account. The point is well taken. The specific text was removed, yet the chapter was rewritten to ensure that the appropriate argumentation is provided before concluding that cost reductions are necessary but not sufficient.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
18323	34	14	34	14	Replace "fossil technology" by "high emission technology". CCS is a fossil technology but with low emission	Rejected. The specific sentence was removed.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
17675	34	22	34	25	Again, meaning what, and with what evidence? I guess its partly clarified in next sentence - they almost definition have an incomplete option set?	Noted. The comment is not clear. The specific sentences commented reads: "On the other hand, IAMs may be too conservative because they leave out a particular set of mitigation options since they cannot appropriately portray mitigation channels such as lifestyle changes". The literature in support of this statement is included in the text above and in the lines following this one (p. 34, lines 24-32). I am then interpreting the comment to mean that the writing of the paragraph could be improved. In fact, this section was extensively revised. A box on the representation of technological change is IAMs is now included.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
9961	34	39	34	42	<p>Frameworks and literature supporting this argument, also include:</p> <ul style="list-style-type: none"> - Doukas, H., & Nikas, A. (2020). Decision support models in climate policy. <i>European Journal of Operational Research</i>, 280(1), 1-24. - van Vliet, M., Kok, K., & Veldkamp, T. (2010). Linking stakeholders and modellers in scenario studies: The use of Fuzzy Cognitive Maps as a communication and learning tool. <i>Futures</i>, 42(1), 1-14. - Nikas, A., Doukas, H., Lieu, J., Tinoco, R. A., Charisopoulos, V., & van der Gaast, W. (2017). Managing stakeholder knowledge for the evaluation of innovation systems in the face of climate change. <i>Journal of Knowledge Management</i>. - Nikas, A., Doukas, H., & López, L. M. (2018). A group decision making tool for assessing climate policy risks against multiple criteria. <i>Heliyon</i>, 4(3), e00588. <p>The need to complement IAMs with other approaches is well documented in:</p> <ul style="list-style-type: none"> - Turnheim, B., Berkhout, F., Geels, F., Hof, A., McMeekin, A., Nykvist, B., & van Vuuren, D. (2015). Evaluating sustainability transitions pathways: Bridging analytical approaches to address governance challenges. <i>Global Environmental Change</i>, 35, 239-253. - Gambhir, A., Butnar, I., Li, P. H., Smith, P., & Strachan, N. (2019). A review of criticisms of integrated assessment models and proposed approaches to address these, through the lens of BECCS. <i>Energies</i>, 12(9), 1747. - Trutnevyte, E., Hirt, L. F., Bauer, N., Cherp, A., Hawkes, A., Edelenbosch, O. Y., ... & van Vuuren, D. P. (2019). Societal transformations in models for energy and climate policy: The ambitious next step. <i>One Earth</i>, 1(4), 423-433. - Doukas, H., Nikas, A., González-Eguino, M., Arto, I., & Anger-Kraavi, A. (2018). From integrated to integrative: Delivering on the Paris Agreement. <i>Sustainability</i>, 10(7), 2299. - Geels, F. W., Berkhout, F., & van Vuuren, D. P. (2016). Bridging analytical approaches for low-carbon transitions. <i>Nature Climate Change</i>, 6(6), 576-583. 	Taken into account. Thank you for the literature suggestions. Relevant references were included in the SOD	Haris Doukas	School of Electrical and Computer Engineering, National Technical University of Athens	Greece

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
17673	34	10	43	15	I don't understand this sentence. In what way are they too optimistic regarding the timing of action? At best this is careless drafting, at worst wrong, since renewables (and PV especially) are progressing much faster than anyone projected, and so are cost reductions in EVs. Again, we come back to the fact that statements to do with progress, rates, etc needed to be grounded in understanding the S-curve dynamics of market penetration and cost reduction, and the associated metrics.	Noted. First, the text does not refer only to renewables, but to all low-carbon technologies in general. Second, in this section, the main point was to claim that other (non-cost related) barriers are critical for technology diffusion, and that even cost-competitive technologies may not diffuse if such non-technical barriers are in place. These include behavioral barriers (EV, for instance, imply behavioral change that has been proven to be resisted by certain groups of users) and institutional and administrative barriers (one example may be nuclear, which is banned in Italy following two referenda). There is a large literature supporting this statement. The text was significantly revised. What remains true is that the S-shaped curve of technology diffusion is not only influenced by cost dynamics, but also by public acceptance, critical mass and other important non-technological, non-cost-related aspects (also related to the demand side). This is now reflected in section 16.4 of the SOD	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
44195	35	1	35	14	This section does not discuss modelling efforts that have looked outside traditional technologies +CDR, e.g. hyperloops, hydrogen planes, fusion (see Napp et al., 2019, already cited in the chapter).	Noted. The chapter has been conceived to provide a general background on innovation dynamics and technological change. Specific technologies (as per relevant sectors) are described in the sector-specific chapters. General purpose technologies, on the other hand, are discussed SOD. A specific cross-chapter box on digitalization has also been included	Ajay Gambhir	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
18325	35	2	35	8	At the beginning of this section 16.4.3.1, describe disruptive technologies such as ICTs and EV equipped cheap battery as key enablers of immediate, non-delayed actions by countries. Then, discuss the consequence of delayed action. Without disruptive technologies, countries facing high perceived mitigation costs do not take action - that is what is occurring in this world.	Taken into account. Due to space constraints we decided not to discuss the role of particular disruptive technologies, which will be discussed in sectoral chapters. However, please note that in SOD we included a cross-chapter box on digitalization and a discussion of general purpose technologies. EV per se will not be described	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
5795	35	2	35	14	The point of this section should be clarified and focused mostly on negative emissions technologies. I don't think it's really about disruptive technologies generally and I don't think the 3 categories in the table are grounded in the analytical literature	Taken into account. Due to space constraints we decided not to discuss the role of particular disruptive technologies, which will be discussed in sectoral chapters. However, please note that in SOD we included a cross-chapter box on digitalization and a discussion of general purpose technologies.	DAVID HART	GEORGE MASON UNIVERSITY	United States of America
74	35	9	35	11	"steep declines of emissions" and "CDR" are very different activities. CDR removes CO2 that is already in the air. To be precise, "steep declines of emissions" may be replaced with "negative emissions". CDR is indeed negative emissions	Rejected. This text is no longer included in the chapter, so the suggestion could not be implemented	Govindasamy Bala	Indian Institute of Science	India

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
46339	35	1	36	19	"Disruptive" really needs to be defined. Disruptive innovation has a particular meaning in the business strategy literature (Christensen 1999), and a more general meaning in 'Silicon Valley' terms (i.e., synonymous with novel, and challenging to incumbents). However (and despite the large literature on disruptive innovation), it doesn't seem like any literature on disruptive change has been reviewed here. Some of the examples given of "disruptive" are in fact the complete opposite as they sustain the path-dependent trajectory of change in the energy system and the role of the energy majors as incumbent suppliers. Large-scale negative emission technologies may be a "backstop" in emissions terms, but they are absolutely not disruptive - rather they would do most to perpetuate a fossil-dependent energy system, and centralised supply-side solutions to climate change. Synfuels and electric planes are technological substitutions that potentially leave unchanged most other elements of the technological system.	Taken into account. Due to space constraints we decided not to discuss the role of particular disruptive technologies, which will be discussed in sectoral chapters. However, please note that in SOD we included a cross-chapter box on digitalization and a discussion of general purpose technologies.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
76	35	16	36	1	Why is "ocean alkalization" a disruptive technology? Why not "Enhanced weathering" or "DAC"? It is not clear what is the basis for transformative and disruptive technology in the case of CDR.	Noted. Thank you for this comment. The table referenced will no longer be included as is, rather in a modified version. The final list of technologies which will be reflected in the table is currently being developed. Your comment directly informs this process.	Govindasamy Bala	Indian Institute of Science	India
78	35	16	36	1	CCS is not energy generation.	Accepted. This is a well taken point, the reference to CCS as an energy technology will be removed	Govindasamy Bala	Indian Institute of Science	India
2533	36	3	36	19	"16.4.3.2 Other disruptive technologies, including digitalization" only talks about digitalization, not "including digitalization". Still, it doesn't seem to show enough evidence for the chapter to conclude that digitalization is the major driver.	Taken into account. The revised version of the chapter includes a specific cross chapter box on digitalization, which will present more comprehensive evidence than what discussed in the FOD. General purpose technologies are also discussed. Due to space constraints we decided not to discuss the role of particular disruptive technologies, which will be discussed in sectoral chapters	Lilia Caiado Coelho Beltrao Couto	University College London	United Kingdom (of Great Britain and Northern Ireland)
2427	36	24	36	26	It is necessary to mention frameworks for studying the determinants of technology innovation (16.5.1) and frameworks for identifying barriers to innovation in climate related technologies(16.5.2) to show how to justify the reason to make the conclusion that the government policy plays a very important role in the climate change innovation.	Noted. This is precisely why these sections are there.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
18239	36	20	60	29	16.5 provides wide range of lessons and policy relevant views. Keep , elaborate further, summarise key findings and reflect them into the executive summary.	Accepted - We agree. We had not included the findings from the section in the Executive Summary. We are including key findings at the end of section 16.5 and including them in the SOD as requested.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
42169	36	20			again boundaries with chapter 13 need to be addressed	Accepted - The start of the chapter will clearly delineate the boundary between chapters 13 and 16. This is done in two dimensions: outcomes and policy instruments. Chapter 16 focusses on what it is known about the innovation outcomes of different policy instruments. We now make an explicit link between this outcome and the broader 'transformative potential' outcome in Chapter 13. Another explicit link we now make with Chapter 13 is in the policy typology. We modified the previous Table 16.6 (which was in page 44) to indicate what policy instruments from the Ch13 typology we assess in terms of innovation outcomes and why. Given that some of the policy instruments are more granular, we also complement the literature review focussed around innovation outcomes with the insights available on distributional and competitiveness outcomes.	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
6531	37	3	37	4	It is necessary to include a discussion between technology-neutral and technology-specific (picking winners) in the paragraph. In particular, I would encourage to state the reason why this section and chapter do not prioritize the specific technology.	Accepted - The new version includes a sentence indicating that some of the policy instruments considered are typically implemented focussed on specific technologies (e.g. solar feed in tariffs) while others (e.g., R&D investments or R&D tax credits) are typically designed to work across technologies. We note that in the previous version we did not prioritize a specific technology but we are making sure that the chapter does not give the impression that all instruments prioritize (or should prioritize) a technology.	Yeong Jae Kim	RFF-CMCC European Institute on Economics and the Environment	Italy
2383	37	4	37	5	It is better to describe examples of "Many considerations" and "Many such considerations" in the text	Accepted - We will include one example of a type of consideration (e.g., the availability of biomass or wind resource), but for reasons of word count, we will not be able to expand this much more.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2385	37	18	37	19	Deletion of Vannebar Bush	Accepted - Thank you for the catch!	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
25447	37	18	37	19	Delete "Vannebar Bush".	Accepted - Thank you for the catch!	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
26051	37	24	37	39	See comment 1 on expanding literature review coverage to other well documented theoretical frameworks such as Strategic Niche Management, Transitions Management, Multi-level perspective, etc	Accepted - Note that old section 16.5.1 has now been moved to the theoretical section 16.4. Following this and other comments, we have also expanded the discussion on Strategic Niche Management and Transitions Management. Although it is in a different place, as requested we have also slightly expanded the previous reference to the Multi-Level Perspective (which was on the first paragraph of previous page 38).	Zyaad Boodoo	Government of Mauritius	Mauritius

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
6533	37	27	37	39	Besides "tecnology innovation systems" approach, "functional innovation system" and "Energy Technology Innovation System" are missing in the paragraph. I know that this is not an exhaustive literature review, but it would be great to mention it so readers can get a holistic overview of the stream of the literature (Technology Innovation System, Functional Innovation System, and the Energy Technology Innovation System).	Accepted - Note that old section 16.5.1 has now been moved to the theoretical section 16.4. Following this and other comments (see also just above), we have also expanded the discussion on Strategic Niche Management and Transitions Management and 'energy technology innovation system'. We are grateful to the reviewer for recognizing that the literature review will necessarily not discuss everything as much as one may want for word count reasons, but we have ensured that beyond TIS we talk about the 'functions' and also we mention the ETIS.	Yeong Jae Kim	RFF-CMCC European Institute on Economics and the Environment	Italy
45119	37	40	37	41	The emphasis on "seven functions (or processes) that are important for well performing innovation systems" may further include an emphasis on functional dynamics and sustainability-oriented innovation systems based on the literature.	Accepted - Thank you for reminding us of this literature. Note that old section 16.5.1 has now been moved to the theoretical section 16.4. Following this and other comments (see also just above), we have expanded the frameworks a little. More specifically, we now include a reference to the 'sustainability-oriented innovation systems' literature. For example, we have included this article: https://www.tandfonline.com/doi/abs/10.1080/2157930X.2012.664037 .	Siir Kilkis	The Scientific and Technological Research Council of Turkey	Turkey
9963	37	43	37	46	References for recent TIS applications for energy transitions focussed on technologies: - Edsand, H. E. (2017). Identifying barriers to wind energy diffusion in Colombia: A function analysis of the technological innovation system and the wider context. <i>Technology in Society</i> , 49, 1-15. - Nikas, A., Doukas, H., Lieu, J., Tinoco, R. A., Charisopoulos, V., & van der Gaast, W. (2017). Managing stakeholder knowledge for the evaluation of innovation systems in the face of climate change. <i>Journal of Knowledge Management</i> . - Hellsmark, H., & Jacobsson, S. (2009). Opportunities for and limits to academics as system builders—the case of realizing the potential of gasified biomass in Austria. <i>Energy Policy</i> , 37(12), 5597-5611.	Accepted - Note that old section 16.5.1 has now been moved to the theoretical section 16.4. Following this and other comments (see also just above), we have expanded the frameworks a little. We agree that adding some examples of the application of TIS to energy transitions beyond what we had in the last paragraph of the previous page 37 is helpful. We have added the first reference suggested as an additional example of the direct application of the TIS approach. The other applications are not so direct and cannot just be listed without additional discussion, which we cannot add because of word constraints.	Haris Doukas	School of Electrical and Computer Engineering, National Technical University of Athens	Greece
2387	37	35	38	5	It is better to combine the sentences from line 35 to line 5 of next page to make a paragraph because they are dealing with framework of technology innovation systems	Accepted - Note that old section 16.5.1 has now been moved to the theoretical section 16.4. We have modified the section a little but we are making sure that there are no confusing breaks across paragraphs like this one. We will keep the TIS theme clear.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
35587	37		38		this discussion appears to be in the wrong place. Much of it is already taken for granted in earlier sections	Accepted - We completely agree that this section should have been earlier in the chapter. As noted in previous responses, we have now moved the conceptual part of the previous section 16.5 (16.5.1) into a new section on innovation concepts and frameworks in section 16.4. As a result, the discussion of TIS and the granularity in the analysis (along with previous table 16.5) has been moved. We think this really improves the clarity and flow of the chapter.	Robert Gross	Imperial College and UKERC	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
8675	37	16	39	14	[16.5.1 Provide more detailed information] - The innovation framework is presented in four ways. The energy system is one of the typical areas where innovation is needed to cope with climate change, and it is deemed appropriate to comment on this. - Both sides of biomass-generated cookstove technologies are being mentioned. However, contradictions between the innovativeness of both climate technologies and general technologies should be addressed, too. - Basic strategies for innovative climate actions for country (developing/developed countries) and sectoral categories should be suggested at a national (government) level.	Accepted - The old section 16.5.1 has been moved to section 16.4 to improve flow and clarity. On the first point, about the framework and how the energy system is a place in which innovation is needed, we agree and we believe that with the move of old section 16.5.2.2 to section 16.4, this framing will be clearer and in a better (more prominent) place. On the second point about climate and general technologies, with the new section on spillovers and General Purpose Technologies we will make clearer that those can also advance climate goals, but we are of course limited to the literature in terms of being able to say much about the balance. On the third point, section 16.4 now includes specific cases and examples directly from developing countries. We are not aware of a specific paper or sets of papers indicating what are the differences in terms of policies, governance or outcomes between all developed and developing countries, but this new version has a more balanced set of examples. We have also explicitly noted that in terms of assessing the impact of policies on innovation, the evidence from countries beyond the OECD, China, India and Brazil is limited.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
46341	37	17	39	14	This section is largely repetitive of earlier section 16.3 and should be deleted. (And like much other material, it's not specific or applied to climate change mitigation).	Accepted - Following this and other comments, we moved the old section 16.5.1 to section 16.4 to introduce the various relevant theoretical approaches. This helps avoid repetition. We also take the point about the need to include more 'climate focussed research.' Since this is the first innovation chapter we believe it is important to include the non-climate literature as well. However, we have now expanded the review of the more focussed literature on Sustainability Oriented Innovation Systems, on Strategic Niche Management and Sustainability Transitions. We now also refer to the innovation part of this useful article https://doi.org/10.1016/j.eist.2019.01.004	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
2389	37	16	43	19	It is necessary to apply consistent methods for the quotation of references such as single author, two authors and several authors	Accepted - Going forward we will be more careful with this, although to the best of our knowledge the number of authors listed in the text actually depends on Mendeley, but we will make sure that the input of the references is consistent.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
17677	37	16			This is an excellent section in many respects, but it is really unclear how it is used by or relates to other sections of the report. If this gravitates towards a multi-level perspective as being the most useful for understanding socio-technical transitions, link it to Chapter 1, and use it.	Noted and accepted - Thank you for the positive comment. Note that to improve the flow within Ch16 and the report we have now moved most of the theory/conceptual discussion to section 16.4. We do not pick a particular understanding as the most useful. But we agree that, given the discussion about Ch1 it is important to link the heavily revised section 16.4 with these sustainability transitions, TIS, MLP and sustainability oriented innovation systems references with Ch1. We are making sure that we discuss them in the context of innovation.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
42171	37	16			16.5.1 - as above, very brief intro - needs to either be beefed up or referred to chapter 13	Accepted - We agree that these frameworks did not flow well here and that this needed some expansion. We have moved section 16.5.1 to section 16.4 with other theories. We have also beefed up as requested the discussion of the innovation systems, transitions, and strategic niche management literature more specific to climate. We will make a specific link to Ch1, which we believe will also discuss some of these theories/concepts in the context of mitigation more broadly, and not innovation.	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
2391	37	40			It is better to show the examples of seven functions (or processes)	Accepted (but different solution) - For word count reasons we will not be able to show examples of each of these seven functions, particularly in the summary of this subsection. But instead, we include examples to illustrate the theories towards the end of 16.4. The content of 16.5.1 has now been moved, integrated and expanded in section 16.4 to improve the flow give this and many other comments. 16.4 now also includes several case studies that illustrate the many drivers (in some cases functions) of innovation. We believe that this addresses the comment although in a way that is different from what the reviewer proposed.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2393	37	46			It seems to be better to delete "focussed on technologies".	Accepted. Removed.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
9965	38	1	38	5	References for recent MLP applications for energy transitions focussed on technologies: - Moallemi, E. A., de Haan, F. J., Webb, J. M., George, B. A., & Aye, L. (2017). Transition dynamics in state-influenced niche empowerments: Experiences from India's electricity sector. <i>Technological Forecasting and Social Change</i> , 116, 129-141. - Rogge, K. S., Pfluger, B., & Geels, F. W. (2018). Transformative policy mixes in socio-technical scenarios: The case of the low-carbon transition of the German electricity system (2010–2050). <i>Technological Forecasting and Social Change</i> , 119, 259. - McDowall, W. (2014). Exploring possible transition pathways for hydrogen energy: a hybrid approach using socio-technical scenarios and energy system modelling. <i>Futures</i> , 63, 1-14. - van Sluisveld, M. A., Hof, A. F., Carrara, S., Geels, F. W., Nilsson, M., Rogge, K., ... & van Vuuren, D. P. (2018). Aligning integrated assessment modelling with socio-technical transition insights: An application to low-carbon energy scenario analysis in Europe. <i>Technological Forecasting and Social Change</i> , 119, 177. - Auvinen, H., Ruutu, S., Tuominen, A., Ahlqvist, T., & Oksanen, J. (2015). Process supporting strategic decision-making in systemic transitions. <i>Technological Forecasting and Social Change</i> , 94, 97-114.	Accepted - Thank you. We have those references to the summary of previous section 16.5.1 (now in 16.4) and the content of 16.4 (not all references in both places). Although the proposed references are quite wide ranging, they all speak to the point about needing to include different stakeholders. They are not all focussed on innovation, but they help make the point.	Haris Doukas	School of Electrical and Computer Engineering, National Technical University of Athens	Greece
11047	38	13	38	19	This topic on policy mixes is covered at length in chapter 13. I do not see the need to cover it so much here. As a general comment, I see a lot of overlap of this chapter and that chapter. In addition, a lot of valuable references and work carried out on these topics is missing.	Accepted - We agree that reducing the discussion of the topic is needed to reduce overlap with Ch13. However, we believe it is important to mention this since literature focussed on innovation outcomes definitely indicates that mixes are important. Note that the previous section 16.5.1 has now been moved higher up in the chapter with other conceptual points. It is now in 16.4. We shorten this description, make it more specific to innovation, and include a link to Ch13 where the topic is covered in more detail.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
45015	38	13	38	33	For an important contribution on the policy mix for innovation, see also Flanagan, Kieron, Elvira Uyarra, and Manuel Laranja. "Reconceptualising the 'policy mix' for innovation." <i>Research policy</i> 40.5 (2011): 702-713.	Accepted - Thank you. We now include this reference to the (now shortened) discussion of policy mixes. Note that this has now been moved to section 16.4 to improve the flow (following the request by several reviewers). We also now include an explicit link to Ch13 which discusses this topic more fully with less focus on the innovation outcome. The paper you recommend is useful to cite in our chapter because it is fully focussed on innovation (although not necessarily on climate).	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
2399	38	15	38	16	" Rationales for additional climate policy instruments under the carbon price" should be replaced by "Towmey" (the author)	Accepted - Corrected. Thank you for the catch!	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
18327	38	18	38	21	This is not specific to energy and environmental space. In all sector, e.g. internet, semiconductor, basic R&D policy was instrumental.	Accepted - We agree that we should have discussed general purpose technologies and spillovers more fully. We now have a fuller discussion of this topic in general (as requested by the reviewer) and in the context of climate/environment/energy technologies in section 16.3.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
2401	38	28	38	29	It is necessary delete " the policy processes that led to the creation of such mix of policies" considering that "building block elements" and "process" are included in the policy mix.	Accepted - Corrected. Thank you for the catch! Again, note that section 16.5.1 has been moved and integrated in 16.4	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
11049	38	41	38	47	Yes, but some of the incumbents have also quite strongly invested in RETs (see Ana Bergek recent work on this).	Accepted - Thank you for the reference. We now note that the role of incumbents is not uniform and that # some incumbents that have engaged more than others. We assume the reviewer is referring to this: https://www.sciencedirect.com/science/article/pii/S2210422419302813 . We now also include a citation to work by Bergek that further supports the other point about incumbents blocking change https://www.sciencedirect.com/science/article/pii/S0048733313000486	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
18329	38	41	38	47	Modify single sided argument. The situation depends on country. Power grid manily established for fossil fuel power polants provides favorable condition for renewable to be connected to the grid. Renewable has been constantly and heavily susidized in many countries for decades at the expense of fossil fuel users.	Noted and partly accepted - We modify the language that could be taken to indicate a completely uniform role for incumbents. We cite this: https://www.sciencedirect.com/science/article/pii/S2210422419302813 . We welcome other references. However, continued fossil fuel subsidies are well documented at least around 330 bn USD in 2015 (Jewell et al Nature 2018). See also: "Why Fossil Fuel Producer Subsidies Matter," by Peter Erickson et al., in Nature, Vol. 578; February 5, 2020 . However, since this paragraph is not about what actors receive more subsidies, but rather about the role that the actors play shaping future policies and regulations, and since Ch13 talks about subsidies, we we have not delved into the subsidy point. But again, point taken that not all fossil actors have behaved in the same way. We are working on a more nuanced expression.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
2395	38	3			It is better to delete "but" and replace with an appropriate word.	Accepted - We have replaced it with 'and'.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2397	38	6		12	It is better to relocate the corresponding paragraph because it looks like a conclusion for the paragraphs from line 24 of page 16-37 to line 5 of page 16-38, but the contents is not related with those of previous paragraphs.	Accepted - We have removed the word 'overall'. We think this solves the problem. As the reviewer noted, this gave the wrong impression. What this section was meant to do is to summarize the insights from the theoretical part. Note that the whole section 16.5.1 is now merged, integrated and expanded with section 16.4.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
17679	38	38			? Is this a reference to the resistance of incumbents and market structure in the meso-layer / markets domain (Chapter 1)	Accepted - We have introduced a link to note that chapter 1 includes more discussion about the role of incumbents beyond innovation.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
2409	39	31	40	0	It is necessary to introduce some policy recommendations described in the reference, Negro et al 2012 in the Table 16.5 and at the text considering lines 19 and 20, page 16-39 which mentions possible policies to address such barriers	Accepted - The Negro et al 2012 reference mentions high level implications from the Table mentioned by the reviewer. We already had one brief sentence just before Table 16.5, but we have expanded it a little to mention capabilities and networks (we had only highlighted the need to invest in institutions). Note that the next figure includes more specific policy implications because the article itself is more specific.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
17681	39	16			See my comment to previous section (16.5.1, pg 37 line 16). There is more good material here, but I ended up quite confused. Decide on the most plausible and evidenced analytic framework around innovation; the classifications of policy instruments that would follow - and try and organise around that. Obviously, that includes tech push and supply pull, but beyond that. eg. in the 3-pillar framework, tech push is predominantly a component of 3rd pillar (strategic investment), whilst there is a clear alignment between the market incentives, pricing, and barriers with the second pillar around market design, whilst first pillar reflect the more specific and individual drivers around niches (experimentation and lead/accelerated adoption, etc). But however done, try to introduce some intellectual consistency into the chapter that flows from understanding nature of innovation processes through to policy packages for transformations	Accepted - We agree that the current flow of the chapter was confusing. We have now moved the theoretical part (16.5.1) to section 16.4 and integrated it with other pieces. We now also connect directly with the policy typology in Ch13 although we make some categories more granular to reflect the literature studying innovation. This makes it easier to see that we are not picking one framework over another. We think this will also improve clarity. Sadly, we cannot really cover policy packages in a lot of detail (it is our understanding that Ch13 is doing a lot of this). Right now section 16.5, given the changes, is more about evidence of the impact on different innovation metrics for different instruments and the conceptual part tries to cover all approaches. This is partly needed by the need to address several of the previous reviewer comments, which asked us to include more and not less frameworks and concepts.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
2403	39	22			It is appropriate to substitute "identified" with "identifying" considering the title of 16.5.2 (line 16)	Accepted - Thank you. Modified. The particular title may change though, but the reviewer is right pointing out the grammatical error.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2405	39	26			It is appropriate to delete "and physical"	Accepted - Thank you again. We deleted that since it we had already written "knowledge and physical infrastructure"	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2407	39	28		29	It is appropriate to delete that sentence because other problems are also related with domestic capabilities	Accepted - Sentence removed. It was repetitive.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2411	40	8	40	18	It is necessary to add (See Figure 16.3) for the quotation	Accepted - We have linked this to the figure, although the figure number will change since we have moved this section to 16.4.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2413	40	9			It is necessary to change the first part of the sentence because "inertia" and "low social returns" are under the "low economic returns" as shown in Figure 16.3	Accepted - We have added "from inertial and low social returns" to more accurately describe the figure.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2415	40	17			It is appropriate substitute "difficult" with "difficulty".	Accepted - Thank you again. We have replaced 'difficult' by 'difficulty' to correct the grammar. Again, note that the section was moved to 16.4	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
2419	41	6	41	9	It is necessary to rewrite the sentences to fit to the grammar.	Accepted - Thank you. We have replaced that sentence by: "Many sectors crucial for climate mitigation invest less than 1% of sales in R&D (citation). These sectors in what may be considered a low R&D intensity category include industrial metals and mining, electricity, construction and materials, oil & gas producers, forestry and paper, gas, water and multi-utilities, and industrial transportation, and banks."	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
17683	41	6	41	11	This has indeed always struck me as a foundational statistic for innovation in context of climate policy, but here it is unreferenced, and has really no theory indicated behind it. If need reference, the Sectoral data on R&D intensity, and an underlying theory (along with implications for policy) are mapped out in Chapter 9 of Planetary Economics Grubb, Hourcade and Neuhoff (2014): Planetary Economics; and also more briefly (but with example applications and relationships to other theories and frameworks of innovation) in Grubb, McDowell and Drummond (2017): On order and complexity in innovations systems: Conceptual frameworks for policy mixes in sustainability, transitions, Energy Research and Social Sciences, Vol.33:pp21-34	Accepted - Thank you for the references! We had data for the OECD but the citation disappeared. We have included both references (and another one we found) to substantiate this important point.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
2421	41	12	41	13	It is necessary to edit "is not have been as suitable" fit to the grammar.	Accepted - Thank you. Corrected. We have corrected the grammar by saying "it has not been as suitable"	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2417	41	0			It is necessary to change words in the boxes according to the words in the reference in Figure 16.3	Accepted - Some of the text in the figure had been cut and, as such, it did not include all the words in the original cited source. We have fixed this in the next version. Note this has moved to section 16.4	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
35535	41	6		14	The sentences are incomplete and therefore hard to understand	Accepted - Thank you. We are sorry about this. As indicated in response to a previous reviewer that pointed this out, we have replaced this by : "Many sectors crucial for climate mitigation invest less than 1% of sales in R&D (citation). These sectors in what may be considered a low R&D intensity category include industrial metals and mining, electricity, construction and materials, oil & gas producers, forestry and paper, gas, water and multi-utilities, and industrial transportation, and banks." We have also now included several citations to support this.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
2423	41	15			It is necessary to add (See Figure 16.4) for the quotation	Accepted - We agree. Thank you. We now cite Figure 16.4. Note that this whole section has moved to 16.4.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
2425	42	7	42	9	It is necessary to write 16.5.1 and 16.5.2 to have more reasonable and smooth flow without showing sudden and short conclusion (lines 24 - 26) considering the lines 24-26, page 16-36. to draw the conclusion that government policy plays an important role in the innovation of climate technologies. 16.5.1 introduces frameworks for studying the determinants of technology innovation and 16.5.2 shows frameworks for identifying barriers to innovation in climate related technologies. But, it is not easy to figure out the necessities or importance of government policy.	Accepted - We have now moved these sections to 16.4. The idea was to link the barriers to the policy (which is what the Hausmann article and the TIS framework do, among others, but it seems like this was not enough. By now having sections 16.3 with the macro considerations and the role of government there, and 16.4 with the more systems based considerations and the role of government we believe that the point about the really essential role of governments comes out more clearly. We are also briefly making this connection at the start of the new 16.5 which is more focussed on specific policy instruments.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
5797	43	6	43	19	This is a good list! Do more with it and feature it more prominently early in the chapter.	Accepted - Thank you. We have moved this section (16.5.2.3) to 16.4 with the other systems research. We have added more references. We believe that with the inclusion (also in 16.4) of cases studies, which also highlight these points, we are substantiating the list. We cannot expand the list as such here (with paragraphs for each point) beyond the references and the link to cases because of space limits.	DAVID HART	GEORGE MASON UNIVERSITY	United States of America
11051	43	23	43	27	Too long, repetitive and redundant. I suggest to synthesise.	Accepted - We synthesize this since we now can draw on the Ch13 typology. We also refer explicitly to that chapter.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
46343	43	22	44	30	This is another generic section about environmental policy and regulation, not about innovation and technological change. It could be deleted without loss.	Noted and partly accepted - For the FOD it was necessary to justify the policies we were evaluating in terms of the evidence regarding the impact on technological change. Luckily we are now in a position to significantly shorten the text suggested by the reviewer. We cannot, however, completely delete. In particular. We merge the old Tables 16.5 and 16.6 with the new typology in Ch13 to indicate what policies we are reviewing. But point well taken. No need to write as much about typologies. We just need to say which ones we are reviewing and how they link to technological change.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
37903	43	23	44	25	<p>Chapter 13 also has a taxonomy of policy instruments. Consistency of taxonomy might be beneficial. Selecting a common one from grey literature of perhaps see Howlett. Howlett, M. (2009), Governance Modes, Policy Regimes and Operational Plans: A Multi-Level Nested Model of Policy Instrument Choice and Policy Design. "Policy Science". Vol. 42, No. 1, pp. 73-89</p> <p>Howlett, M. (2019), "Designing Public Policies: Principles and instruments". 2nd Edition. London and New York: Routledge</p>	Accepted - We now better link to the Ch13 typology, which (like the one in Table 16.6 in the previous version) is based on the literature. As noted in our response to previous comments, we have shorted the start of section 16.5.3 (which now is at the start of section 16.5) and we have merged Tables 16.6 and 16.7 to better link with Ch13 and indicate where we analyze more or less granular policy instruments. Given that all the reviewers have recommended that we increase the connection with the main typology introduced and discussed in Ch13 and that we should shorten the introduction, we believe that the two useful references provided by the reviewer would be most appropriate in Ch13.	margot Hurlbert	University of Regina	Canada
43751	43	6	47	3	This is a general comment that may apply to the whole chapter and is similar to an earlier comment (p25 lines 19-29) - what defines of 'innovation' and 'technology development' and, for differentiation from other chapters, what is the boundary between policies to drive innov & tech devt (out of lab, to first stages of commercialisation through 'valley of death' R&D+?); policy to support innovation in business model development; and policy to drive sector change more broadly - e.g. uptake of mature renewables and indeed the linkage to policies that drive investment (across low carbon technologies). FITs and auctions are covered in this chapter for example, policies that tackle project economics but which might have indirect impacts on stimulating technology innovation or not (raised under 16.5.5/16.5.5.5). But take renewables - from an IPCC WG3 perspective there seems to be overlap between this chapter, the Energy System chapter (Ch 6) and 'Finance & Investment (Ch 15) - the three chapters I am reviewing.	Accepted - Thank you for the comment. As the reviewer points out, this chapter lays out a definition of technological innovation grounded in the literature that recognizes that it is not just driven by R&D given the induced innovation and the linkages across stages. Although several chapters talk about FITs, this one is the only chapter that talks about FITs in the context of the full suite of policies used to incentivize innovation across the full cycle. It is also the only chapter that presents the empirical evidence available about the impact of FITs and other policies on innovation and the two other outcomes. But to make sure that the distinction in terms of the goal of the chapter is clear, we now include references to chapters 6 and 15 in terms of their more specific discussion for the impact of FITs on technologies (Ch6) and on finance (Ch15), as opposed to on innovation outcomes.	Kirsty Hamilton	Chatham House (Associate Fellow, unpaid)	United Kingdom (of Great Britain and Northern Ireland)
8677	43	21	47	3	<p>[16.5.3. Provide more information (e.g. Case study)]</p> <p>- The theory of innovation of both general science and environmental economics is presented in a list. Presenting the innovation theory for environment (green) and introducing successful case studies of policy effectiveness would help the readers who would like to learn more about climate change response.</p>	Accepted - We have fully taken this onboard in the reorganization and changes in Ch16. Specifically, we have moved sections 16.5.1 and 16.5.2 on the concepts and theories of innovation to 16.4, where they are being supplemented by case studies (one on solar, for instance) that illustrate the drivers. At the end of section 16.5 we also have a couple of cases on policies. The environmental impact of these policies, however, is largely covered already in Ch13, so we do not include that impact here to avoid duplication.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
35537	43	21	47	3	Other relevant policies are intellectual property (patent pools, patent length etc), creating innovation networks (cluster policy, smart specialization strategies, etc.), and all financing policies (public investment banks providing investment capital, loans, collaterals, etc.)	Accepted - Certainly the IP part. We had actually thought about the fact that we should cover IP, as this is not really covered elsewhere in the IPCC. This comment further prompted us to bring in a contributing author from Delft that is an expert on this: Prof. Ruidi Bekkers. We now have a section on IP policies in 16.5. The network creation point is harder because 'creating networks' is not really a policy instrument in most categories and we have not really come across papers evaluating them in terms of their direct impact on innovation. Same with the link between public investment banks and innovation outcomes. There is some research linking them to deployment (which is of course part of the innovation process), but the metrics we use in the innovation outcomes are different. Some of these topics are more on governance of the transition and are covered in Ch13. We have, however, added a comment about those two policies and how, at least in theory (given the TIS analysis) they should lead to innovation outcomes.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
42173	43	21	48	13	16.5.3 again - boundaries with chapter 13	Accepted - We have merged and changed Tables 16.6 and 16.7 and indicated how the policies we evaluate link to the Ch13 typology, which ones are more granular, which ones we add, and why we cover the ones we cover. We also make even more explicit the fact that we focus on the innovation outcomes and on this modified set of instruments. We also link in more places to Ch13.	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
11053	44	27	45	1	I see a clear overlap with another classification (price-based vs. quantity-based), which might be more relevant in this context. Some instruments that you include under "fiscal/financial incentives" can be considered market-based (auctions) and those which deemed "market-based" are financial incentives (TGCs). So, for me, those that you call "market-based" are quantity-based and those that you call "financial and fiscal" are mostly price-based.	Noted - We are now connecting more directly to Ch13 to avoid the proliferation of policy typologies. We are merging Tables 16.6 and 16.7 and indicating where we build on or depart from the Ch13 policy typology. Our understanding is that the classifications that our original typology and the Ch13 typology are based on (and referenced) used the market vs. regulation nomenclature. Following the comments of other reviewers, we have opted to shorten the introduction to 16.5 on the typology as opposed to devoting more space to explaining it. This additional terminology may be something worth considering for Ch13, where the overall typology is introduced.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
2501	45	5	46	1	It is better to delete Table 16.7 considering that the Table is summary of part of Chapter 13 and it does not provide important information.	Accepted - We have merged and changed Tables 16.6 and 16.7 and indicated how the policies we evaluate link to the Ch13 typology, which ones are more granular, which ones we add, and why we cover the ones we cover. We also make even more explicit the fact. We agree that this was confusing.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
2429	46	3	46	3	It is appropriate to change the first Table 16.4 into Table 16.5 and the second Table 16.4 into Table 16.8, respectively.	Accepted (I think) - We are making a big rewrite and reorganization of 16.4. This will bring together cases, technologies and systems theory. Given that some of these tables will disappear, be moved, or be merged, we think that the flow (which seems to be what the reviewer rightly is concerned about) will be improved. So although it will not exactly as the reviewer suggests, the concern will be addressed.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2431	46	4	46	4	It is appropriate to change Table 16.3 into Table 16.5.	Accepted (I think) - We are making a big rewrite and reorganization in 16.4. This will bring together cases, technologies and systems theory. It will also integrate 16.5.1 and 16.5.2. Given that some of these tables will disappear, be moved, or be merged, we think that the flow (which seems to be what the reviewer rightly is concerned about) will be improved. So although it will not exactly as the reviewer suggests, the concern will be addressed. will bring together cases, technologies and systems theory. Given that some of these tables will disappear, be moved, or be merged, we think that the flow (which seems to be what the reviewer rightly is concerned about) will be improved. So although it will not exactly as the reviewer suggests, the concern will be addressed.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2433	46	5	46	7	It is appropriate to change Figure 16.5 into Figure 16.3.	Accepted (I think) - We are making a big rewrite and reorganization in 16.4. This will bring together cases, technologies and systems theory. It will also integrate 16.5.1 and 16.5.2. Given that some of these tables will disappear, be moved, or be merged, we think that the flow (which seems to be what the reviewer rightly is concerned about) will be improved. So although it will not exactly as the reviewer suggests, the concern will be addressed. will bring together cases, technologies and systems theory. Given that some of these tables will disappear, be moved, or be merged, we think that the flow (which seems to be what the reviewer rightly is concerned about) will be improved. So although it will not exactly as the reviewer suggests, the concern will be addressed.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2435	47	5	47	5	The title of 16.5.4 "Rationales for and policitics of national policies" is to be changed	Accepted - We agree the title of this section was unclear. We have renamed it 'Drivers of national policies in the climate change mitigation and adaptation space'	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
5799	47	5	47	6	This section heading points up the fact that successful adaptation will also require a lot of technological innovation and diffusion, including in agriculture and urban infrastructure. The chapter would benefit from a specific focus and highlight on this key point.	Accepted - We have added in the new version of section 16.4 an agriculture case (Rice Intensification is the main candidate). We are also adding a policy example at the end of section 16.5 on agriculture in developing countries).	DAVID HART	GEORGE MASON UNIVERSITY	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
35539	47	7	47	33	The policy discussion would benefit from integrating insights from the literature on complex systems, particularly the idea that small changes near a tipping point can have large effects by triggering positive feedback. See e.g. Farmer, J. D., et al (2019). Sensitive intervention points in the post-carbon transition. <i>Science</i> , 364(6436), 132-134. ; Otto, I. M. et al (2020). Social tipping dynamics for stabilizing Earth's climate by 2050. <i>Proceedings of the National Academy of Sciences</i> , 117(5), 2354-2365.	Accepted - We will include limited evidence and high agreement. This is really emerging (2 papers), the studies are mostly theoretical, and they focus on the possible impact of tipping points on broad social change. The papers are not focussed on the impact of tipping points on technological change, although they mention it, so it seems appropriate to include briefly.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
2673	47	18	47	21	The focus is on renewable energy technologies; probably right, and is not this a pity? There is a lot of technology in buildings, and still more in the various aspects of managing the biosphere with climate change in mind.	Noted - We agree that ideally we would also be able to cite studies on the role of political economy and politics driving national low-carbon innovation policy from the buildings sector, but unfortunately we have not been able to find anything. If the reviewer knows of something, please send it our way.	Philippe Waldteufel	CNRS/IPSL/LATMO S	France
46345	48	7	48	9	Yes! Understanding ex post evidence linking policy to innovation metrics for low-carbon and clean-energy technologies should be one of the main emphases of the whole chapter!! This is a welcome recognition after all the theory and exposition.	Noted - Thank you. Also note that, following many of the reviewer comments (including yours) the theory part is now condensed in 16.3 and 16.4 and 16.5 is mostly dedicated to empirical evidence on policies and a couple of cases.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
2445	48	9	48	9	The reference (Penasco et al, 2019) is under review. Therefore, it should be quoted after the acceptance.	Noted/Agreed - Indeed. If this is not accepted by the deadline, we will take it out. The reference is not so essential right now since we will connect more directly with the typology on Ch13.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2437	48	11	48	11	The Table 16.4 is replaced by Table 16.6.	Accepted - We are making a big rewrite and reorganization in 16.4. This will bring together cases, technologies and systems theory. It will also integrate 16.5.1 and 16.5.2. Given that some of these tables will disappear, be moved, or be merged, we think that the flow (which seems to be what the reviewer rightly is concerned about) will be improved. So although it will not exactly as the reviewer suggests, the concern will be addressed.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2439	48	12	48	12	"competitiveness" should be added in the sentence.	Accepted - Thank you. We have added the word competitiveness.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2441	48	15	48	19	It is better move the far-right column(criteria, outcomes, and indicators) of Table 16.9 to the first column	Accepted - We agree this improves clarity and have moved the figure. Note that we have also simplified it to reduce the duplication with the metrics on other outcomes covered in Ch13.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
11055	48	18	48	19	Sorry, but I do not understand this criterion “relevance” or, at least, why you call it that way. Relevance for what? Aren’t the other criteria relevant? It seems this category does not stand by itself. What you there are rather “local socioeconomic impacts” and should be called this way (see del Río et al 2012, 2015) for a classification of criteria which includes this criterion. Del Río, P. et al (2012). Assessment criteria for identifying the main alternatives - Advantages and drawbacks, synergies and conflicts. D2.2 Report. A report compiled within the European IEE project beyond2020 (work package 2) - Intelligent Energy - Europe (IEE), ALTENER (Grant Agreementno. IEE/10/437/SI2.589880). https://www.res-policy-beyond2020.eu/pdf/final/Assessment%20criteria%20for%20identifying%20the%20main%20alternatives%20(beyond2020%20-%20D2-2).pdf Del Río, P., Wigan, F., Steinhilber, S. 2015. Assessment criteria for RES-E Auctions. Informe del proyecto europeo AURES D2.2 (b) for the project AURES (Promoting Effective Renewable Energy Auctions). http://www.auresproject.eu/publications/assessment-criteria-res-e-auctions	No longer applies - This table has been significantly modified to reflect the focus of Ch16 on innovation outcomes. Ch13 has the broader typology of policy evaluation outcomes and metrics and these references would be really useful there. This table now just has the innovation outcomes and metrics (we have removed the 'criteria') and (for completeness) the metrics for competitiveness and distributional outcomes.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
11057	48	18	48	19	Not only the “incidence of support costs” and “the change in spending”, but the level of support costs itself should be here (see del Río and Cerdá 2014, cited above). Such level should not be under the efficiency criterion (you do not put it under the efficiency criterion anyway) but a distributional one. I suggest you change “incidence of support costs”, which suggests impacts on different actor categories, by “level and incidence of support costs”, which covers the aforementioned relevant aspect.	Accepted - Thank you. We have modified this since we include metrics for competitiveness. We will also add that reference.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
2443	48	20	48	20	It is appropriate change "the impact of 10 of policies" into "the impacts of ten out of 21 policies".	Accepted - We agree it is useful to specify. Note that we are looking at a broader set of policies and we no longer use the policy typology in the previous Table 16.6 since we instead merge 16.6 and 16.7. But the need to specify that we do not cover in detail all of them is useful.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
46347	48	1	54	13	This is a welcome section as it focuses on (1) synthesis of empirical evidence and (2) innovation outcomes relevant to climate change mitigation. However, it's largely a review of one study (Penasco et al. 2019). Although this is a meta-study of evidence from the literature, I would suggest using this section as a framework for the whole chapter, then each section can also embed evidence from single studies or elsewhere in the literature (i.e. chapter structure could be: (1) this is innovation and technological change (2) this is policy and regulation relevant to low-carbon innovation and technological change (3) here is all the evidence linking one to the other.	Accepted - We have changed the structure to include in 16.3 innovation and technological change and in 16.4 the systemic frameworks and theory. We rely to some extent on Ch13 policy typology but now start 16.5 with an integrated typology specifically useful for innovation. In terms of the evidence, the previous reliance on one study was due to availability and also to the fact that we had no space to discuss individual studies on all the policies. Now that we are reducing a little the space devoted to typologies and outcomes we highlight a little more individual studies. In addition, we have now added reviews on intellectual property (by bringing an expert contributing author, Prof. Rudi Bekkers). We also review briefly the literature on voluntary agreements and standards. But we are keeping the summaries from Penasco et al (augmenting them with a couple of examples based on individual papers) because the overall analysis from the policies covered in that study is systematic and hard to convey otherwise given word limitations. We have complemented it significantly, but not using it would reduce the value of the analysis. It would actually reduce the usefulness.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
26053	48	1	56	2	This section 16.5.5 may benefit from adding a new sub-section on ex-ante assessments of policy instruments conducive towards promoting innovation. See, for example the paper by ICAT (2019) on "Transformational Change Methodology: Assessing the transformational impacts of policies and actions. June 2019 Version. Olsen, K.H. & Singh, N. (Eds.). Initiative for Climate Action Transparency (ICAT), UNEP DTU Partnership and World Resources Institute, Copenhagen and Washington. https://climateactiontransparency.org/icat-guidance/transformational-change/ "	Accepted - Thank you for the references. We make this ex ante ex post point more explicit and we include the references. Note that we already talked about quantitative, qualitative and theoretical study but these papers are useful too.	Zyaad Boodoo	Government of Mauritius	Mauritius
25733	48		56		This section on 'Assessment of innovation and other impacts of policies shaping innovation' might be strengthened by a short additional section on policies that support later stages of innovation (besides R&D). This could, for example, include the potential importance of creating niches for technologies to mature before directly competing with more established technologies, test infrastructure that offer controlled environments to foster knowledge and development, and the role of stable institutions. A useful reference might be Chapter 13 in Skea, J., van Diemen, R., Hannon, M., Gazis, E., and Rhodes, A. (2019) Energy Innovation for the Twenty-First century: Accelerating the Energy Revolution. Edward Elgar Publishing.	Accepted - we include policies beyond R&D, but we now add a demonstration niche section that will separate R&D funding and performance to policies directed at scale up. We also include this reference and others on demonstration/experimentation. We had some discussion on demonstration but including the niche terminology, which we also introduce in 16.4, would be useful. Thank you.	Renee van Diemen	WG III TSU	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
42175	48	15	59	8	indicators of effectiveness etc need to be agreed across report - these differ from chapter 13	Accepted - We are removing Table 16.9 and instead just keeping the innovation outcome and the metrics, making the link to transformational outcomes in Ch13. We will also keep competitiveness and distributional outcomes (using the Ch13) terminology and the metrics we found. We wil also explicitly link back to the broader set of outcomes and metrics in Ch13.	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
18331	49	1	49	8	Important finding. Keep these paragraphs.	Noted/Accepted - Thank you!	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
11059	49	5	49	8	This suggests that there are unavoidable trade-offs which should be taken into account when proposing and designing policies.	Accepted - I think this comment means we should make the trade-offs (at least in some cases and in the short- to medium-term) point more explicitly. We agree.	PABLO DEL RÍO	Consejo Superior de Investigaciones Cientificas (CSIC)	Spain
2447	49	13	49	13	It is necessary to include (Table 16.3) after "From the policy categorization above"	Accepted/Unclear - I think the reviewer means Table 16.6, not 16.3? If this is what it is meant, yes, we will add the explicit reference to new policy typology table linking the policy instruments we analyze to Ch13.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2449	49	13	49	13	It would be more appropriate to change "the economic and direct investment categories" into " in the direct investment category under the economic and finanacial instruments".	Accepted - Yes, clearer. Thank you.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
18333	49	18	49	28	Important finding. Copy it to the esective summmary.	Accepted - Thank you. Yes, we agree, this should be in the executive summary and are including it there in the SOD.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
45017	49	29	49	40	This paragraph refers to "a smaller number of evaluations", but gives no citation. On evidence on public procurement instruments as innovation policy, a useful text is Edler, Jakob, and Luke Georghiou. "Public procurement and innovation—Resurrecting the demand side." Research policy 36.7 (2007): 949-963.	Accepted - Thank you. Yes, we are adding this useful reference.	Will McDowall	UCL	United Kingdom (of Great Britain and Northern Ireland)
43753	49	41	58	17	These two specific lines say the same thing - so check overlap.	Accepted - Thank you. We have removed the repeated sentence.	Kirsty Hamilton	Chatham House (Associate Fellow, unpaid)	United Kingdom (of Great Britain and Northern Ireland)
2453	50	10	50	21	It is necessary to describe the explanaton on the data in Table 16.11 in the text.	Accepted - We agree. We now include sentences in the text that help interpret this Table.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2451	50	7			It is reasonable to add "and distribution" right after "competitiveness" in the tile considering the text (line 22 to line 2, page 16-51)	Accepted - Thank you. We may shorten the title a little but the previous title did not reflect that we were covering those two additional outcomes beyond innovation.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2455	50	11			"and" should be added right after "renewables,".	Accepted - Thank you. We have introduced it.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
5801	51	4	52	14	This section is too ambitious - I don't think it's feasible to provide general direction as to how to design R&D programs across such a wide range of goals and countries. The list at the very end isn't bad but it isn't supported by the text that comes before it.	Accepted - We will reframe this and be more precise about the limits about transferability across countries. We have also changed the title to reflect that only some strategies are considered. Thus, in the text we also explain that only a subset of many strategies are covered because it is not feasible to cover the full space. In general, the section has more limited claims and caveats. We disagree that the list at the end is not supported by the previous sections or the evidence, but we take the point that the references were not included in that paragraph -- something we are now resolving. We are adding a paragraph at the end to denote that for different countries the gaps, strengths, and options may be different.	DAVID HART	GEORGE MASON UNIVERSITY	United States of America
2457	51	4			"the impact" would be added and the title becomes 'the impact of the design of'.	Accepted - Thank you. We have very long titles here but agree that it is needed.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2459	51	38			The first "US" would be deleted.	Accepted - Thank you for the catch. We removed the repetition.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2463	52	18	52	21	It is better to make this paragraph shorter. e.g. When it comes to other policies in the market pull category (such as tradeable green certificates, taxes, or auctions, for instance), the literature indicates diverse results. And feed-in tariffs would be added in the examples in the parenthesis.	Accepted - We have made the changes to improve the flow.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
18335	52	22	52	22	It is not appropriate to say "most" . 73% is not "most".	Accepted - We have made it more precise by saying that 'almost three quarters of the analysis'... We agree that 'most' can be interpreted as a much higher percentage. Thanks.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
18337	52	22	52	37	It should be noted that the impact of innovation may be narrowly analysed in the research outcomes cited here. FIT mechanism favors existing PV (polysilicon) among alternative PVs including more advanced and potential PVs (thin-film PV, amorphous PV, perovskite PV). Generally speaking, a governmental policy that favors an existing technology can result in hindering innovation of competing alternatives in infancy. See Meckling et al 2017 for such lock-in (such as corn biofuel in US) to suboptimal technologies. Meckling, J., Sterner, T., & Wagner, G. (2017, December 1). Policy sequencing toward decarbonization. Nature Energy. Nature Publishing Group. https://doi.org/10.1038/s41560-017-0025-8 Such consideration is perhaps lacking in the researches cited in the draft, and it should be considered and the conclusion must be modified.	Accepted - This is a point worth making. We agree. As a result, we are also adding this reference. Thank you for reminding us of this important literature.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
2465	52	25	52	27	It is necessary to provide the references for the distribution impacts.	Noted - we include the page number in the source article but it would be really clunky to add all the references everywhere. We include a couple of examples here, but not all of them as it would be too many references.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
18339	52	34	52	34	"generally" is not appropriate wording. 73% is not enough to say "generally".	Accepted - We agree. We are making it explicit.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
2467	52	38	53	15	It is better to separate these paragraphs because they are not dealing with policy instrument but dealing with domestic environment such as capacity and maturity with other parts such as line 22 to line 29, page 16-58.	Accepted - We have separated the points.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2461	52	16			It is necessary to add " competitiveness and distribution" right after "innovation".	Accepted - Thank you.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2469	52	47			"from" should be deleted at "competitiveness from outcomes".	Accepted - Thank you.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2471	54	4	54	5	It is necessary to clarify again because both Figure 16.5 and 16.3 are not fit to the text.	Accepted - Yes, the last version will make sure that the figure references match with the text.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
18341	54	10	54	13	Soft policy instruments can promote innovation and fit stringent climate target. For example, energy star labelling system and the top runner based regulation in Japan have spurred innovation for energy efficiency improvement of various electric appliances. Modify the text.	Accepted - We are expanding the text here to include also some of the examples mentioned to complement the references that were already included. Language there will be more uncertain and contingent indicating differences in outcomes. Thank you.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
35541	54				Table 16.12 incomplete	Accepted - We are working on completing it! It will certainly not end up like this. If we cannot do a systematic review, we will take out of the table the policies for which we can only do a less systematic literature review.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
18343	55	10	55	12	It was FDI that made economic miracle of east and southeast Asian countries. And FDI included many energy efficient technologies. See Gao and Wang 2013. Gao, X., & Zhang, W. (2013). Foreign investment, innovation capacity and environmental efficiency in China. <i>Mathematical and Computer Modelling</i> , 58(5–6), 1040–1046. https://doi.org/10.1016/j.mcm.2012.08.012 The conclusion here regarding impact by FDI on innovation is strange. Regarding the importance of FDI further, see Zanello, G., Fu, X., Mohnen, P., & Ventresca, M. (2016). THE CREATION AND DIFFUSION OF INNOVATION IN DEVELOPING COUNTRIES: A SYSTEMATIC LITERATURE REVIEW. <i>Journal of Economic Surveys</i> , 30(5), 884–912. https://doi.org/10.1111/joes.12126	Accepted - We will expand a little, but the evidence is indeed mixed. We will add the references suggested but others suggest no impact. But point taken. We will make it even clearer that the evidence is mixed. Note that here we are not talking about whether FDI results in economic growth. We are only assessing the evidence linking it directly to innovation outcomes (those in the table). We will make clearer the fact that the objective of our analysis is narrower.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan
11061	55	38	55	38	See, e.g., del Río and Cerdá 2017, del Río 2009, del Río 2014, Howlett and del Río 2015, all cited above	Accepted - We will include the references on system policies.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
11063	55	41	55	43	Please, rephrase. It is very difficult to understand the message here.	Accepted - We have rephrased it.	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
46349	55	1	56	2	These sections seem like a bit of a non-sequitur from the previous section, and not clearly relevant to or about climate change mitigation.	Noted - Given the previous sections on the drivers of innovation and environmental innovation, and also other reviewer comments, we need to include how these other factors affect innovation and (when possible) climate related innovation. We are introducing them a little more to explain why the format of the discussion is different. Hopefully the rationale and flow is clearer!	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
45121	55	35	56	2	The section on "system-oriented policies and instruments" may be expanded considering its importance for system transitions as emphasized in Chapter 4 of the Special Report on Global Warming of 1.5°C.	Accepted - There is a whole section on the system transitions management. We now reference it directly since we cannot fit this here too and there is a whole chapter on the topic of managing transitions.	Siir Kilkis	The Scientific and Technological Research Council of Turkey	Turkey
2473	55	35			It is necessary to revise the title because the tile can not cover the content (effect of policy mix).	Accepted - here we now mention policy mixes and innovation outcomes instead of system oriented policies.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
8679	56	9	56	20	[16.5.6. Necessary for careful suggestion of nuclear power] - Nuclear power undoubtedly is a source of clean energy, but it is contentious to claim that the weight of its RD&D should be increased due to the issues of waste disposal and safety (the German case). - In Figure 16.6, although minimizing renewable energy and energy efficiency sectors is not desirable, it is risky to interpret only based on the weights, given that it is only applicable to OECD countries and that the cross-cutting sectors are on the rise. - In developing countries, it is advisable to develop nuclear power to secure base power, but only when a consensus with neighboring countries are reached. - The investment portion for renewable energy in 2010-2018 may be reduced relatively because they are already commercialized and distributed widely due to active investment in its R&D in 2000-2010. - As such, there are many ways to interpret the figure 16.6.	Noted but out of scope - This graph (or the chapter) is not about making a judgement about what is desirable, but rather about noting the trends in the R&D investments. It is also not about forecasting (how the share will evolve). As the reviewer notes, however, we now mention in the text something that we already had in the Figure caption: that the data is for OECD countries mainly. Thanks.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
6535	56	15	56	16	A minor suggestion: In addition to Figure 16.6, it would be extremely informative to add data shows the number of innovation output (e.g., patents) by public energy RD&D expenditure over time for IEA data.	Accepted - But note that the evolution of patents will not be here (which is on public R&D investments) but instead in section 16.3 on metrics.	Yeong Jae Kim	RFF-CMCC European Institute on Economics and the Environment	Italy
2475	56	4	57	11	16.5.6 is directly related with 16.5.5.2 and paragraphs do not mention the impact on innovation. Therefore, 16.5.6 may be relocate to appropriate part and the impact on innovation need to be described.	Accepted - We now make the link between the discussion on trends and the evidence of the positive impact of public energy RD&D on innovation from the assessment of the policy instrument in the previous section.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
35543	57	13		17	Sections incomplete. I do believe the regional dimension is very important, as we know from economic geography that activities are highly clustered, so transforming existing industrial structures into a post-carbon economy will create winners and losers and they will be highly concentrated. This means that some regions are at significant risk if policy does not anticipate this.	Accepted - But note that this will be necessarily very brief. There is some work on the impact of regional policies on energy innovation (note that other outcomes are out of scope), but there is less policy evaluation on this so it will be much shorter and less structured (we will not go through every policy instrument). But we will note some of the data limitations. While the economic geography literature is very rich as pointed out by the reviewer, the analysis of the impact of specific regional policy instruments on climate technology innovation outcomes is not as rich.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
2479	58	10	58	21	This paragrah is very identical to lines 29-44, pages 16-49 of 16.5.5.2. Because 16.5.9 is directly related with 16.5.5.2, the revision of this paragraph is also related with the relocation of 16.5.9 as suggested in the right above mentioning.	Accepted - Thank you. We have removed this duplication.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
2481	58	22	58	29	This paragraph has very low relevance to other paragraphs in 16.5.9. It may moved another part to describe the importance of domestic environment.	Accepted - We agree that it does not fit.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2485	58	46	58	47	The last part of line46 would changed as follows; defined in the Kyoto Protocol (IPCC, 2007) and the corresponding reference (IPCC AR4 WG3 report, Annex 1) would be included in the References.	Not relevant any more - Thank you, but we have removed this paragraph as it did not fit too well in this section.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
25449	58	46	58	47	Delete "defined in the IPCC 20117".	Not relevant any more - Thank you, but we have removed this paragraph as it did not fit too well in this section.	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
2477	58	1	59	8	16.5.9 is directly related with 16.5.5.2. Therefore, 16.5.6 may be relocate to appropriate part.	Accepted - We are integrating this section with the other one on procurement.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
46351	58	2	59	8	I found this section interesting, important (for climate policy) and so highly relevant ... and therefore very bizarre that public procurement had scarcely been mentioned in all the previous text on policy, metrics, innovation processes, etc. Procurement needs tying into the conceptual framework of innovation and technological change from the outset.	Accepted - We are integrating this section with the other one on procurement.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
1121	58	46	59	2	The contribution of the CDM to technology transfer is ignored in this chapter. It could be argued that the CDM was more than a government procurement program. Most of the units (CERs) were purchased by private firms albeit for compliance with government imposed emissions limitation obligations -- ETS compliance in the EU, Switzerland and elsewhere. A substantial literature exists on technology transfer under the CDM, for example Murphy, Kevin, Grant A. Kirkman, Stephen Seres and Erik Haites, 2015. Technology Transfer in the CDM: An updated analysis, Climate Policy, 15:1, 2015, pp. 127-145, DOI:10.1080/14693062.2013.812719. Indeed, that whole issue 15(1) of Climate Policy is devoted to technology development and transfer for climate policy.	Not relevant any more - Thank you, but we have removed this paragraph as it did not fit too well in this section. But the whole section on technology transfer 16.6 will comment on CDM.	Erik Haites	Margaree Consultants Inc.	Canada
2483	58	46	59	8	The CDM and GEF are the facilities under UNFCCC and UN, respectively. Therefore, they are not fir to the 16.5 National and subnational innovation policies and activities and 16.5.9 government procurement and it would be better to delete this paragraph.	Accepted - Indeed, we have taken these out. We only talk about CDM in the section about technology transfer and international cooperation, section 16.6	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
10935	58	46	59	8	This section provides brief textbook descriptions of the GEF and CDM but does not appear to engage with the large critical literature on the CDM. Not all of this literature is relevant to innovation but a proportion of it is, and Peter Newell's work is particularly recommended here.	Accepted - This section was not substantive (no references to actual policy assessments) and not in the right place. We have completely removed these paragraphs. We only talk about CDM in the section about technology transfer and international cooperation, section 16.6.	Ian Bailey	University of Plymouth	United Kingdom (of Great Britain and Northern Ireland)
35545	58	7		15	repeats from p.49 l.34	Accepted - We are integrating this section with the other one on procurement. Thus we are getting rid of it here and are adding the right context to the policy assessment above.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
35547	59	1	8		has there been an evaluation of this policy? What have we learned from this experience?	Accepted - This section was not substantive (no references to actual policy assessments) and not in the right place. We have completely removed these paragraphs. We only talk about CDM in the section about technology transfer and international cooperation, section 16.6.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
26055	59	6	59	8	It is rather awkward to conceptualise the CDM and GEF as "government procurements". They are both mechanisms through which Governments in developing countries may access funds and are not procurement instruments per se. It is suggested that the language be reframed accordingly.	Accepted - This section was not substantive (no references to actual policy assessments) and not in the right place. We have completely removed these paragraphs. We only talk about CDM in the section about technology transfer and international cooperation, section 16.6.	Zyaad Boodoo	Government of Mauritius	Mauritius
8681	59	11	59	23	[16.5.10 Replace the unacceptable result and discussion to the other reference] - "Among the problem ~ or social responsibility" is not appropriate to be included. Examples of Korean cases in responding to climate change include realizing the green public procurement and leading in using systems and platforms for monitoring. As a result, the green product market experienced an 11.1% increase in compound annual growth (CAGR) between 2005 and 2016, and the government-led demand-expansion policy that exceeded the GP market with a size of 2 trillion won in 2014 produced substantial results. - Please refer the following document (UNEP, Green Public Process in the Republic of Korea : A decade of progress and lessons learned, 2019 ~p.83)	Accepted - We will amend this and consider the useful references provided by the reviewer to produce a more nuanced assessment avoiding normative language. Thank you.	Soonuk Yoon	Green Technology Center Korea	Republic of Korea
2493	59	25	59	40	The reference for those information in this paragraph would be included, if any.	Accepted - Indeed, we will only keep this if we find the reference. We are trying to find more recent examples as suggested by the next comment.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
38097	59	25	59	40	The case cited here seems a bit outdated, there are recent examples that could be well referenced	Accepted - We are working to find something more current and better referenced. We will not keep as is.	Xiusheng Zhao	Tsinghua University	China
46353	59	10	60	30	I found these case studies very useful, but they need 'wrapping up' with some integrative text on generalisability, and how they link to the earlier frameworks on policy and innovation.	Accepted - We will try to better tie them to the previous text in sections 16.3, 16.4 and 16.5 in particular. The reviewer is right that they need tying up.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
2495	59	42	60	9	The reference for those information in this paragraph would be included, if any.	Accepted - We will only keep this is we find appropriate references. The reviewer is right	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
17685	59	10			It does seem a little odd not to include the two biggest and most dramatically successful national efforts which have transformed the global landscape: the German Energiewende and in particular PV; and the UK transformation that has reduced power sector emissions by over 50% and reduced the cost of offshore wind by a factor of 3. The former is well covered in the literature, happy to provide references to the latter.	Accepted - We have now introduced the PV solar case as an example in section 16.4 on a technology and the various drivers. We have brought in Greg Nemet as a contributing author for this. We also have an agricultural case. For the offshore wind in the UK, we could possibly add it in this part of the chapter as a case if we can mostly explain it by one or two policies. Please send the articles. It is a good idea.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
2487	59	11			"and Lessons Learned" would be deleted, if they will not be mentioned the text additionally.	Accepted - Thank you.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2489	59	14			In my knowledge, the reference for Ko and Office is a PPT presentation file by Kyu Woong KO, Researcher, Sustainability Lifestyle Office, Korea Environmental Industry & Technology Institute. I wonder whether the PPT file is eligible as a reference. If not, the authors may find appropriate reference written by KO.	Accepted - We need to find references for this. If you have any others, contact us.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
2491	59	18			"The Act" should be changed into "The Act to Promote the Purchase of Eco-friendly Products".	Accepted - Thank you.	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
2497	60	11	60	29	The reference for those information in this paragraph would be included, if any.	Accepted - We will only keep this is we find appropriate references. The reviewer is right	SUIL KANG	Gwangju Institute of Science and Technology	Republic of Korea
8771	60	32	60	32	[16.6. Placeholder introductory para] - I think there should be some explanation that this section is limited to international cooperation for the further development and transfer of climate technologies in order to tackle the global commons of climate mitigation. It is because there are many governance modes of technology cooperation in business as well. - Also, I have a question. What is meant by 'international cooperation' in this chapter? International cooperation to support developing countries? International cooperation for technological innovation? Or, international cooperation for technology development and transfer in general? International cooperation for the development and transfer of 'climate technologies'? Current writing from line 31 in p.60 to line 32 in p.63 makes me puzzled.	Accept, the term international cooperation will be defined with chapter 14, and the scope of the chapter will be clarified.	Chaewoon Oh	Green Technology Center	Republic of Korea
8765	60	33	60	36	[Consisten between Executive Summary and Section 16.6: Indication of the UNFCCC mechanisms for technology development and transfer] - The author mentioned 'the UNFCCC mechanisms for technology development and transfer'. Currently, there is not any indication on this in section 16.6 (International cooperation). If this is included as one of essential elements in the Executive Summary, the author needs to prepare some space to indicate this part. - Also, I think that the UNFCCC mechanisms for technology development and transfer can include the Technology Mechanism, the Financial Mechanism, the Kyoto Mechanism under the Kyoto Protocol, and the voluntary cooperation types of cooperative approaches, the SDM, and the non-market approaches under the Article 6 of the Paris Agreement. There are some studeis that the CDM of the Kyoto Mechanism has contributed to the transfer of low carbon technologies in an indirect manner. However, if I read the relevant section 16.6.6 (assessment of how international initiatives are fulfilling roles), this section does not fully support the Executive Summary. I wonder the author in the Executive Summary only alludes to 'the Technology Mechanism'. If so, the Executive Summary should specifically name the 'the Technology Mechanism' under the UNFCCC, and the section 16.6.6 needs to explore more on this.Otherwise, if the author in the Executive Summary alludes to 'the afore-mentioned seveal mechanisms for technology development and transfer' under the UNFCCC, the section 16.6.6 needs to cover these mechanisms.	Accept. The literature on tech transfer in the CDM has already been addressed in the SR1.5 and AR5. On the PA Technology Framework, no literature could as of yet be identified.	Chaewoon Oh	Green Technology Center	Republic of Korea
8773	60	34	60	34	[16.6.1. Terminology] - I suggest the consistency of terminology. If this section is for international cooepration, the sub-section should be titled as 'modes of international cooperation on technology development and transfer'.	Accept. Title will be reconsidered. The bigger problem may be that the section is not about 'modes' but more about 'motives'.	Chaewoon Oh	Green Technology Center	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
8775	60	35	60	42	[16.6.1. Motives and modes of cooperation on technology development transfer] - With regard to 'motives', line 20-28 in p39 in Chapter 14 explains the reason why international cooperation is needed. I hope that the author can consider this. - When the author utilizes the 'modes of cooperation', the author needs to clarify what it means by the modes of cooperation. There are so many modes/approaches: i) north-south/south-south/trilateral cooperation, ii) agreement approach by the article 10 of the Paris Agreement with the Technology Mechanism under the UNFCCC (Technology Mechanism), iii) agreement approach outside the UNFCCC such as Mission Innovation or Asia-Pacific Partnership on Clean Development and Climate, etc. Even the voluntary agreements on technology development and transfer, there are so many modes that functionalize the knowledge-sharing, RD&D, technology transfer, technology mandates and incentives. I hope that the author can give us a clear meaning and boundary on the modes of cooperation.	Accept. See response to comment 8773.	Chaewoon Oh	Green Technology Center	Republic of Korea
8767	60	31	63	32	[16.6. Differentiation between Chapter 16's section 16.6 on international cooperation and chapter 14's section 14.5.3 on international cooperation in science, technology, and innovation] - Section 16.6 regards international cooperation under chapter 16 of 'innovation, technology development and transfer, while there is a section of 14.5.3 regards 'international cooperation in science, technology, and innovation' under chapter 14. - I wonder how the author will differentiate two sections. Currently, section 14.5.3 is rather related with international cooperation in science. Is the author concerned about focusing on international cooperation on 'technology innovation'?	Noted. Indeed, the agreement with chapter 14 is that that chapter focuses on science collaboration, and chapter 16 on technology cooperation.	Chaewoon Oh	Green Technology Center	Republic of Korea
8769	60	31	63	32	[16.6. Indication on international cooperation on 'technology innovation'] - Currently, the Paris Agreement emphasizes 'innovation' under article 10.5, and the technology framework as a Paris Rulebook was elaborated with 'innovation' as one of key themes. The Technology Mechanism of the UNFCCC has unfolded activities to support developing countries in terms of innovation and RD&D, and it recently attempted to reflect the guidance from the technology framework in its 2019-2022 work plans and work programmes. Innovation is to be also reflected into the work of the GEF and the GCF of the Financial Mechanism.	Noted. Peer-reviewed literature on the results of the GEF and GCF activities around technology cooperation unfortunately is scarce.	Chaewoon Oh	Green Technology Center	Republic of Korea
18241	60	31	63	32	16.6 needs more drafting efforts before meaningful review. SOD must be well drafted.	Accept. We have given section 16.6 a much clearer storyline.	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
38609	60	31	63	32	I would suggest that role of CTCN is quoted somewhere (at this stage this section seems in progress for some parts, and a relevant room should be chosen at the best depending on the overall balance of the section). I understand that the overall chapter is stressing innovation, but it is made often reference to LDCs. From my experience, for the latter, it is far more important to make sure that it exists enabling environment for the best existing technologies (which is not the case very often), before taking into consideration innovation. That does not mean that innovation has no role to play but priorities have to be delineated according to the needs. Even if the CTCN initiative undertaken under auspices of UNEP, UNFCCC and UNIDO can appear small compared to the needs, it has the benefit to exist, to articulate its action on an international network of experts which could play a stronger role with enhanced funding. UNEP, UNFCCC, UNIDO, 2019 : CTCN Progress Report, Connecting countries to the technologies they need. Web link : https://www.ctc-n.org/file/25117/download?token=M4i4Oz5kB	Accept. It was excluded so far because the peer-reviewed literature on the CTCN was older than the SR1.5 and this aspect was addressed in the SR1.5 (Section 4.4). But for an assessment report, it needs to be included.	Jean-Yves CANEILL	IETA	France
43613	60	11			Nice example! Fine print: I believe electric ferries were in place already 120 years ago. I think there is a ferry in Bavaria on a lake for transporting people that is still running after 120 years.	Noted. Interesting fact! However, no literature provided, and it's not clear whether 120 years ago a ferry for cars would already be needed?	Felix Creutzig	MCC Berlin	Germany
42177	60	31			International coop section 16.6 - still a very weak section, and given it is in the title of the chapter	Thank you. It is work in progress.	Catherine Mitchell	University of Exeter	United Kingdom (of Great Britain and Northern Ireland)
26057	61	1	61	14	This section seems to hinge on a handful of papers. Inspiration may be sought from Boodoo, Z (2018) (Donor Support for Sustainability Transition: The case of low-carbon development in the cement sector of Tunisia) available on https://backend.orbit.dtu.dk/ws/portalfiles/portal/157801577/PhD_Thesis_Zyaa_d_Boodoo.pdf . See page 13 of Boodoo, Z (2018) referring to some other papers covering this literature include (van Alphen et al. 2008; Arkesteijn et al. 2015; Amars et al. 2016; Fridahl & Johansson 2016; Hansen & Nygaard 2013; Marquardt et al. 2016; Power et al. 2016; Tigabu et al. 2017). Boodoo & Olsen 2017 (https://www.tandfonline.com/doi/abs/10.1080/14693062.2017.1386081) also covers the role of donors in sustaining transformational change across developing countries.	Thank you for the suggestions for literature.	Zyaad Boodoo	Government of Mauritius	Mauritius
46355	61	1	62	62	I think there are some really important general issues on innovation and technological change relevant to climate change mitigation which are not covered meaningfully or at all in the chapter, including (but not limited to): recent evidence on leapfrogging, how innovation dynamics interact with 'varieties of capitalism' in different styles of economic and regulatory jurisdictions, the evidence on whether (normative) carbon pricing works to stimulate innovation in real-world institutional settings relative to regulatory and sectoral policies, whether mission-style programmes work for climate change mitigation.	Accept. This literature did not come up in our literature search, and is partly covered in other chapters and in section 16.5 on policy. Better references will be made.	Charlie Wilson	Tyndall Centre for Climate Change Research	United Kingdom (of Great Britain and Northern Ireland)
35549	61	1			Do we learn something from other technologies? There exist large scale programmes of international cooperation for disruptive technologies, e.g. ITER, space programmes, etc.	Accept. Literature on this will be included, although it was assessed in earlier IPCC reports.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)

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35551	61	9		11	What do these papers find? Note that there are also papers testing relevant game theoretical aspects in the lab, e.g. Milinski, M., Sommerfeld, R. D., Krambeck, H. J., Reed, F. A., & Marotzke, J. (2008). The collective-risk social dilemma and the prevention of simulated dangerous climate change. Proceedings of the National Academy of Sciences, 105(7), 2291-2294. And a large literature following up	Accept. This part will be expanded. Thank you for the useful references.	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
16429	61	36			In Section 16.6.4.2 Capabilities for innovation, engineering, consider adding a description related to hot dry rock geothermal energy and the potential for oil and gas companies to transition their drilling infrastructure to the geothermal industry, thereby leading a transition in the energy sector. Plant cost is mostly upfront, and funding provided by developed countries might be used to install geothermal power generation in developing countries to help decarbonize their energy sectors, while at the same time facilitating oil and gas companies to transition their assets to increase drilling capacity for hot dry rock geothermal. Research is ongoing to enable this process. Notably, there are differences in rock type with this kind of project that require more durable drilling technology.	Noted. We will check where this kind of cross-sectoral innovation can be included. We will search for literature references, without which we cannot incorporate this comment.	Daniel Helman	College of Micronesia-FSM	Micronesia, Federated States of
8777	63	24	63	32	[16.6.6 the boundary of international initiatives] This section titles makes me puzzled about the boundary of 'international initiatives'. In the paragraph, the author mentioned only the role of the UNFCCC. Is the author saying that the Technology Mechanism of the UNFCCC represent 'international initiatives'? Also, this section is the last sub-section of 16.6. However, the Technology Mechanism under the UNFCCC first appeared in this last sub-section. I hope that the author consider and clarify what is intended by the section 16.6 of 'international cooperation'.	Noted. International initiatives cover all technology-related initiatives that cover multiple countries. Including multilateral (like UNFCCC), bilateral and private-sector. Literature however is limited on many of those. We will search for more.	Chaewoon Oh	Green Technology Center	Republic of Korea
26059	63	24	63	32	Boodoo (2018) (Donor Support for Sustainability Transition: The case of low-carbon development in the cement sector of Tunisia) and Boodoo et al 2018 (The implications of how climate funds conceptualize transformational change in developing countries, https://doi.org/10.1080/17565529.2018.1442788) are also good sources for this section of the chapter.	Accepted. Thank you for the suggestions, this literature will be included.	Zyaad Boodoo	Government of Mauritius	Mauritius
35553	63	1		22	The citations made here are missing from the bibliography	Noted. This will be repaired	François Lafond	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
12					In the disruptive technologies, there is no mention of Cold Fusion, better known now as Low Energy Nuclear Reactions. Since the announcement in 1989 by Pons and Fleischmann of the discovery of Cold Fusion in a test tube, a lot of work has been made. Thousands of papers have been published on the subject that can be downloaded from lenr-canr.org or iscmns.org . Recently a book(Cold Fusion, Advances in Condensed Matter Nuclear Science) published by Elsevier gives the latests information on the subject. I believe that this chapter dedicated to innovation should mention this new science and technology which is carbon free and nuclear waste free. When developed at an industrial level could replace many sources of CO2 producing energies.	Reject. While cold fusion may be interesting, it is too specific a technology to discuss in this chapter. In the energy systems chapter this may be discussed. Also, the developments lately have been modest and it would probably come late to make a difference for the emission trajectories to 2050.	Jean-Paul Biberian	Aix-Marseille University	France

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9431					ok chapter 16	Thank you.	ANNA LAURA PISELLO	DEPARTMENT OF ENGINEERING - UNIVERSITY OF PERUGIA, ITALY	Italy
20305					Waste management is talked about a lot in most of the chapters. It should be reasonable to expect an assesment of affordability and likely investment required. Not sure where you put this. Waste management is often considered as an affordable item in developing countries. However many middel and low income developing countries only have rudimentary collect and dump systems. Affordability criteria of 1% GNI (Gross National Income) for waste management systems have been set out in the Global Waste Management Outlook (UNEP 2015) for developing countries However, in West Asian countries , many beset or affected by conflict and refugee issues UNEP(2019) estimates that the middle income countries such as Jordan (spend 0.5% GNI), Lebanon (spend 0.4% GNI), Palestine (spend 1.0%), Syria (unknown), the affordability has been estimated at 0.5% of GNI. Current spending is significantly higher than for high income GCC countries with an average of 0.1% with fully integrated waste management systems (High GHG emission mitigation) available at very much less than the UNEP2015 1% GNI criteria. References: UNEP (2015). Global Waste Management Outlook. Available at http://wedocs.unep.org//handle/20.500.11822/9672 . UNEP (2019) Waste Management Outlook for West Asia, Authors: Ihab Tarek, Abdul Sattar Nizami, Paul Dumble, UN Environment Programme, p85-101, ISBN No 978-92-807-3767-7. "	Noted. Waste management is an important sector indeed. The most recent literature on that will be assessed in the appropriate chapter. In connection to innovation and technology for sustainable development we will consider it in section 16.2.	Paul Dumble	Paul's Environmt Lentd	United Kingdom (of Great Britain and Northern Ireland)
25543					Please take care not to use value-judgement terms such as 'important', 'significant' and also prescriptive terms such as 'need' and 'must'. Some readers will interpret these statements as policy prescriptive.	Accept. There is no place for such terms in IPCC reports and the SOD will be more carefully checked.	Sarah Connors	IPCC WGI TSU	France
25577					As a reader who isnt familiar with all the topics being discussed in your chapter, it might help many Exectutive Summaries to include subheadings to cluster the statements by topic or overarching chapter themes.	Noted, good suggestion.	Sarah Connors	IPCC WGI TSU	France
28823					The text currently does not recognised the role of governance in responsible innovation, nor the interrelationship between governance and policy delivery where they interface with technology. These issues are expected to be important considerations in debates about CDR and SRM and could be usefully included in the summary of barriers to climate-related technology innovation.	Accept, this is an interesting field that can be explored. Task division with chapter 12 to be discussed.	Paul Rouse	Carnegie Climate Governance Initiative	United Kingdom (of Great Britain and Northern Ireland)
34789					It is very good that one separate chapter is dedicated to innovation. The Chapter 16 includes useful information for policy makers to incentivize innovation in energy technology. However, if the Chapter's target audience are in fact policy makers, the general analysis of innovation at the beginning of the chapter might be too scholarly or academic. There are a lot of "a bit philosophical" discussions on innovation in general, not specifically related to Climate Change. Chapter 16 and Chapter 6 need synergy.	Noted. We got special permission to review the literature a bit further back as this is the first innovation chapter in IPCC's history. But we will make every effort to make also that policy-relevant.	Masami Nakata	Shiga University	Japan
38333					The implications of lifestyles -and their potential changes- on technological innovation capabilities should be considered and analysed more deeply. I suggest that you add bibliography, like: D'Alisa G., Demaria F., Kallis G. Degrowth: A Vocabulary for a New Era. 2014. 248. ISBN: 9781138000773	Noted. Lifestyle and behaviour are part of chapter 5, but indeed there are interactions and technology always has a behavioural side. We will put this more in context. Thank you for the reference.	Lucrecia Wagner	CONICET	Argentina

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
38335					<p>It would be important to emphasize that the training of the workers in the use of new technologies must be reinforced by the policies and regulations, in order to protect their employment continuity, especially in developing countries and in those with weak unions. Perhaps, these kind of policies and regulations should be driven by international organizations, in order to motivate equal politics between different countries and global regions.</p> <p>In addition to this, there should be a consideration of the relocation -to new jobs related to clean energy- of workers from sectors that will need to be reduced (for instance: private transport of goods, like truck transport). These worker sectors can have power over and put pressure on governments, and this can be an obstacle to measures aimed at sustainable development.</p>	<p>Taken into account. Capacity development is clearly part of our chapter. Reschooling and employment continuity can also be included. This is related to the question of just transitions. The report is considering a x-chapter box on this topic. We will look for literature reflecting this aspect.</p>	Lucrecia Wagner	CONICET	Argentina
38337					<p>It is important to assess the total environmental and social impacts of clean technologies from the preparation until their being put into operation, for example: the effects on the sources of the extraction of natural resources that you need to build them (lithium, steel, among others), their territorial impacts (such as the case of wind energy), and the potentially conflicting relationships of energy companies with local communities. See:</p> <p>Ávila S. "Environmental justice and the expanding geography of wind power conflicts". Sustainability Science. 2018, p. 1-18</p> <p>Avila-Calero S. "Contesting energy transitions: wind power and conflicts in the Isthmus of Tehuantepec". Journal of Political Ecology. 2017, vol. 24, p. 992-1012</p> <p>Barandiarán, J. "Lithium and development imaginaries in Chile, Argentina and Bolivia". World Development. 2019, v. p. 381-391, https://doi.org/10.1016/j.worlddev.2018.09.019</p> <p>Marchegiani, P., Höglund Hellgren, J. and Gómez, L. "Lithium extraction in Argentina: a case study on the social and environmental impacts", FARN. 2019, Buenos Aires. Available in: https://farn.org.ar/wp-content/uploads/2019/05/DOC_LITHIUM_ENGLISH.pdf</p> <p>Zicari, J. and Fornillo, B. "The Power of Lithium in South America". Entreciencias: diálogos en la Sociedad del Conocimiento. 2017, vol. 5, no. 12. Available in: http://www.redalyc.org/articulo.oa?id=457650040006</p>	<p>Noted. The life cycle impacts of technologies and other mitigation options are considered in for instance the industry chapter, and in the discussion of feasibility. We will suggest the sources to those sections.</p>	Lucrecia Wagner	CONICET	Argentina
38339					<p>Regarding the research teams who will develop technological innovations, it is important to consider the equity between their members, including members of developed and developing countries, and making them disciplinarily diverse, in order to integrate different perspectives of analysis necessary to address the sustainability of these technologies.</p> <p>Within each country, a diverse composition among members of different research teams from different universities and research institutes, and linked to research teams from other countries, can avoid clientelist ties between researchers and governments or companies, which weaken the scope of sustainable development policies.</p>	<p>Noted. It is a fair point, but the composition of research teams is getting into too much detail for this chapter. Also, not aware of literature sources.</p>	Lucrecia Wagner	CONICET	Argentina

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38341					It is necessary to have an assessment of the energy and material investments required over time to achieve energy transition. In some case, this transition could drive a substantial re-materialization of the economy, exacerbating extraction of minerals and others controversial activities which generate social and environmental risks, as well as increasing net imports from countries with laxer environmental policies. See: Capellán-Pérez, I, De Castro, C. I and Miguel González, L. J., "Dynamic Energy Return on Energy Investment (EROI) and material requirements in scenarios of global transition to renewable energies". Energy Strategy Reviews, 2019, v. 26, 100399. Available in: https://doi.org/10.1016/j.esr.2019.100399	Taken into account. This is most relevant to chapter 12, will lead the source and the comment to that chapter.	Lucrecia Wagner	CONICET	Argentina
38343					A perspective of "social metabolism" should be considered, in order to reduce environmental impacts of technologies, through identifying relevant social actors who could participate as "intermediaries" in decision making regarding technological changes. See: Haberl, H., Fischer-Kowalski, M., Krausmann, F., Martinez-Alier, J. and Winiwarter, V. "A Socio-metabolic Transition towards Sustainability? Challenges for Another Great Transformation". Sustainable Development, 2011, 19, p. 1–14. DOI: 10.1002/sd.410 Fischer-Kowalski, M. and Haberl, H. (eds.), Socioecological Transitions and Global Change: Trajectories of Social Metabolism and Land Use, Edward Elgar Publishing, 2007.	Noted, this is interesting work. Will discuss with chapter 5 where it belongs.	Lucrecia Wagner	CONICET	Argentina
48095					The chapter ES has a strong emphasis on technological innovation (what about social innovation, frugal innovation)?	Taken into account. We have in the meantime included an additional author with a focus on frugal innovation. Social innovation is more part of chapter 5, but interactions could and will be fleshed out better.	Valérie Masson-Delmotte	CEA, IPSL/LSCE	France
1097					* Fouquet R, Pearson P J G. 2006. Seven centuries of energy services: the price and use of lighting in the United Kingdom (1300-2000). Energy J. 27(1):139-77 ** Fouquet R, Pearson P. 2012. Past and Prospective Energy Transitions: Insights from History. Editorial for Energy Policy (Special Issue on Past and Prospective Energy Transitions) 50: 1-7. *** Stern D I. 2012. Modeling international trends in energy efficiency. Energy Econ. 34:2200–208 **** Stern D I. 2017. How accurate are energy intensity projections? Clim. Change 143:537-45 ***** Stern D I, Kander A. 2012. The role of energy in the industrial revolution and modern economic growth. Energy J. 33(3):125-52	Noted. This list belongs to comments submitted to section 16.2, and will be included there when appropriate.	Harry Saunders	Carnegie Institution for Science	United States of America