Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
15887	0	0			I would suggest for this chapter to include a paragraph covering the emerging role of agent based modelling (ABM) within integrated assessment modelling (IAM) frameworks. ABM models and simulates a number of agents who are players and especially investors, operating and decommissioning or refurbishing old assets and investing in new assets. Their investment decision making process is based on a number of criteria including capital and operating costs, return on investment, etc., and are strongly influenced by regional and international economic and policy environments. References: 1- An agent-based model for energy investment decisions in the residential sector Sachs, J., Meng, Y., Giarola, S., Hawkes, A. Energy, 2019, 172, pp. 752–768	Noted: Modelling methodologies are part of Annex C to which the suggested reference has been added in section I.4 on buildings	Sara Budinis	International Energy Agency	France
84083	0	0			May be useful to examine evidence on the limited number of carbon pricing-related schemes that have impacted energy use in buildings - which generally seem to have significant impacts IF they are designed in ways that address informational/behavioural as well as economic incentives. Most recent, a new book with analysis of how combinations of economic and behavioural incentives arising from the metropolitan ETS schemes in Tokyo and Saitama led to substantial emission savings across multiple sectors: Arimura, T. H., and S. Matsumoto, 2021: Carbon Pricing in Japan. SpringerLink, Tokyo. Some other Asian schemes have some similarities, and they have some things in common with the UK 'CRC energy efficiency scheme' which had a major impact when introduced, - AR5 may have evaluated but I dont think so (Grubb, M; Haney, A; Wilde, J. (2009), Plugging the gap in energy efficiency policies: the emergence of the UK carbon reduction commitment. European Review of Energy Markets, Vol. 8)	Taken into account in section 9. 9	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
2301	0	0	0	0	The authors may consider moving the discussion around the sources of direct and indirect emissions from FAQs section to the earlier sections for completeness	Noted: Emissions included in teh assessemn t are clarified in 9.3 and in (see Cross -Chapter Box 3 and Cross -Working Group Box 1 in Chapter 3	Siddarth Durga	PNNL	United States of America
2301	0	0	0	0	The authors may consider moving the discussion around the sources of direct and indirect emissions from FAQs section to the earlier sections for completeness	Noted: Emissions included in teh assessemn t are clarified in 9.3 and in (see Cross -Chapter Box 3 and Cross -Working Group Box 1 in Chapter 4	Siddarth Durga	PNNL	United States of America
2313	0	0	0	0	The authors should consider using colorblind friendly palettes when generating figures - for better accessiblity (please ignore if already implemented)	Accepted: All figures use IPCC colours	Siddarth Durga	PNNL	United States of America
2325	0	0	0	0	Section 9.9 can be further divided into two or more sections (one for barriers and one of policies etc.)	Accepted: barriers and policies are two separate sub-sections	Siddarth Durga	PNNL	United States of America
36979	0	0	0	0	I suggest a chapter dedicated to the life cycle of the building after the introduction.	Noted: Section 9.4.2 assesses the literature on embodied emissions and energy	Antonio Garcia-Martinez	Universidad de Sevilla	Spain
49649	0	0	0	0	Manipal School of Architecture and Planning-MAHE, Manipal Faculties- Dr.(Prof.) Nandineni Rama Devi; Prof. Amit C Kinjawadekar; Ms.Trupti Amit Kinjawadekar; Ms. Sahana Ganesh; Ms. Roshan Shetty; Ms. Gowri Shenoy B; Mr. Satyaprakash Das. Students- Mr. Kishan Sakri; Ms. Archana K Harith; Ms. Spoorthi C.	Rejected: Comment missing	Satyaprakas Das Das	Manipal Academy of Higher Education	India
78221	0	0	0	0	Multi-storied residential buildings with highend elevator systems, Sewage Treatment Plant, Water Treatment Plant and non-residential/commercial buildings with escalators & multiple appliances operating at the same time are some of the topics that require inclusion, as these are significant energy end-uses.	Rejected: The scope of the chapter relates to buildings only.	SUCHANDRA BARDHAN	Jadavpur University	India
19483	0				I lack, in the chapter, a stronger connection to the need for a circular construction and circular buildings. Circular economy is mentioned on a few pages but comes a little in the shadows (9.5.2.4 and 9.5.3.6). Circular solutions mentioned is reduced waste, materials reuse and recycling. There are more circular solutions such as for example to build for a long life-time and for flexibility and sharing, early planning for circular construction etc. That is crucial to reduce greenhouse gas emissions from buildings. For example Ellen McArthur Foundation writes: A circular scenario for the built environment could reduce global CO2 emissions from building materials by 38% or 2.0 billion tonnes CO2 in 2050, due to a reduced demand for steel, aluminium, cement, and plastic (source, page 32: https://www.ellenmacarthurfoundation.org/assets/downloads/Completing_The_Picture_How_The_Circular_Economy-_Tackles_Climate_Change_V3_26_September.pdf). Also the European Commission promotes construction and buildings as a key product value chain in its circular economy action plan presented 2020: https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf (page 13). I call for a greater focus in the report on circular construction/circular buildings and the connection to reduce green house gases. Nothing about circular economy is mentioned in the executive summary in chapter 9, and I assume most people might only read the summary.	Noted: Reference is made to circularity in the executive summary and the circularity interventions suggested in the comment are included in the section on teh definition of sufficiency in box 9.1. Section 9.5.4.2 has also been extended with additional literature on circular economy	Therese Rydstedt	Environmental department at the city of Stockholm	Sweden
22103	0				This chapter's cover of near-shore building plans and management of sea-level risk could be further developed (Moosa et al., 2020) (Barnett et al. 2014) (Barnett and Hill, 2007)	Noted: Section 9.7 assessed the literature on see level rise	Government of France	Ministère de la Transition écologique et solidaire	France
61113	0				While building's energy demand is substantial and still the major contributor to their contribution to climate change, the absence of a careful (reflecting state-of-the-art) consideration of embodied GHG emissions in buildings raises concerns. One increasingly sees governments starting to include building's embodied emissions in procurement processes and regulations of different kinds, which represents a major step towards low carbon buildings, and which was achieved through the effort of international researchers in the field. The lack of attention given to this matter in the chapter weakens the subject, whereas if it was properly covered it could represent a great stimulus towards policy changes.	Accepted. Embodied emissions are now given more attention in the chapter, including text describing the importance of embodied emissions and how they will grow over time, collection and presentation of scenario results from literature which models future embodied emissions from residential buildings, and discussion of options to mitigate embodied carbon in buildings.	Marcella Saade	Graz University of Technology	Austria
69751	0				This chapter would strongly benefit from building on the IEA 2020 World Energy Outlook's Chapter 4 "Achieving net zero emissions by 2050" which focuses entirely on the actions to be undertaken by 2030. The Chapter 11 Industry quotes it extensively, but the IEA 2020 covers all sectors. It notes the critical role over the current decade in determining the pathway to 2050, as total CO2 emissions would need to fall by around 45% from 2010 levels by 2030. IEA 2020 assesses notably that close to half of the existing building stock in advanced economies should be retrofitted by 2030 (this means 2 million homes per month), and a third of buildings are retrofitted elsewhere. Moreover, this retrofitting should bring the buildings sector near zero emissions, as would all new buildings do. This means the addition of top-rated insulation for ceilings, floors and walls, low-emissivity triple or double glazing, and the integration of passive heating and cooling solutions wherever possible. Bans on the sale of new fossil fuel-fired boilers should be introduced very soon. Heat pumps become the standard. Efficient appliances help balance the growth in electricity consumption.	Rejected: Discussion on 2030 potentials for all sectors is included in Chapter 12	Cédric PHILIBERT	Institut Français des Relations Internationales	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
79129	1	0	92	21	The discussion of embodied energy touches briefly on circularity but omits a major category of opportunities. Most of the world's concrete (which uses half of cement directly, the rest in blocks, plasters, mortars, screeds,... mainly for buildings), as well as most of the world's structural steel, are wasted, on two different lines of analysis. The first (doi:10.1038/s43017-020-0093-3) notes a >2x, generally ~3x, cement-saving potential by designing out excessive cement and wasted concrete (due to sloppy construction practices). The second is synthesized and documented in Lovins 2021, "Profitably decarbonizing heavy transport and indusrial heat," provided to WG3 leaders in draft in Nov 2020, in press for April 2021 release by RMI (www.rmi.org), summarized and strategically augmented by "Six business revolutions to decarbonize heavy transport and industrial heat," in press for June 2021 publication by MIT Sloan Management Review. This second opportunity space shows that proven innovations in structural design, used by the world's best civil/structural engineers but not yet by most designers, can at least double concrete and steel's structural efficiency at dramatically lower cost: e.g. 80–90% materials savings from tension structures, ≥50% from fabric-form beams and sheets, 70–76% from thin corrugated or vaulted/ribbed floorslabs, and most of the mass of bridges and pillars from 3D-printed dendritic forms. Past assessments such as Energy Transitions Commission's 2018 Mission Possible seem to overlook these structural-design opportunities, whose description in engineering literature is evocative but fragmented. This Chapter, and probably the Industrial chapter, should note these major structural-design opportunities to avoid, at a profit, most of the ~15% of CO2 released from cement and steel manufacture and use (not counting additional savings up to ~25–30% from carbonation enabled by noncorroding concrete reinforcement, nor potential carbon-negative cements such as Solidia's carboxylate chemistries).	Accepted. The treatment of embodied energy and emissions has been augmented in the revised chapter. The suggested article from Habert et al 2020 is now referred to directly in the text in section 9.5.2. Scenarios of future global embodied emissions from residential construction are now presented in section 9.4, including a scenario incorporating material efficiency which incorporates many of the elements referred to in the coment amd more, i.e. avoding excessive material in the design phase, improving material fabrication yields at production facilities, extending building component lifetimes, and switching to lower carbon-intensive material when possible.	Amory B. Lovins	Rocky Mountain Institute; also Adjunct Professor of Environmental & Civil Engineering, Stanford University	United States of America
79785	1	1	211	36	In the text there is almost no reference and evaluation of the solar heating issues, that can cover a significant part of the energy demand and can support the efforts of decarbonization. The solar heating systems can reduce the need for fossil heating energy, and can significantly support the heat pumps in delivering space heating and domestic hot water. Also, they can be used to cover the needs for many human activities, even support the efforts for solar cooling. this issue is well addressed by IRENA and REN 21, as well as from IEA please see https://www.iea.org/reports/technology-roadmap-energy-efficient-buildings-heating-and-cooling-equipment, http://www.iea-shc.org/data/sites/1/publications/Solar-Heat-Worldwide-2014.pdf, etc Solar thermal and cooling energy are of paramount importance to reduce heavily the emissions and the energy costs in residential and non-residential sector. Solar heating systems can cover both hot water for sanitary usage and space heating, even to cover a small part of them. Of course, in the MENA regions or in regions with hot climates the space heating is not needed, but there the increased solar energy can be used to drive solar cooling applications reducing further the electricity demand. this is of paramount importance to reduce the use of fossil energy and electricity at the same time. Many applications exist mainly in EU with the supply of district heating and cooling driven by solar energy or even by biomass and wastes (biomass-fossil) like the Barcelona case, with Mediterranean climate with high summer temperatures. These technologies already proven but not very broadly applied, can have a paramount role in the future of low-carbon homes. In addition, geothermal energy is widely used in many countries to reduce the demand of fossil energy for delivering space heating and cooling and hot water. These issues are not clearly presented and demonstrated in this chapter even though can significantly reduce the carbon footprint of the buildings sectors. It is not only solar PV and small wind for the domestic sector. Solar thermal is by far the most applied and the easiest to adapt and install RES in all types of buildings. The EU barometer in solar thermal and cooling in EU is one of the proves the authors of this chapter should include in their analysis. Just see the above-mentioned references and of course use the https://www.eurobserv-er.org/pdf/solar-thermal-and-csp-barometer-2020-en/ https://www.eurobserv-er.org/19th-annual-overview-barometer/ which presents the most updated and comprehensive data for EU	Noted: Section 9.4.3 assesses technologies including solar ones. For more details, see SM related to this section	Constantinos Psomopoulos	University of West Attica, Department of Electrical and Electronics Engineering	Greece
5483	1	1	211	37	A strange feeling at the end of this chapter. I believe I have read a documentation pleading in favor of on-site renewabes, sometimes based on fantasies like the Negawatt reports instead of scientific studies. I was expecting a report dealing with the reduction of GHG, the results obtained so far, what to do to improve the performance, etc.. Instead, renewables and often on-site renewabes are referred to as THE solution to be implemented, even when other sources are much more economic and environnementally superior. With that behavior, i fear that IPCC is not playing its rôle of information and counsel.	Noted: The chapter assessed the literature on reducing teh demand of energy and the one on the supply of energy to buildings. It does not soly focus on renewables. However, teh emerging literature and policies on positive energy buildings consider supply of buildings with on-site renewable	Michel SIMON	Retraité/ Pdt d'association	France
3661	1	1	211	38	The format of the reference in the literature need to be futher rivised.	Accepted: The format fellows IPCC guidelines	Xinyan Yang	China Academy of Building Research	China
20351	1	1	211	38	Comment for the entire chapter: a point missing relates to the buildings as part of the smart city - see comment above about smart grids and EV charging	Noted: Literature on cities is assessed in the urban chapter	Thibaud Voïta	IFRI	Germany
20353	1	1	211	38	Since the first draft was developed, several interesting building efficiency initiatives has been announced and launched. It may be interesting to at least mention them, see for instance the European Bauhaus	Rejected: The chapter assesses literature on buildings. To our knowledge the new initiatives mentioned have not yet been analysed in the literature	Thibaud Voïta	IFRI	Germany
3617	1	1	89	9	The chapter is missing a lot of relevant research from building performance simulation, i.e., researchers and institutions broadly working on changing building design and operation to be "greener" (the list of included studies is both long and incomplete). There is the briefest of mention of relatively inconsequential actions in section 9.5.2.1. Many of the references are quite old, which is important for a field that evolves as fast as building performance simulation. There exist numerous recent studies that have quantified the impact of climate change on building performance, both energy consumption and thermal health, through simulation. Newer work has proposed techniques to incorporate previous (AR5) projections into building practice (e.g., those by V. Nik et al, P. Rastogi et al, D. Crawley et al, M. Eames et al). Talking about these helps understand the challenges of translating the higher-level policy work included in this chapter to standards, tools, and methods that can be used by practitioners. While I understand the need to focus on journal papers, a lot of relevant research is presented in conferences and theses. Including these would be instructive for policymakers, especially as a lot of the simulation work by researchers and practitioners discusses pathways to Net-Zero Energy Buildings, tools for evaluating and incorporating climate resilience and adaptation in building design and operation, and the impacts of policies so far. A good place to begin would be the studies published in the Journal of Building Performane Simulation (JBPS) and International Building Performance Simulation (IBPSA) conference.	Noted: since the technologies available are so wide, these were compiled in a Table in the Supplementary material and this comment was considere	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
3619	1	1	89	9	The amount of work put into the chapter is impressive. However, I am concerned that for my profession - building services engineering - it will be very hard to translate this into actions. Engineering and architectural professional bodies such as ASHRAE, CIBSE, REHVA, ISHRAE, AIA, RIBA, RIAS, IESNA write standards that are adopted by governments to promote or enforce energy efficiency and building performance in general. While these standards tend to focus on mitigation rather than resilience or adaptation, these remain the most relevant technical resources for achieving building-related emissions targets. Ignoring the work of these bodies entirely is missing a substantial portion of the training, rule-making, and standard-setting activity that is necessary to meet any buildings-related targets. These organisations have been broadly slow to improve resources for resilience and adaptation, but ASHRAE will be including a chapter on climate change (science, mitigation, adaptation) in its 2021 Handbook of Fundamentals and CIBSE also have guidelines on adaptation for residential buildings in the UK. Similar efforts exist in several other developed and developing countries. Asking ASHRAE to acces the chapter may be particularly useful as it aligns well with several sections of this chapter.	Noted: since the technologies available are so wide, these were compiled in a Table in the Supplementary material and this comment was considere	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
3621	1	1	89	9	This chapter does not seem to include any voluntary certification schemes that address mitigation and adaptation at the building level, e.g., USGBC's LEED, BREEAM, IFC's EDGE, and at the portfolio level, e.g., GRESB. These are valuable resources that building owners, designers, and operators can access. They are also important market-pull forces as they can be used to demonstrate leadership and potentially increase value.	Accepted: Section 9.9 discusses certification of buildings	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
3623	1	1	89	9	I like that the chapter includes references to traditional, non-technical building or architectural solutions. However, the discussion is lacking important references and studies. A good place to begin would be the studies published in the Passive and Low-Energy Architecture (PLEA) conference.	Noted: New references assessed	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
3627	1	1	89	9	The chapter is thorough in many aspects. Reading it as an engineer, however, I am struggling to make sense of outcomes relevant to me professionally. The writing too often reads like a laundry list of existing scientific literature. It would be really helpful to have a "path" or signposts that point to specific technical or policy actions or milestones that are needed or have been implemented. I'm thinking something like those used by the Summary for Policymakers in AR5. I tried to use the figures, boxes, and tables as signposts but often struggled to understand them properly due to lack of sufficient captions.	Accepted: all chapter has been widely rewritten and this comment was taken into consideration	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
3629	1	1	89	9	I really like the discussion of sufficiency in the chapter, which is often ignored by those of us in engineering and architecture. It would be a lot more powerful if this discussion could be followed up with concrete recommendations or examples. Sorry if I missed those!	Accepted: Box 9.1 includes more details on sufficiency measures and section 9.5 provides additional examples	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
3631	1	1	89	9	When trying to convince building owners, operators and other stakeholders about the need for mitigation and adaptation, uncertainty is a difficult concept to communicate and incorporate into the design and operation of buildings. It will be useful to see some discussion of how uncertainty can be handled and recommendations on how it can be incorporated into laws or guides. It's not enough to just say "there will be uncertainty", but rather what can be done about it to motivate present action. The guidance in this chapter can be specific to buildings but potentially draw upon the expertise in other chapters?	Noted: Acceptance rather than uncertaintity is discussed in 9.5 and 9.9	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
3633	1	1	89	9	I missed discussions about the mistakes and unintended consequences of previous mitigation policies, e.g., decrease in ventilation in energy-efficient homes (see, e.g., T Sharpe, J Foster, P Tuohy et al).	Noted: See section 9.9	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
80871	1	1	89	9	The green Public Procurement and the EcoDesign Regulations adopted by EU and other countries is of paramount importance, as these cover many equipment used both in non-residential and residential sector, and both push energy efficiency improvements, by removing from the market hthe less efficient products. The Green Public Procurement Documents prepared by the EU and the EcoDesign Regulations for a significant number of products both industrial, commercial (e.g Fans, Transformers, Ovens, etc) and of course residential goods including white goods push the efficincy in buildings in the use face and at the same time change the behavior of the users This should be pointed out as important action towards a greener industrial sector.	Noted: See section 9.9	Constantinos Psomopoulos	University of West Attica, Department of Electrical and Electronics Engineering	Greece
3591	1	4	1	6	Many sentences have small but irritating grammatical mistakes. Sentence construction needs to be more coherent in general.	Noted: Text revised and improved	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
79673	2	2	3	14	The general structure of chapter is very unclear. It mixes GHG emissions with operational and embodied energy/GHG from building and construction having a very strong focus on operational energy demand side. The chapter would benefit from adopting the Life Cycle approach of buildings (i.e. ISO and CEN standards) with a chapter structure accordingly. 9.1 Introduction / 9.2 Building life cycle / 9.3 Operational GHG emissions including trends and drivers / 9.4 Embodied GHG emissions including trends and drivers / 9.5 Mitigation technological options an strategies towards zero operational emission buildings / 9.6 Mitigation technological options an strategies towards zero embodied emission buildings / 9.7 Global and regional costs / 9.8 Building related policies and their level of acceptance. Sections on non technological and behavorial mitigation options (current section 9.5) can be included in new 9.8. Climate change impact adaptation (current 9.7), sustainable development (current 9.8) can be shorten and be used only to make link to other chapters	Rejected. The advised restructuring of chapter sub-sections is not adopted. There is however more extensive attention on embodied emissions in the revised chapter, including presentation and decomposition of scenario results from literature which model future embodied emissions from residential buildings. In this manner the future trends and drivers of embodied emissions are given equal presentation as energy emissions. There is not data available to present decompositions of past embodied emissions as we have done for energy emissions	Alexander Passer	Graz University of Technology	Austria
43631	2	2	3	19	Structure of chapter 9 / content: The current structure or the content of the chapter does not cover all relevant aspects. The following sub-topics are missing and should be added: (a) building life cycle - modelling and assessment; (b) topics and trends in the embodied part of GHG-emissions; (c) mitigation potential in the embodied part of GHG-emissions; (d) terms, definitions and system boundaries for (net) zero GHG-emissions; (e) examples for (net) zero GHG-emissions in operation and use; (f) possibilities of compensation of GHG-emissions in building assessment; (g) buildings as prosumers - the role of BIPV; (h) assessment of purchased/imported energy during use of buildings; (i) assessment of "exported" energy to third parties and consequences for building-related LCA; (k) importance of F-gas emissions. The network of researchers from IEA EBC Annex 72 is able and willing to provide you with additional parts - see https://annex72.iea-ebc.org/	Accepted. Many, but not all of the requests were present in some form in the second order draft, or have been incorporated in the revised chapter, including trends in embodied emissions, mitigation potential for embodied emissions, links to definitions of NZEBs in section 9.9.3, and reference to scarce data on F-gas emissions.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
60205	2	3	3	14	General structure of chapter is not clear as it mixes energy and GHG emissions related with energy demand from building and construction, while at the same time having a very strong focus on energy demand. Adopting a clear life Cycle approach of buildings would help to structure the chapter. I like to suggest structuring Chapter 9 as follows: 9.1 Introduction / 9.2 Building life cycle / 9.3 Operational GHG emissions including trends and drivers / 9.4 Embodied GHG emissions including trends and drivers / 9.5 Mitigation technological options an strategies towards zero operational emission buildings / 9.6 Mitigation technological options an strategies towards zero embodied emission buildings / 9.7 Global and regional costs / 9.8 Building related policies and their level of acceptance. Sections on non technological and behavorial mitigation options (current section 9.5) can be included in new 9.8. Climate change impact adaptation (current 9.7), sustainable development (current 9.8) can be shorten and be used only to make link to other chapters.	Rejected. The advised restructuring of chapter sub-sections is not adopted. There is however more extensive attention on embodied emissions in the revised chapter, including presentation and decomposition of scenario results from literature which model future embodied emissions from residential buildings. In this manner the future trends and drivers of embodied emissions are given equal presentation as energy emissions. There is not data available to present decompositions of past embodied emissions as we have done for energy emissions	Guillaume Habert	ETH Zurich	Switzerland
79419	2	3	3	14	The general structure of chapter is not clear as it mixes energy and GHG emissions related with energy demand from building and construction, while at the same time having a very strong focus on energy demand. Adopting a clear life cycle approach towards buildings would help to structure the chapter. In accordance with what other colleagues and building life cycle assessment scholars will likely recommend I suggest structuring Chapter 9 as follows: 9.1 Introduction / 9.2 Building life cycle / 9.3 Operational GHG emissions including trends and drivers / 9.4 Embodied GHG emissions including trends and drivers / 9.5 Mitigation technological options an strategies towards zero operational emission buildings / 9.6 Mitigation technological options an strategies towards zero embodied emission buildings / 9.7 Global and regional costs / 9.8 Building related policies and their level of acceptance. Sections on non technological and behavioural mitigation options (current section 9.5) can be included in new 9.8. Climate change impact adaptation (current 9.7), sustainable development (current 9.8) can be shorten and be used only to make link to other chapters.	Rejected. The advised restructuring of chapter sub-sections is not adopted. There is however more extensive attention on embodied emissions in the revised chapter, including presentation and decomposition of scenario results from literature which model future embodied emissions from residential buildings. In this manner the future trends and drivers of embodied emissions are given equal presentation as energy emissions. There is not data available to present decompositions of past embodied emissions as we have done for energy emissions	Martin Röck	KU Leuven	Austria

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
86055	2	3	3	17	The general structure of this chapter is not clear, the section topics due not build upon each and particular important issues are missing altogether. It is recommended to include a life Cycle approach of buildings, sections on operation and embodied GHG emissions, as well as, a section on (net) zero GHG emission – (including definition, calculation rules and system boundaries) followed case study examples of exemplar buildings achieving those targets. Please consider a restructure of Chapter 9 and to change and further develop 9.1 Introduction in particular. The proposed revised structure is proposed as follows: 9.1 Introduction 9.2 (net) zero GHG emission + carbon neutral buildings – (including definition, calculation rules and system boundaries) 9.3 Building - components + services, classification 9.4. Building life cycle 9.5 Trends and drivers of Operational GHG emissions 9.6 Trends and drivers of Embodied GHG emissions 9.7 Mitigation technological options and strategies towards (net) zero GHG emission(operation) buildings 9.8 Mitigation technological options an strategies towards (net) zero GHG emission (operation + embodied emission) buildings 9.9 Non technological and behavorial mitigation options towards) buildings 9.9 Global and regional costs 9.10 Links to Climate Adaptation 9.11 Links to Sustainable Development * (Consider shortening, moving to introduction or removing altogther, as many issues already discussed in the Introduction) 9.12 Building related policies - feasability, barriers and opportunities 9.13 Research Gaps, Conclusions, Future Outlook	Rejected. The advised restructuring of chapter sub-sections is not adopted. There is however more extensive attention on embodied emissions in the revised chapter, including presentation and decomposition of scenario results from literature which model future embodied emissions from residential buildings. In this manner the future trends and drivers of embodied emissions are given equal presentation as energy emissions. There is not data available to present decompositions of past embodied emissions as we have done for energy emissions	Aoife Houlihan Wiberg	The Belfast School of Architecture and the Built Environment, Ulster University, UK	United Kingdom (of Great Britain and Northern Ireland)
4563	2	33	2	33	Add Livability criteria	accepted, will consider	Alka Bharat	Maulana Azad National Institute of Technology (An Institute of National importance), Bhopal	India
56263	3	15	3	18	Include consideration that air conditioning can be important for health, not just comfort. See: Fann, N., T. Brennan, P. Dolwick, J.L. Gamble, V. Ilacqua, L. Kolb, C.G. Nolte, T.L. Spero, and L. Ziska, 2016: Ch. 3: Air Quality Impacts. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. U.S. Global Change Research Program, Washington, DC, 69--98. http://dx.doi.org/10.10.7930/J0GQ6VP6	Noted: Link between climate mitiagtion and health is discussed in section 9.8	Government of United States of America	U.S. Department of State	United States of America
43633	4	1	4	5	Executive summary: "Buildings" are not a sector in the macroeconomic sense - this term leads to misunderstandings. "Buildings" are an "area of activity"! Sectors affected are among others "construction product industry", "construction industry", "real estate industry" as parts of the overall sector "industry" and the sector "energy supply". A cross-sectoral approach is needed.	Rejected: The outline adopted by Govts for the report refers to building sector	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
79437	4	1	5	9	The Executive Summary currently falls short of making clear the growing importance of addressing and reducing embodied GHG emissions from building material processing - please consider adding a paragraph on this. As recent meta-studies have shown, the contribution to GHG emissions across the building life cycle has grown both in relative as well as absolute terms. While improvements in energy efficiency have led to a successful reduction of operational GHG emissions, the additional investment in building materials - in particular for complex, advanced buildings - are found to have increased the embodied GHG emissions across the life cycle. Embodied GHG emissions of new buildings are dominating the timeframe relevant for effective climate change mitigation, hence representing a substantial challenge and potential for unintended lock-in effects due to new building construction! These effects have been shown based on the comprehensive analyses of several hundreds of building LCA case studies in Röck M, Saade MRM, Balouktsi M, Rasmussen FN, Birgisdottir H, Frischknecht R, et al. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Appl Energy 2020;258:114107. DOI: https://doi.org/10.1016/j.apenergy.2019.114107.	Accepted. Embodied emissions are now given more attention in the chapter, including text describing the importance of embodied emissions and how they will grow over time, collection and presentation of scenario results from literature which models future embodied emissions from residential buildings, and discussion of options to mitigate embodied carbon in buildings. The suggested Röck et al (2020) paper is referred to in the revised chapter, with regard to the increasing importance of embodied emissions in the coming decades.	Martin Röck	KU Leuven	Austria
3659	4	1	6	9	The first sentence of each paragraph is not clear enough to sum up the meaning of the paragraph. For example, the sentence "The decarbonization of buildings is constrained by multiple barriers and obstacles."can be changed to"Because of the complexity of building types, beneficiaries etc., the decarbonization of buildings is constrained by multiple barriers and obstacles, except rely on policies alone."	Noted: Text revised	Xinyan Yang	China Academy of Building Research	China
7833	4	1	6	9	In decarbonizing building sector, heat pump and hydrogen should be essential choices, especially in winter in the Northern Hemisphere. Only in Box. 9.4 in page 22, comparison between those two technologies are explained. The essence of Box. 9.4 should be upgrded in the executive summary.	Rejected: Based on the data available, hydrogen was not used in buildings over the period 1990-2019 and scenarios assessed do not project an essential role for hydrogen in buildings. Heat pumps are discussed in the technology section	Mitsutsune Yamaguchi	Research Institute for the Innovative Technology for the Earth (RITE)	Japan
17795	4	1	6	9	(9 ES) needs checking from language point of view as does not seem to be written by native speaker	Noted: Text revised	Jonathan Lynn	IPCC	Switzerland
60561	4	1	6	9	The executive summary does not refer to substantial parts of the chapter. In particular, there is no mention of non-technological and behavioural mitigation (section 9.5) , links to adaption (9.7), links to suystainable development (9.8) or secoral barriers (9.9). These are - in my opinion - equally important as the technological solutions the summary focuses on.	Accepted: ES revised and reference is made to all sections of teh main report	Evyatar Erell	Ben-Gurion University of the Negev	Israel
77117	4	1	6	9	Comment #13 applies on likely double-counting of emissions.	Rejected: Comment unclear	Jim O'Brien	Expert Reviewer AR6 SOD WG1	Ireland
16505	4	2			Please check the number 22%. 9.1 section (7page) has the number 30~40%.	Rejected: The 22% refers to GHG shares and statement in the introduction refers to CO2 emissions shares.	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17011	4	2			Please check the number 22%. 9.1 section (7page) has the number 30~40%.	Rejected: The 22% refers to GHG shares and statement in the introduction refers to CO2 emissions shares.	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
56265	4	2			"In 2018, the buildings sector accounted for more than 22% of global GHG emissions." This statement is inconsistent with the first sentence in Introduction (page 7, lines 2-3).	Rejected: The 22% refers to GHG shares and statement in the introduction refers to CO2 emissions shares.	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
86041	4	2			1) General comments in section 9.1 Introduction 22% does not align with the GABC report and the source reference is unclear. Typically, embodied emissions accounts for 11% rest indirect and direct emissions; Embodied emission includes materials, technical systems and other components (See National standards i.e. NS 3451 - 2009Table of Building Elements) 'Emissions from the use' is not scientifically accurate. 2)Missing aspects in Introduction a)Contribution of buildings to climate change and sustainable development b)Perspectives on buildings and constructed assets ((1) sectoral approach with construction product -, construction- and real estate – industry, (2) buildings as area of action, (3) housing as area of need c)Contribution of buildings to GHG-emissions from perspectives (1), (2) and (3) d)Objects of assessment like (a) construction product/construction process; (b) single building; (c) group of buildings/urban district; (d) city; (e) institutional, regional, national building stock	Rejected. The 22% figure refers percent of global GHG emissions, not CO2. The contribution of buildings to global CO2 emissions, including embodied emissions, in now stated clearly in the introduction 9.1	Aoife Houlihan Wiberg	The Belfast School of Architecture and the Built Environment, Ulster University, UK	United Kingdom (of Great Britain and Northern Ireland)
79435	4	2	4	14	"In 2018, the buildings sector accounted for more than 22% of global GHG emissions." - This drastically underestimates the GHG emissions from "buildings" and should be revised The annual "Global Status Report for Buildings and Construction", issued by UNEP and the Global Alliance for Buildings and Construction (GABC), specifically investigates the share of GHG emissions from buildings (residential and non-residential). In the 2019 report (analysing 2018 emissions) the report found direct emissions to be 6% for residential buildings (similar to the current SOA draft states) plus another 3% for non-residential buildings, and further indirect emissions of 11% for residential and 8% for non-residential buildings, respectively. The study furthermore shows that in 2018 11% of global GHG emissions are attributed to the "construction sector", hence again related to buildings construction and opertation. Overall, this drastically changes the picture as it shows the importance of building construction and operation in being responsible for a staggering 39% of global GHG emissions in 2018! [See: Figure 2 in Global Alliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme (2019): 2019 global status report for buildings and construction: Towards a zero-emission, efficient and resilient buildings and construction sector. https://www.worldgbc.org/sites/default/files/2019%20Global%20Status%20Report%20for%20Buildings%20and%20Construction.pdf)	Rejected: The 22% refers to the share of buildings out of all GHG emissions. The latter includes N2O, CH4, and F-gases, while the global alliance report refers only to CO2 emissions, which is also refered to in the chapter	Martin Röck	KU Leuven	Austria
21965	4	2	4	2	the section to be referred should be specified	Accepted	Government of France	Ministère de la Transition écologique et solidaire	France
28291	4	2	4	2	The 22% appears odd and not in line with other UN publications, such as the UNEP & IEA 2019 Global Status Report for Buildings and Construction, which allows 11% of global emissions to construction (i.e. part of embodied emissions) and 28% to direct and indirect for both residential and non-residential buildings. Even if the 22% were to be a lower bound estimate for operational emissions I would disagree with continuing the unnecessary dichotomy between operational and embodied emissions. A building cannot be operated unless it's construction and construction materials and methods deeply influence operational emissions. Therefore an aggregated figure of emissions that can be attributed to buildings is in my view a more meaningful way forward.	Rejected. The 22% figure refers percent of global GHG emissions, not CO2. The contribution of buildings to global CO2 emissions, including embodied emissions, in now stated clearly in the introduction 9.1	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
43635	4	2	4	2	The value "22%" is not in agreement with other values found in literature and leads to a clear underestimation of the importance of the area of action "buildings". Alternative sources assume that the share of direct and indirect emissions as well as emissions associated with the manufacturing of building products is around 40% of the total GHG emissions. This is not only the case in the global average but also in individual countries. Source (international): https://www.worldgbc.org/sites/default/files/2018%20GlobalABC%20Global%20Status%20Report.pdf - page 11 and https://www.worldgbc.org/sites/default/files/2018%20GlobalABC%20Global%20Status%20Report.pdf - page 54 ; Source (situation in Germany): https://www.bbsr.bund.de/BBSR/DE/veroeffentlichungen/bbsr-online/2020/bbsr-online-17-2020-dl.pdf?__blob=publicationFile&v=3 (in German only)	Rejected: The 22% refers to the share of buildings out of all GHG emissions. The latter includes N2O, CH4, and F-gases, while the UNEP&IEA report refers only to CO2 emissions share	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
60553	4	2	4	2	statement that building sector accounted for 22% of GHG emissions does not agree with thestatement on page 9-7, line 3.	Rejected: The 22% refers to the share of buildings out of all GHG emissions. The latter includes N2O, CH4, and F-gases, while the UNEP&IEA report refers only to CO2 emissions share	Evyatar Erell	Ben-Gurion University of the Negev	Israel
29937	4	2	4	3	Please consider clarifying whether the 22 % share of GHG emissions from the buildings sector and the explanation of this value also includes the heat and electricity consumed during the construction (and demolition) phases, or only the use phase of the buildings. There is an increasing policy attention toward the emissions from construction machines (excavators, building heaters and dryers etc.), and it may be unclear whether "direct emissions produced on-site, indirect emissions from electricity and heat consumed on-site" covers these emissions or not.	Accepted: A figure is now added to clarify the type of emissions included	Government of Norway	Norwegian Environment Agency	Norway
3253	4	2	4	5	Per page 7 line 2, the building sector is responsible for 39% of global emissions when the embodied carbon of building materials is included. This aggregate number should be noted on this page, as embodied carbon emissions are starting to be included in building codes, standards and municipal sustainability criteria.	Accepted. We have clarified the emissions considered and the share of embodied emissions	Rachel Bannon-Godfrey	Stantec	United States of America
3253	4	2	4	5	Per page 7 line 2, the building sector is responsible for 39% of global emissions when the embodied carbon of building materials is included. This aggregate number should be noted on this page, as embodied carbon emissions are starting to be included in building codes, standards and municipal sustainability criteria.	Accepted. We have clarified the emissions considered and the share of embodied emissions	Rachel Bannon-Godfrey	Stantec	United States of America
2231	4	2	7	3	In the Executive Summary >22% is used. In the introduction a range of 30-40% is used. Should there be consistent values?	Rejected: The 22% refers to GHG shares and statement in the introduction refers to CO2 emissions shares.	Stephen Wilkinson	University of Wollongong in Dubai	United Arab Emirates
64201	4	2	7	3	In the executive summay it is stated that the global emission from building sector is more thn 22%, but then in the introduction it is stated that 30-40%. Its better to have the same figures. Also. 30-40% is quite large percentage. Furthermore to define "more than 22%".	Rejected: The 22% refers to GHG shares and statement in the introduction refers to CO2 emissions shares.	Ova Candra Dewi	Universitas Indonesia	Indonesia
79693	4	4			The 22% appears odd and not in line with other UN publications, such as the UNEP & IEA 2019 Global Status Report for Buildings and Construction, which allows 11% of global emissions to construction (i.e. part of embodiede emissions) and 28% to direct and indirect for both residential and non-residential buildings; Cite GABC report: The buildings and construction sector accounts for nearly 40 percent of total energy-related CO2 emissions and 36 percent of final energy use worldwide. A growing population, as well as rapid growth in purchasing power in emerging economies and developing countries means that energy demand in buildings could increase by 50% by 2060. At the same time, global building floor area is expected to double by 2050, driving energy demand and related GHG emissions for construction. On the other hand, the building sector offers the largest cost-effective GHG mitigation potential, with net cost savings and economic gains possible through implementation of existing technologies, policies and building designs. See: https://collaborativeplatform.globalabc.org	Rejected. The 22% figure refers percent of global GHG emissions, not CO2. The contribution of buildings to global CO2 emissions, including embodied emissions, in now stated clearly in the introduction 9.1	Alexander Passer	Graz University of Technology	Austria

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
61115	4	4	4	4	the phrase "emissions from the use of cement, steel" might be misleading. The emissions technically do not come from using these materials, but from extracting raw materials, transporting, manufacturing, installing, maintaining and disposing of them (i.e. embodied emissions). Since manufacturing is – in this case – the most emission-intensive stage, simplifying the description as "emissions from manufacturing cement, steel (…)" would be less confusing.	Accepted. 'Use' has been replaced by 'production'.	Marcella Saade	Graz University of Technology	Austria
61115	4	4	4	4	the phrase "emissions from the use of cement, steel" might be misleading. The emissions technically do not come from using these materials, but from extracting raw materials, transporting, manufacturing, installing, maintaining and disposing of them (i.e. embodied emissions). Since manufacturing is – in this case – the most emission-intensive stage, simplifying the description as "emissions from manufacturing cement, steel (…)" would be less confusing.	Accepted. 'Use' has been replaced by 'production'.	Marcella Saade	Graz University of Technology	Austria
52339	4	4	4	5	Why include the embodied emissions in concrete and steel? The authors should add a justification here.	Rejected. Emissions from production of construction materials are commonly allocated to the buildings sector as the relevant demand sector	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
61117	4	4	4	5	The percentage metioned in this line (22%) is not aligned with the most recent published report by the Global Alliance for Buildings Construction (2018), which claims that 39% of global GHG emissions come from buildings, from which 11% refer to embodied emissions.	Rejected. The 22% figure refers percent of global GHG emissions, not CO2. The contribution of buildings to global CO2 emissions, including embodied emissions, in now stated clearly in the introduction 9.1	Marcella Saade	Graz University of Technology	Austria
19129	4	5	4	5	Its unclear how the characterisation of 'robust evidence, high agreement' has been concluded	Rejected: Characterisation is based on IPCC Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties	Paraskevi Dorizas	BPIE	Belgium
72037	4	5	4	8	The author mentions "global scenarios" without giving details on which exact scenario the figure of 16 GtCO2/year refers to.	Accepted: reference to scenarios used is added	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
56267	4	6	4	24	Page 4, lines 6-8, states that "The analysis of global scenarios illustrates that currently implemented policies lead to an increase of direct, indirect, and embodied CO2 emissions of buildings from around 12 GtCO2 yr-1 in 2020 to around 16 GtCO2 yr-1 in 2050." Later, the authors state (page 4, lines 22-24), "Significant lock-in risks arise from the long lifespans of buildings and low ambitious policies. If only today's stated policies are implemented, CO2 emissions from the building use phase that would be locked in buildings by 2050 would reach 9.3 GtCO2 yr-1." It would be helpful for the authors to make an explicit connection for the reader between the statements in lines 6-8 and lines 22-24 in the text. Is the anticipated 9 GtCO2 yr-1 in 2050 from currently implemented policies from the use phase a component of the 12 GtCO2 yr-1 of direct, indirect, and embodied CO2 in 2050 from currently implemented policies? If the authors could indicate more clearly how these two metrics relate, that would be helpful for the reader.	Accepted: Text clarified	Government of United States of America	U.S. Department of State	United States of America
52341	4	8	4	12	In some analysis, grouping countries in only devleoping and developed countries and making general statements insufficient. The growth in floor area in China, Middle Eastern Countries, and African countries to be faster than the growth in European countries, for example. This is confirmed by Figure 9.1(c).	Taken into account: degrouping included when data available	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
3255	4	8	4	13	One of the most significant drivers is the lack of consitent adoption and enforcement of the most current building codes and regulations, which require a fairly high level of energy efficiency. Other drivers also include increasingly process-dominated buildings such as data centers, ageing and increasingly inefficient existing building stock, and a preference in the private sector for building new instead of efficient retrofits of existing buildings.	Taken into account: see section 9.9 where enforcement of policies is discussed	Rachel Bannon-Godfrey	Stantec	United States of America
56269	4	9	4	13	Other factors are equally important: (1) aspirations of growing young populations for buildings and services that counter the climate and cultural considerations; (2) increased BAU deployment of higher embodied carbon materials and equipment during construction; and (3) changing microclimate in dense urban centers with significant growth in cooling, heating, and lighting demand serviced primarily through active energy systems instead of through building envelope and landscape/microclimate/urban fabric strategies.	Taken into account where references identified	Government of United States of America	U.S. Department of State	United States of America
30775	4	10	4	11	Since there is no direct description in the body text of " (iii) the inefficiency of the newly constructed buildings, especially in developing countries, and existing ones, especially in developed countries," the authors should revise the description. At least, it would be better to modify "inefficiency" as "energy inefficiency."	Accepted: text revised	Government of Japan	Climate Change Division - Ministry of Foreign Affairs	Japan
56271	4	11	4	12	Extreme temperature events (e.g., the 3-day record heatwave during the 2017 Labor Day weekend of San Francisco Bay Area, the record winter storm in February 2021 of Texas) can trigger the purchase and installation of HVAC equipment, which will be used beyond the extreme events, thus increasing cooling or heating energy use and associated GHG emissions. Suggested changes: ""... (iv) the use, number, and size of appliances and equipment, especially ICT and cooling, driven by growing welfare, as well as extreme temperature events that trigger the purchase and use of HVAC equipment.""	Accepted: text revised	Government of United States of America	U.S. Department of State	United States of America
56273	4	12			ICT is used without definition in the Executive Summary or indeed in the entire buildings chapter. For readers who are not looking at the entire document, it would be useful to define this term: "information and communication technology".	Accepted: Products included under ICT listed and the acronym is now spelled out	Government of United States of America	U.S. Department of State	United States of America
21967	4	12	4	12	The acronym ICT needs to be broken down	Accepted: spelled out	Government of France	Ministère de la Transition écologique et solidaire	France
56275	4	15			The term IAM is used without definition in the Executive Summary and indeed in the entire buildings chapter. For readers who are not looking at the entire document, defining this term would be helpful: "integrated assessment model".	Accepted: spelled out	Government of United States of America	U.S. Department of State	United States of America
2227	4	15	4	15	IAMs should be defined here (i.e. replace with "Intergrated Assessment Models (IAMs)")	Accepted: spelled out	Stephen Wilkinson	University of Wollongong in Dubai	United Arab Emirates
19127	4	15	4	15	IAMs (stands for Intergated Assessment Modeling?) acronym should be spelled out the first time it mentioned, unless there is a glossary at the beginning for the entire report. Same for all acronyms throughout the text	Accepted: spelled out	Paraskevi Dorizas	BPIE	Belgium
21969	4	15	4	15	The meaning of the acronym « IAM » should be added	Accepted: spelled out	Government of France	Ministère de la Transition écologique et solidaire	France
28289	4	15	4	15	Comma after "Both" is not needed	Accepted: revised	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
52343	4	15	4	15	Remove the word 'Both' and the two commas so the sentence reads better.	Accepted: text revised	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
72039	4	15	4	18	Is IAM (integrated assessment modelling) mentioned before? Otherwise it would be great to remind about the definition here.	Accepted: spelled out	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
30777	4	15	4	24	L17 "very low GHG emissions" and L22 "Significant lock-in risks" are inconsistent. L28-36 on p.87 of the body text describes both in an integrated manner. It would be better to revise the description on L15-24 on p.4 to integrate both.	Accepted: text revised	Government of Japan	Climate Change Division - Ministry of Foreign Affairs	Japan

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
19131	4	18	4	18	Its unclear how the characterisation of 'medium evidence, high agreement' has been concluded	Rejected: Characterisation is based on IPCC Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties	Paraskevi Dorizas	BPIE	Belgium
60555	4	18	4	20	There is practically no evidence to support the statement that *at least* 80% of CO2 emissions can be mitigated.	Rejected: The figure is based on the scenarios assessed	Evyatar Erell	Ben-Gurion University of the Negev	Israel
2273	4	20	4	20	Does "compared to their reference" refer to "business as usual"? The word usage can be more specific	Rejected: most of baselines were BAU, however it would be incorrect to say, all were BAU, these were 77 studies.	Siddarth Durga	PNNL	United States of America
30779	4	20	4	22	It would be better to mention something about the consumption-based GHG emissions to understand more realistic situation.	Rejected: no data to support consumption-based assessment	Government of Japan	Climate Change Division - Ministry of Foreign Affairs	Japan
19133	4	21	4	21	Its unclear how the characterisation of 'low evidence, high agreement' has been concluded	Rejected: Characterisation is based on IPCC Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties	Paraskevi Dorizas	BPIE	Belgium
11471	4	22	4	24	The source of the statement "If only today's stated policies are implemented, CO2 emissions from the building use phase that would be locked in buildings by 2050 would reach 9.3 GtCO2 yr-1" cannot be found in the main text. Please check.	Accepted: Text revised based on the latest scenarios included in the assessment	SAI MING LEE	Hong Kong Observatory	China
18435	4	22	4	24	Regional differences elaborated in the text are not captured	Taken into account: text revised	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
19135	4	24	4	24	Its unclear how the characterisation of 'robust evidence, high agreement' has been concluded	Rejected: Characterisation is based on IPCC Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties	Paraskevi Dorizas	BPIE	Belgium
18431	4	25	4	34	Great to see sufficiency highlighted together with efficiency measures to reduce demand. It also resonates with commonly used resilience framework pillars of infrastructure + people+ systems. Suggest this link to adaptation and sustainability is considered in Box 9.1 and is more explicilty reflected in the contribution to multiple SDGs. Rebound effect minimisation and key sectoral coupling wins based on evidnece in the report could be enhanced in the exec summary.	Accepted: text revised	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
29941	4	25	4	35	Is it relevant to refer to some of the measures listed as "sufficiency" in chapter 9 as "nature-based solutions" as featured in chapter 9 in the adaptation report? Please consider including some of the nature-based solutions measures mentioned as Sufficiency measures from 9.4.3.2 and other sections if relevant.	Taken into account: sufficiency interventions included in 9.5	Government of Norway	Norwegian Environment Agency	Norway
56277	4	25	4	35	The discussion of sufficiency models focuses on unnecessary floor area as well as a few other items. It would be helpful to point out that, for heating and cooling, the actual sufficiency measure that should be addressed is building volume rather than building floor area, as it is the conditioned volume that is important. With the possibility that ceiling heights could be much larger than the 7 or 8 feet that might be "sufficient", the volume of a space with a 16 foot high ceiling is double that of a space with an 8 foot high ceiling. Thus, ceiling height or volume could and should be mentioned. Another sufficiency measure is window area. While an occupant might like floor to ceiling windows and a designer might accommodate that desire, the amount of glass or window or fenestration actually needed for views and daylighting is less than floor to ceiling. Thus, window area is another important sufficiency measure.	Taken into account: sufficiency interventions included in 9.5. However, no literature identified on the volume issue	Government of United States of America	U.S. Department of State	United States of America
2517	4	28	4	29	Reducing the demand fo materials is a significant focus area in regions where buildings are highly energy efficient and supplyed with low carbon energy such as district heating.	Taken into account	Johanna Wikander	Company	Sweden
19139	4	29	4	29	As the reduction of demand for materials may be challenging, a reference and link to circular economy and recycled materials coud be made here	Rejected: references to circularity included in 9.5	Paraskevi Dorizas	BPIE	Belgium
18429	4	29	4	30	Is the text 'within the planetary boundaries' necessary? I don't see what this adds or what other scope there could be.	Rejected: The planetary boundaries put a upper limit to emissions from buildings	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
30781	4	30	4	32	Although L30 notes "unnecessary floor area," floor area is actually necessary and important in terms of comfort and affluence. Moreover, this mention contradicts L28,29 on p.5 "The building sector stands out for its high heterogeneity, with many different building types, sizes, and operational uses." It would be better to revise the description on L30 "unnecessary floor area."	Accepted: Text clarified	Government of Japan	Climate Change Division - Ministry of Foreign Affairs	Japan
18433	4	31	4	32	Unclear if 80% emission mitigation using existing technologies and practices includes sufficiency measures or that would further boost this? Link to statement made in lines 33-34 unclear.	Accepted: text revised and clarified	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
19137	4	34	3	34	Its unclear how the characterisation of 'medium evidence, high agreement' has been concluded	Rejected: Characterisation is based on IPCC Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties	Paraskevi Dorizas	BPIE	Belgium
2275	4	36	4	37	While zero energy/carbon buildings have shown a strong growth in the past few years, I am not sure if categorizing them as widespread is accurate	Accepted: text revised	Siddarth Durga	PNNL	United States of America
3257	4	36	4	37	This sentence is incomplete: "The development, since AR5, of integrated approaches to construction and retrofit of buildings has led to the widespread (MISSING WORD) of zero energy/carbon buildings in all world relevant climate zones.	Accepted: text revised	Rachel Bannon-Godfrey	Stantec	United States of America
3259	4	36	4	37	Actually, as a percentage of total building construction, net zero energy buildings are a tiny percentage in North America. Refer to New Buildings Institute database for the current number of verified Net Zero buildings. This is a significant issue, one that the architecture industry is painfully aware of. Net Zero energy buildngs are still seen as a luxury, and net zero carbon buildings are very rare.	Accepted: text revised	Rachel Bannon-Godfrey	Stantec	United States of America
3261	4	36	4	37	Recommend the use of the term 'net zero energy' or 'net zero carbon' instead of zero energy/carbon to be more consistent with building industry standards, regulations and frameworks. Add a note stating that in California the term is zero net energy.	Accepted: the terminology for "net zero" was used following the definition agreed within all th	Rachel Bannon-Godfrey	Stantec	United States of America
56279	4	36	4	37	"... wide spread of zero energy/carbon buildings in all world relevant climate zones ..." is not an accurate statement, as such buildings are still very limited in practice. Suggest changing to: "... has led to increasing adoption of zero energy/carbon buildings in all world relevant climate zones."	Accepted: text revised	Government of United States of America	U.S. Department of State	United States of America
60557	4	36	4	37	Zero energy/carbon buildings are hardly 'widespread' - in fact they are a very small proportion of construction in most countries. Zero carbon buildings are in fact still rare.	Accepted: text revised	Evyatar Erell	Ben-Gurion University of the Negev	Israel
72041	4	36	4	39	"Lock-in" effect could be shortly described.	Noted: text revised	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
19141	4	37	4	37	Perhaps a link to zero energy or plus energy neighbourhoods can be added here as well	Accepted: see Section 9.4	Paraskevi Dorizas	BPIE	Belgium
43637	4	37	4	37	A definition for "zero carbon buildings" is needed, please take a look to: https://journal-buildingscities.org/article/10.5334/bc.66/ Lützkendorf, T., & Frischknecht, R. (2020). (Net-) zero-emission buildings: a typology of terms and definitions. Buildings and Cities, 1(1), 662–675. DOI: http://doi.org/10.5334/bc.66	Rejected: definitions are all in the Glossary	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
52345	4	37	4	37	Missing word after widespread.	Accepted: text revised	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
81977	4	37	4	37	There is a missing word, after 'widespead', in this section heading.	Accepted: text revised	Berrill Peter	Yale University	United States of America
19143	4	39	4	39	Its unclear how the characterisation of 'medium evidence, high agreement' has been concluded	Rejected: Characterisation is based on IPCC Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties	Paraskevi Dorizas	BPIE	Belgium
52347	4	39	4	41	The potential for exchange is given units of USD per tonne of CO2 (abated). This is an awkward sentence, and it is not clear what the authors mean when they write that the potential is below 0 USD per tonne of CO2. Retrofitting or replacing appliances and equipment with more efficient ones has negative net abatement costs. Nevertheless, there are some studies that have shown that retrofitting policies that appeared to have higher benefits than costs were found to have higher ex-post costs than initially predicted. Th authors need to look into this strand of literature.	Accepted: Text revised	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
81979	4	40	4	40	There is possible a missing word after 'potential', looks like 'cost' would fill the gap	Accepted: text revised	Berrill Peter	Yale University	United States of America
25027	4	40	4	41	The statement "The potential associated with the exchange of appliances, equipment, and lights with efficient ones is below 0 USD tCO2-1" is not clear. What about the costs of exchanging the equipment/appliances/lights? Are the authors assuming that these costs are offset by a CO2 tax/incentive payment? This is not applicable in most countries.	Accepted: Text revised	Bassam AbuHijleh	The British University in Dubai	United Arab Emirates
56281	4	40	4	41	Is the potential referring to the life cycle cost-benefit? A clarification would be great.	Noted: text has been revised	Government of United States of America	U.S. Department of State	United States of America
60559	4	41	4	45	The cost premium of high-performance buildings is highly variable. The summary should be evidence-based. What is needed here is a range reflecting the diversity of solutions and locations.	Noted and considered in Section 9.6	Evyatar Erell	Ben-Gurion University of the Negev	Israel
19145	4	42	3	42	Its unclear how the characterisation of 'medium evidence, high agreement' has been concluded, same comment applies to all similar parenthesis across the text	Rejected: Characterisation is based on IPCC Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties	Paraskevi Dorizas	BPIE	Belgium
2519	4	43	4	44	Deep retrofitting does require higher investments and can therefore result in a need to increase rent. Deep retrofits therefore need to also take social aspects into consideration.	Accepted: Text revised	Johanna Wikander	Company	Sweden
11473	4	45	4	45	The figures "20-50 USD tCO2-1" are different from those presented in the main text (0-20 USD/tCO2, P.53, line 42-43). Please check and revise as appropriate.	Accepted: Text revised	SAI MING LEE	Hong Kong Observatory	China
47495	4		6		Creating an international collaboration (international development) category to share the good experiences and lessons learned from countries could be considered in this point.	Taken into account: International collaboration discussed in 9.9	Gonzalo Sánchez	European Environmental Bureau	Belgium
47491	4		88		The point of view and the vision for a sustainable built environment and the inclusion of the SER (sufficiency, efficiency and renewables) approach in this chapter are welcome. The SER approach will play a vital role in the decarbonization of the sector Nonetheless, of the three mentioned, sufficiency is the one that should be defined more in-depth. The description of precise sufficiency measures are missing in all the sections. Sufficiency will be the crucial point to ensure a sustainable future in the coming years. Some energy and climate policies in the EU will also be revised, taking into account these principles. Including more visibility, clear and detailed sufficiency measures in the chapter should be the main task for this revision.	Accepted: Sufficiency interventions are included in 9.5 and policies in 9.9	Gonzalo Sánchez	European Environmental Bureau	Belgium
2277	5	1	5	12	Along with the preventitive maintenance of centralized HVAC systems, COVID retrofits have also been widely discussed in the industry and should be discussed here	Accepted: Text revised but only for the discussion withing the scope of this chapter	Siddarth Durga	PNNL	United States of America
3263	5	1	5	12	At the same time as COVID raised awareness of the importance of indoor air qualtiy and engingeering organizations increased requirements for outdoor air flow rates, making operable windows the preferred solution, the increased frequency and severity of wildifres has rendered operable windows unreliable as a means of delivering fresh air. The conflict between use of operable windows as a low-energy, healthy design solution, and the need to aggresively filter outdoor air during wildfires, is one that needs to be addressed more as the likelihood of fires increases.	Accepted: Text revised	Rachel Bannon-Godfrey	Stantec	United States of America
25029	5	1	5	12	Could mention the increased importance of filtration sub-systems in HVAC systems; natural ventilation is not always the solution and is not applicable under all outdoor climatic conditions. This could be mentioned under the Indoor Air Quality (IAQ) codes/guidelines, e.g. referring to ASHRAE code 62.1-2.	Accepted: Text revised	Bassam AbuHijleh	The British University in Dubai	United Arab Emirates
56283	5	1	5	12	This COVID impacts section would be stronger/more relevant if the potential energy impacts of increased ventilation, for example, were more explicit. This should also be in the full document (on page 8).	Accepted: Text revised	Government of United States of America	U.S. Department of State	United States of America
56285	5	1	5	12	Check COVID information (natural ventilation with outdoor air). It's more complicated than that. Most buildings have mechanical ventilation, and these systems can actually increase risk if not operated properly. See ASHRAE guidance on operating buildings with COVID. Also, COVID is showing that there are a lot of phantom energy uses in commercial buildings, so it would be helpful to point out that a new emphasis is needed on better monitoring of buildings and optimizing for fluctuating usage now and post-COVID.	Accepted: Text revised	Government of United States of America	U.S. Department of State	United States of America
28293	5	2	5	2	"measures…" [have] not has	Accepted: Text revised	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
19151	5	3	5	3	Apart from mentioning daylight and clean air, thermal and acoustic comfort should also be mentioned as they are equally important for occupants.	Accepted	Paraskevi Dorizas	BPIE	Belgium
56287	5	4	5	4	For most commercial buildings, natural ventilation might be limited or impossible. Instead, a higher rate of outdoor air (up to 100%) is used in centralized HVAC systems.	Accepted: text revised	Government of United States of America	U.S. Department of State	United States of America
18437	5	4	5	5	'Natural ventilation with outdoor air has been the privileged option to respond to the new health requirements raised by COVID-19.' – what is the privilege referring to? And is a well-ventilated building really a 'new' requirement?	Taken into account: Text revised	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
19147	5	5	5	5	Its not clear which are the new health requirements raised by COVID-19	Accepted: References added	Paraskevi Dorizas	BPIE	Belgium
52349	5	5	5	5	Remove comma after requirements.	Accepted: text revised	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
16491	5	5	5	7	Because of COVID19, the importance of the introduction of an external ventilation system has increased. However, there is too much scientific uncertainty about whether the central heating and cooling system is effective against COVID19. So it seems that it is inappropriate to describe the importance of managing central heating and cooling system due to COVID19.	Accepted: text revised, additional evidence provided about the need to better manage HVAC systems	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56289	5	5	5	7	This is a place to more explicitly discuss the integral role Indoor Air Quality (IAQ), more specifically ventilation, plays in both new construction and retrofits of existing buildings. 1.https://doi.org/10.1016/j.enbuild.2019.109683 2.https://onlinelibrary.wiley.com/doi/full/10.1111/j.1600-0668.2010.00703.x 3.https://doi.org/10.1016/j.enbuild.2017.12.051 4.https://iopscience.iop.org/article/10.1088/1748-9326/8/1/015022 5.https://doi.org/10.1016/j.buildenv.2014.12.024	Accepted: proposed references added	Government of United States of America	U.S. Department of State	United States of America
20329	5	7	5	11	Please explain officetel? What is it? Who invented this name? Why is it relevant here?	Accepted: Text revised	Thibaud Voïta	IFRI	Germany
56291	5	7	5	12	The term officetel-schooling seems a little misleading (at least in the contexts of large demographics such as the U.S. and India). It would be more like home offices Offires-schooling maybe? "Repurposing" may be also re-termed as Adaptive re-use and social resilience, for which a strong business case will need to be developed.	Accepted: additional clarifications included	Government of United States of America	U.S. Department of State	United States of America
86611	5	7		8	The concept of officetel and officetel-schooling need explaining. They are new and not universal concepts. Im not sure they mean what the author think they mean. (I think the author means working or schooling from home). I believe also that behind this there is a likelihood (low certainty) that buildings will have to become more flexible in use. Working from home is one such trend but generally reducing family size in most countries and also increasing tendency for young people to live otgether for longer in shared houses (partly for social reasons partly for financial reaosns) measn buildings may have to be more flexible. In the UK former commercial space is often turned into housing (including shared housing with shared facilities including work from home space). More flexible space implies more frequent refurbishment with more opportunitities to intervene to drive deep refurbishment.	Accepted: the officetelschool concept clarified and the flexibility in the use and share buildings added	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
72043	5	8	5	10	The projected growth for residential buildings surface may not be sufficient, ok, but is it balanced with any trend in reducing office surface?	Taken into account	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
16493	5	8	5	11	Regarding global residential floor area, it seem that it is inappropriate of analyzing repurposing of non-residential building with uncertain data related to COVID19.	Rejected: COVID Is only accelarting a tendency, text slightly revised to clarify this point	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
2521	5	11	5	12	If non-residential buildings are to be transformed into residential buildings, building codes may have to be further developed.	Rejected: Building codes refered to in this chapter are only those related to energy	Johanna Wikander	Company	Sweden
56293	5	13	5	13	Inconsistent use of "the buildings sector" and "the building sector". Most places use the singular.	Accepted: text revised to singular	Government of United States of America	U.S. Department of State	United States of America
21971	5	15	5	15	It should be specified in parenthesis what the sustaianble development goals 13 corresponds to.	Accepted: text revised	Government of France	Ministère de la Transition écologique et solidaire	France
3587	5	18	5	19	Normally, the use of the word "mitigation" implies building-level action to mitigate the impact of buildings on climate change. In this sentence, "mitigation" is confusingly used to mean "adaptation", i.e., changes in building design and operation to adapt to a changing climate.	Noted: Text clarified	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
56295	5	19	5	23	Another place to mention the impact of climate change on Indoor Air Quality (IAQ) and how mitigation measures to reduce GHG emission must consider IAQ. 1.https://doi.org/10.1016/j.enbuild.2017.12.051 2.https://doi.org/10.1088/1748-9326/8/1/015022 3.https://doi.org/10.1111/j.1600-0668.2012.00768.x 4.https://doi.org/10.1016/j.egypro.2015.11.625	Rejected: due to lack of space this aspect was not considered	Government of United States of America	U.S. Department of State	United States of America
3589	5	20	5	21	What are concentrations of "chloride" in this context? And why are they lumped with CO2?	Noted: the text has changed	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
19149	5	21	5	21	Sea level rise could be added as well in relation to coastal areas	Noted: the text has changed	Paraskevi Dorizas	BPIE	Belgium
56297	5	24	5	25	Higher cooling demand may not necessarily imply lower heating demand in certain regions such as South/South East Asia. First, there is the re-heat component in cooling in commercial buildings in the summer. Second, with increasingly inadequate building envelope and urban fabric strategies, winter heating in residences is becoming necessary, and will create significant peak loads. Lack of attention to heating is leading to dampness, air quality (using biomass for heating), and cold-related respiratory health issues especially in vulnerable populations. Typically this happens during cloudy days and evenings, when renewables cannot provide direct energy without storage.	Noted: the text has changed	Government of United States of America	U.S. Department of State	United States of America
28295	5	24	5	26	You might want to partly reconsider this statement in light of research that has shown that "the climate feedback induced by adaptation of the energy system to heating and cooling is found to be insignificant, partly because heating and cooling-induced changes compensate and partly because they represent a limited share of total final energy consumption". Ref: https://doi.org/10.1007/s11027-013-9522-7	Noted: the text has changed	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
82549	5	28	34	5	There is currently no mention of carbon-intensive building materials in this important executive summary paragraph. Finding viable, cost-effective and scalable zero emission alternatives to current carbon-intensive steel and cement is fundamental to building decarbonization. Suggest adding this point and initial analysis either in this paragraph or elsewhere as a separate analysis in the chapter executive summary.	Noted: the text has changed	Constabile Kerry	Oxford University School of Geography	United States of America
8415	5	28	5	31	In Hong Kong, landlords develop their properties at minimum costs and leave any decarbonization investment to the tenants or the new owners.	Noted: the text has changed	Otto Poon	President, Hong Kong Academy of Engineering Sciences.	China
2279	5	28	5	34	The text here should discuss or mention other barriers and obstacles in addition to principal/agent problems for the completeness of the argument	Noted: the text has changed	Siddarth Durga	PNNL	United States of America
77119	5	28	5	34	The report rightly acknowledges that mitigation in buildings faces multiple barriers and obstacles; experience shows that deep building retrofits take place only every generation or so, is very costly and has a payback of ~20 years; for poorly constructed buildings, new-build may be the more viable option.	Noted	Jim O'Brien	Expert Reviewer AR6 SOD WG1	Ireland
2523	5	30	5	31	Tenants may benefit from the landlords investments if the decarbonisation is subject to energy efficiency and the tenants are individually metered and billed for the use of energy. But if the investments are made to reduce carbon related to material use during new contruction or retrofit that will not be of benefit for the tenants. And individual metering and billing of energy for heating differs between regions.	Noted	Johanna Wikander	Company	Sweden
56299	5	30	5	31	Sentence about decarbonization benefiting tenants over landlords goes both ways. The issue is that any investment by a tenant ultimately benefits a landlord and vice versa. To say it is only a tenant benefit is extremely mis-leading. See U.S. comment for page 70, line 43.	Noted: See section 9.9	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
5445	5	35	5	36	You refer exlusively to SER to grasp the full mitigation potential in urban areas and buildings. This is clearly not complete. In dense areas, large cities with heavy consumption levels , it is clear that mass production units are more approriate. In advanced countries, including China, India, South korea, most EU and US countries, Brazil, etc.. nuclear is the first solution to be supported and implemented. If not, gas turbines will be used to stabilise the grid, and the result will be negative for the climate. There may be a share of renewable electricity, up to 40%, but it is established that beyond that limit, the risk of blaackout is too high to be accepted in large cities.	Rejected: Energy production is out of the scope of the building chapter. Reference is made to renewables because positive energy buildings require integration of renewable technologies to buildings	Michel SIMON	Retraité/ Pdt d'association	France
2795	5	35	5	37	A number of countries do not have energy efficiency building codes yet. In other countries, energy efficiency building codes do exist but they still have to be enforced. Enforcement is key for building code to deliver energy savings and CO2 reductions on the ground. Implementing EE building codes requires substantial capacity building for local authorities, architects, civil engineers, and construction workers	Noted: See section 9.9	Leonardo Barreto	Head of center "EU&International"	Austria
11923	5	35	5	38	• The building energy codes if on paper often not implemented unless ratified by the states despite incentives of additional FAR among others and thus a challenge in assumption that SER can grasp full mitigation potential.	Noted	Anjali Sharma	Research, Projects and Collaborative initiatives, Delhi.	India
9711	5	35	5	46	Can the attribute of "smart building" also contribute to emissions reduction from the building sector in addition to SER framework?	Noted: literature on smart technologies is assessed in 9.4	Mustafa Babiker	Saudi Aramco	Saudi Arabia
47493	5	35	5	46	Point out the need to specify the policies which focus on the sufficiency approach. Most of the referred policies tackle the efficiency approach. However, the ones which are based on sufficiency should be clearly presented.	Accepted: see box 9.1	Gonzalo Sánchez	European Environmental Bureau	Belgium
56301	5	35	5	46	This is a good discussion of building energy codes. Recommend mentioning the emergence of building performance standards (BPS). BPS are mandated performance targets for a building (e.g., annual greenhouse has emissions, site energy use intensity, or U.S. Environmental Protection Agency ENERGY STAR rating) that increase in stringency over time. Jurisdictions in the United States that are adopting BPS include New York City, the state of Washington, the District of Columbia, and St. Louis, Missouri. An advantage of BPS is that they provide flexibility. Operators can implement any mix of technologies and operational strategies, as long as they meet the performance target. Unlike prescriptive codes, BPS ensure actual reduction in operating energy use and GHG emissions during the operational phase of the building (which is what is necessary to limit global surface temperature rise).	Noted: See section 9.9	Government of United States of America	U.S. Department of State	United States of America
81981	5	35	5	46	Codes currently cover only efficiency and renewables. Despite the clear importance and need for sufficiency, it is not yet reflected in building codes or policies. Further, although this paragraph heading refers to sufficiency, none of the content of this paragraph contains reference to sufficiency related policies. I suggest to either suggest potential sufficiency-related policy options and point out that these do not yet exist, or else remove reference to sufficiency in the paragraph heading. Policies that can help support sufficiency (reduction of m2/cap) in the US include removal of restrictions on multifamily housing and small single-family housing (http://www.nber.org/papers/w26573), and equalization of tax and finance regulation for investment in single- and multifamily housing (https://doi.org/10.1021/acs.est.0c05696)	Rejected: The 2012 French building energy code covers some of the sufficiency measures, see section 9.9 on policies. Regarding sufficiency potentials: see section 9.3	Berrill Peter	Yale University	United States of America
28297	5	36	5	36	"codes" are, not is	Accepted: Text revised	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
43639	5	40	5	40	The introduction of a law on environmental performance of buildings including a targeted reduction of embodied GHG emissions has already been announced for France - see: https://ec.europa.eu/growth/tools-databases/tris/en/search/?trisaction=search.detail&year=2020&num=792	Rejected. This is a good example of a policy considering embodied emissions. There are no citations included in this section of the report. The suggested policy is considered for inclusion in the policy section.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
43641	5	45	5	45	in most of the cases, the term "budget" is used instead of "allowance" in literature, see also https://journal-buildingscities.org/articles/10.5334/bc.73/	Noted: the text has changed	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
30783	5	47	5	48	The description of L17 on p.5 "Provision of financing with several effective instruments and technical assistance are of a paramount..." contradicts L22 on p.4 "Significant lock-in risks arise from the long lifespans of buildings and low ambitious policies." and L28 on p.5 "The decarbonisation of buildings is constrained by multiple barriers and obstacles." It would be better to revise this statement to "Provision of financing and technical assistance alleviate barriers such as lack of funding and access to technology."	Noted: the text has changed	Government of Japan	Climate Change Division - Ministry of Foreign Affairs	Japan
50077	5	47	5	48	"of a paramount" should be "of paramount importance."	Accepted: Text revised	Masahiro Sugiyama	University of Tokyo	Japan
52351	5	48	5	48	"Are of paramount importance"	Accepted: text revised	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
5447	6	1	6	9	This paragraph confirms -it's not a surprise- the previous note N° 144. In urban areas with dense population and heavy consuption of electricity, renewables alone cannot be the solution. I am surpise to see in a draft IPCC report such promotion of renewables where they cannot be the solution. I call for more objectivity.	Rejected: The chapter is about buildings and not about energy production. Positive energy buildings do integrate renewable energy solutions, see the French building energy code which includes requirement on on-site production of electricity	Michel SIMON	Retraité/ Pdt d'association	France
2797	6	2	6	4	Cooperation between Local Authorities and citizens is essential to implement energy efficiency programmes in residential buildings. This includes several forms of citizen´s engagement ranging from awareness raising for homeowners to cooperative approaches that provide support to homeowners for building renovation and citizen-led renovation schemes	Noted: the text has changed	Leonardo Barreto	Head of center "EU&International"	Austria
2229	6	6	6	6	"at least USD billion in 2019" surely there is a number missing from this, how many USD billion?	Accepted: Text revised	Stephen Wilkinson	University of Wollongong in Dubai	United Arab Emirates
3593	6	6	6	6	Last of three USD X billion figures is missing.	Accepted: Text revised	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
11475	6	6	6	6	Missing information in the text "at least USD billion". Please revise.	Accepted: Text revised	SAI MING LEE	Hong Kong Observatory	China
27781	6	6	6	6	The amount for investment in onsite renewable electricity is missing.	Accepted: Text revised	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
28685	6	6	6	6	Value missing from the onsite renewable investment	Accepted: Text revised	Asa Hopkins	Synapse Energy Economics	United States of America
43005	6	6	6	6	Missing amount in USD billion for 'onsite renewable electricity'.	Accepted: Text revised	Doris Toe	Universiti Teknologi Malaysia	Malaysia
52353	6	6	6	6	Missing number at the end of sentence.	Accepted: Text revised	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
56303	6	6	6	6	Missing the value of USD billion in "and at least ??? USD billion in 2019".	Accepted: Text revised	Government of United States of America	U.S. Department of State	United States of America
81983	6	6	6	6	Missing value in "at least ___ USD billion in 2019 respectively"	Accepted: Text revised	Berrill Peter	Yale University	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
81985	6	7	6	7	"by far not enough" sounds odd. "wholly insufficient" may read better.	Accepted: Text revised	Berrill Peter	Yale University	United States of America
18439	6	7	6	8	'depending on the country the incremental investment cost to decarbonise buildings is up to 3.5% of its GDP per annum' – given the caveats of 'depending on the country' and 'up to', is this 3.5% an upper limit? If so, why state this and not an average?	Noted: Text revised	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
86613	6	11		12	There is lots of evidence (at least in the UK) of the need to repurpose not only retail outlets but whole shopping districts as shopping moves online. There is also lots of evidence (at least in the UK) that business are seeking to reduce office footprint. ANd evidence that people are seeking to move out of very denseand expensive cities like London. SO it isnt clear if all the buildings are int he right place. However, for buildings that ARE repurposed, the major refurbishment is a once-in-a-generation opportuntity to achieve low carbon refurbishment.	Accepted: text revised	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
86615	6	23			Cooling demand isnt guranateed and can be reduced by many passive measures	Accepted: passive solutions included in 9.5	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
43645	7	1	9	9	9.1 Introduction: It is recommended that the content of the introduction be supplemented and expanded. In particular, the following basic principles should be presented: (a) Construction industry and real estate industry as sectors, Buildings as an area of activity, housing as an area of need - see e.g. https://journal-buildingscities.org/articles/10.5334/bc.47/; https://journal-buildingscities.org/articles/10.5334/bc.38/; https://journal-buildingscities.org/articles/10.5334/bc.32/; (b) a system of objects of assessment such as construction product, building component, building and constructed asset, institutional/national building stock; (c) a typology of involved actors and decision-making situations; (d) modeling of buildings and building life cycle; (e) modeling of the building stock including dynamic development; The network of researchers from IEA EBC Annex 72 is able and willing to provide you with additional parts - see https://annex72.iea-ebc.org/	Rejected: due to lack of space this aspect was not considered	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
52355	7	2	7	10	Poor sentence structure and some grammar mistakes.	Accepted: Text revised	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
5135	7	2	7	2	Further explain the term embodied emissions and the fact that the embodied emissions in the building sector overlap emissions that originates in the Industry sector, e.g. the Cement Industry. Also explain, that with embodied emissions, a lifecycle perspective is used, compared to before (AR5). Could be made more clear with an illustration in a figure and with cross-references to chapter 11 and 12.	Accepted. The novelty of considering embodied emissions since AR5 is now noted in the introduction.	Jonas Persson	Malmö Stad	Sweden
21973	7	2	7	2	The executive summary, line 2, says "In 2018, the building sector accounted for more than 22% of the global GHG emissions". For the building sector, boundaries of emissions are not obvious (embodied, in use, needs for the use of the building, and needs for the specific activities practiced inside). It should be usefull to make it clearer for the reader, and identify why the figure is 22% here and 30-40% there.	Accepted. The figure for both CO2 and GHG is now included in the executive summary to avoid this confusion.	Government of France	Ministère de la Transition écologique et solidaire	France
21973	7	2	7	2	The executive summary, line 2, says "In 2018, the building sector accounted for more than 22% of the global GHG emissions". For the building sector, boundaries of emissions are not obvious (embodied, in use, needs for the use of the building, and needs for the specific activities practiced inside). It should be usefull to make it clearer for the reader, and identify why the figure is 22% here and 30-40% there.	Accepted. The figure for both CO2 and GHG is now included in the executive summary to avoid this confusion.	Government of France	Ministère de la Transition écologique et solidaire	France
2233	7	2	7	30	In several places the written English is not correct or unclear.	Noted: Text revised	Stephen Wilkinson	University of Wollongong in Dubai	United Arab Emirates
72045	7	2	7	4	In the executive summary, buildings GHG emissions are evaluated to 22% of global emissions, but here, we mention 30-40% of global emissions, eventually stick to one figure to avoid confusion or provide more details. In the summary for policy makers, buildings are said to contribute to 6% of global GHG emissions.	Rejected: The 22% refers to GHG emissions shares while the 39% refers to CO2 emissions shares	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
28299	7	3	7	3	the 30-40% figure here further reinforces my comment on the 22% used instead in the exec summary. Also, why so much variation? A 10% variation is not reflective of the uncertainty we have on this figure. If instead it refers to whether or not embodied emissions are included, better to be clear and give the 39% figure broken down tow 28% + 11%.	Rejected: The 22% refers to GHG emissions shares while the 39% refers to CO2 emissions shares	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
28299	7	3	7	3	the 30-40% figure here further reinforces my comment on the 22% used instead in the exec summary. Also, why so much variation? A 10% variation is not reflective of the uncertainty we have on this figure. If instead it refers to whether or not embodied emissions are included, better to be clear and give the 39% figure broken down tow 28% + 11%.	Rejected: The 22% refers to GHG emissions shares while the 39% refers to CO2 emissions shares	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
43643	7	3	7	3	The magnitude of GHG emissions is correctly stated here! Why does it differ from the information in the summary?	Rejected: The 22% refers to GHG emissions shares while the 39% refers to CO2 emissions shares	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
56305	7	3	7	3	"30-40% global CO2 emissions" is incosistent with stated 22% GHG emissions figure on page 4, line 2. Suggest using the same value in both places.	Rejected: The 22% refers to GHG emissions shares while the 39% refers to CO2 emissions shares	Government of United States of America	U.S. Department of State	United States of America
86617	7	3			The point isnt clear here, why is the range as wide as 30-40%? Should this be over different countries? Or on different definitions?	Accepted: Text revised	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
43007	7	6	7	7	The original statement points to 'improved of Standard of Living' as the main factor to 'a fast increase in buildings emissions in the developing world'. However, in our humble opinion, this factor is written in a too simplistic way. It is irresponsible over-development which also cause much deforestation, urban sprawl, and poor quality in building design and construction that lead to fast increase in buildings emissions. We believe much energy and emissions are wasted unnecessarily in the 'good name of improved standard of living'. In fact, sometimes the wasted energy and emissions do not contribute anything for occupancy purpose nor actual standard of living of people. Hence, we opine that the AR6, being such a very essential report, shall note on the complexity of the issue in real contexts and not carry a misconception. We propose, to put forward the idea that we could make high standard of living based on sufficiency and efficiency in relevant section of the AR6 or to revise this original statement for such meaning.	Accepted: Text revised	Doris Toe	Universiti Teknologi Malaysia	Malaysia
78175	7	11	7	14	Materials and construction methods may also be added. Additionally, it may be good to mention the life cycle stages of buildings, as embodied emission has been included in the scope of this chapter.	Accepted.	SUCHANDRA BARDHAN	Jadavpur University	India
86619	7	15		16	"This chapter aims at updating the knowledge on the building sector since the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5). It would be useful to summarise they findings of AR5 on buildings (I see this is later, at page 25 line 40, section 9.4.1, at least for mitigation options, but the headlines from AR5 need to be earlier- its the starting point). It feels like the chapter is trying to find new things to say (eg sufficiency) and infact maybe what needs to be said is that AR5 is still largely vali and not enogh of its findings ahve been implemented yet! A key (unstated) difference is that AR5 was prior to Paris so that target has moved and is clearly a temperature based taregt implying net zero warming impact.	Accepted: text was revised	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
43009	7	23	7	29	These four novelties are very good inclusion in the AR6. We propose, to note the importance to tackle abandoned construction projects (i.e. buildings under construction and never completed), abandoned new buildings (usually units that are not sold or not occupied since completion due to over-development) and abandoned existing buildings in relevant section of the AR6. These issues tie holistically to the four novelties because they are root problems to increasing buildings emissions. Measures to stop the above abandonment should be made one of the top priorities in mitigation.	Accepted: the issue of abandoned buildings is tackled in 9.5 and in box 9.1 on sufficiency interventions	Doris Toe	Universiti Teknologi Malaysia	Malaysia
81987	7	24	7	24	The current phrasing suggests that now only embodied emissions are considered. I suggest adding the work "include" before "embodied emissions".	Accepted.	Berrill Peter	Yale University	United States of America
81989	7	25	7	25	Missing word "of" after "contribution"	Accepted: Text revised	Berrill Peter	Yale University	United States of America
16507	7	29			Delete 'consumers'.	Noted	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17013	7	29			Delete 'consumers'.	Noted	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
78177	7	29			The statement is unclear.	Accepted: Text revised	SUCHANDRA BARDHAN	Jadavpur University	India
72047	7	31	8	19	The box on SER is very clear and informative.	Taken into account	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
5449	7	31	9	9	So far, I thought that IPPC reports where based on scientifi review of publications. I am amazed that you refer to Negawatt report, which definitively a non scientific report but a paper issued by an activist anti nuclear group. For your information, Negawatt reports have ben several times blamed by academic or professional organisation, under several aspects. When evaluating the "reduction of demand " impact, you conclude that the perspective is not socially acceptable.Same for technical and economical aspects. The whole chapter should be deleted.	Rejected: The French 2015 energy transition law is based on teh SER Framework. Furthermore, IPCC report assesses both scientific and grey literature.	Michel SIMON	Retraité/ Pdt d'association	France
44081	7	39	8	18	Sufficiency concept (within Box 91 SER framework introduction) sustainable development paradigm “Decent living standard” is crucial to advancing both mitigation and adaptation. The references given would allow a forthright assertion that air-conditioning may be necessary under certain circumstances. Policy makers should be aware that attention to establishing sufficiency of passive design can defuse the issues of efficiency-and renewable in many situations. Consider adding an explicit statement that SER is a hierarchical layering in terms of cost-versus-benefit.	Taken into account: The hierarchical layering considered	Eric Peterson	University of Leeds	United Kingdom (of Great Britain and Northern Ireland)
37231	7	40	7	40	The main question is that whether any developed country follows the sufficiency framework?	Accepted: Added reference to the French 2015 energy transition law, which is based on the SER framework	Arun kumar Nayak	Bhabha Atomic Research Centre Trombay Mumbai	India
21975	7	43	7	43	The concept of Self-immunity evokes an attack on the original body or system. Is-it what this expression means here, in the Thaï approach ?	Accepted: text revised and concept clarified	Government of France	Ministère de la Transition écologique et solidaire	France
81991	7	44	7	45	Can you give a reference for this definition of sufficiency?	Accepted: Reference included	Berrill Peter	Yale University	United States of America
10731	8	1	8	3	No culture in the decent living standard?	Rejected: Definition referenced is the one from the Decent living standard researchers	Philippe Waldteufel	CNRS	France
76527	8	3			What you call "embodied" emissions can be sustantial - in emerging economies the emissions related to construction are often larger than those related to energy use in buildings. I very much appreciate that you attempt to quantify this here. In https://doi.org/10.1088/1748-9326/aae19a I quantified this as 'scope 3' emissions of the buildings sector, in https://doi.org/10.1038/s41561-021-00690-8 I specify the GHG emissions of materials used in the construction industry. Typically, materials constitute 60% of the carbon footprint of a building at the point when people move in, the rest is from construction machinery, transport, and services. In the UNEP IRP report https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change we provide a calculation for a number of large industrialized and developing countries. I could potentially update any of those calculations to 2018 (data has now become available), contact me at edgar.hertwich@ntnu.no. For a role in the larger policy context, see https://www.iea.org/reports/globalabc-roadmap-for-buildings-and-construction-2020-2050	Accepted. Unclear where the comment was referring to, but the chapter now contains and assesses scenarios of embodied emissions from the work that followed the UNEP IRP report referred to here.	Edgar Hertwich	Norwegian University of Science and Technology	Norway
11217	8	4	8	4	Missing reference to Cezard and Mourad 2019 in References.	Taken into account: Reference included	Bianka SHOAI-TEHRANI	RTE Réseau de Transport d'Electricité, CentraleSupelec Paris Saclay University	France
78179	8	4	8	6	Role of building design seems to have been omitted here. Bio-climatic design of buildings is an important measure of sufficiency, esp. in view of the texts of lines 14-16.	Accepted: Bioclimatic design referenced among the sufficiency measures	SUCHANDRA BARDHAN	Jadavpur University	India
56307	8	7	8	7	In the U.S., a distinction is made between residential (usually referencing single family homes) and multi-family buildings. This is because the building types are quite different.	Noted: Available data on the building stock in otehr countries does not make this distinction	Government of United States of America	U.S. Department of State	United States of America
18441	8	9	8	10	Clarification of how this addresses rebound effect would be helpful or reference to later section.	Noted: rebound effect discussed in section 9.9	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
2281	8	10	8	10	Providing a short definition of direct rebound effect here could be helpful for the readers (or an in-text reference to the section)	Taken into account: direct rebound effect defined	Siddarth Durga	PNNL	United States of America
4565	8	16	8	17	Box 9.1 , Fig. 1 .. Add with Energy Efficiency .. 'Design and material choices'	Noted: Figure revised	Alka Bharat	Maulana Azad National Institute of Technology (An Institute of National importance), Bhopal	India
52357	8	16	8	17	In Box 9.1 Figure 1, you could add "energy/carbon pricing policy" along with (or instead of?) "local taxes" as a policy instrument that cuts across S and E and R. For some countries, this policy could be energy price reform, while in other countries it may be a carbon tax.	Noted: Carbon pricing and taxation are discussed in section 9.9	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
84825	8	17	8	17	Strictly speaking, does "land use" apply to the buildings chapter? Although it is certainly interrelated, it appears slightly out of place.	Noted	Thomas Chen	U.S. Technology Policy Committee	United States of America
78181	8	17	8	18	Development Control Rules, Building Codes and bylaws need to be mentioned under policy instrument	Noted: see section 9.9	SUCHANDRA BARDHAN	Jadavpur University	India
3265	8	20	8	25	At the same time as COVID raised awareness of the importance of indoor air qualtiy and engingeering organizations increased requirements for outdoor air flow rates, making operable windows the preferred solution, the increased frequency and severity of wildifres has rendered operable windows unreliable as a means of delivering fresh air. The conflict between use of operable windows as a low-energy, healthy design solution, and the need to aggresively filter outdoor air during wildfires, is one that needs to be addressed more as the likelihood of fires increases.	Taken into account: Figure modified	Rachel Bannon-Godfrey	Stantec	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
66819	8	20	8	33	Covid-19 highlighted the needs of people locked down in buildings. Buildings' potential to serve human's wellbeing must be optimized, while addressing climate change adapatation and mitigation. This section only covered the importance of indoor air quality. This pandemic is teaching us to prepare for succeeding ones and therefore, water and food for sustenance and immunity (physical health) are a critical component of designing buildings of the future. Views to the outside which is a good component of mental health should as well be part of. The Phiippines' Climate-Smart Building's Triple S Approach: Survivability, Self-Sufficiency and Sustainability is a good reference as a standard component of any new or old building.	Noted	Maria Luisa Garcia	Green Architecture Advocacy Philippines; United Nations Development Program; Climate change Commission of the Philippines	Philippines
86621	8	20		27	Significant repetition in lines 20-27 compared to p5, lines 1-12	Accepted: text revised	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
56313	8	23			This line refers to natural ventilation with outdoor air as the "privileged option" for dealing with COVID-19. While there may be countries where only the "privileged" have access to operable windows, leaving the "less privileged" to fixed windows, there are also plenty of countries where natural ventilation is the norm for everybody, privileged and nonprivileged alike. Many occupants of naturally ventilated buildings are eagerly embracing mechanical ventilation and mechanical cooling and are happy to give up their "privileged" natural ventilation. It is true that increasing ventilation rates are a common approach for dealing with COVID-19, but this increased ventilation need not come from natural ventilation, as mechanical ventilation systems can provide the same impact with suitable controls.	Accepted	Government of United States of America	U.S. Department of State	United States of America
9971	8	23		24	While natural ventilation with outdoor air may become a privilege in high density urban areas due to land scarcity, it is not a new health requirement of a building caused by Covid-19 pandemic. It has always been a requirement that must be fulfilled to build a healthy house or building and has been stated in several government policy documents.	Taken into account: Text modified	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
56309	8	23	8	24	Sometimes supplemented by filtration	Noted	Government of United States of America	U.S. Department of State	United States of America
56311	8	23	8	25	This is a good place to more explicitly highlight the integral role Indoor Air Quality (IAQ) plays in both new construction and retrofits of existing buildings. 1.https://doi.org/10.1016/j.enbuild.2020.110102 2.https://doi.org/10.1016/j.egypro.2015.11.625 3.https://doi.org/10.1111/ina.12555 4.https://doi.org/10.1016/j.enbuild.2016.04.049 5.https://doi.org/10.1016/j.egypro.2016.09.134	Accepted: References added	Government of United States of America	U.S. Department of State	United States of America
56315	8	26	8	26	It is not clear that the concept of office hoteling or shared space emerged from South Korea. It is a long-standing practice in the U.S. with whole companies dedicated to it. Most U.S. offices have had some hoteling space for period visitors and off-site staff for decades. Also, more importantly, it isn't clear how this section connects to the rest. It seems to be a random reference.	Noted: literature refers to the concept as born in South Korea	Government of United States of America	U.S. Department of State	United States of America
2283	8	26	8	27	Can the authors provide a citation for this statement?	Accepted: Citation included	Siddarth Durga	PNNL	United States of America
61119	8	26	8	27	Is officetel the best concept to mention, or could one be generic and claim that home-office/schooling activities have increased?	Accepted: Text clarified	Marcella Saade	Graz University of Technology	Austria
64187	8	26	8	27	I am not sure the Korean example fits well here. Do you mean teleworking and remote schooling?	Noted: See references included on the officetel	Minal Pathak	WGIII TSU, Ahmedabad University	India
81993	8	26	8	29	Most readers will be unfamiliar with the concepts of officetel and officetel-schooling. Can you provide more detailed descriptions of what is meant by these terms, and why the projected growth of residential floor area may be insufficient?	Noted: See references included on the officetel	Berrill Peter	Yale University	United States of America
20331	8	26	8	33	Same comment as for page 5. What is this concept of officetel? "the lockdown measures have led to the spreading of the South Korean of officetel"- this is questionnable, this concept seems pretty unknown. I would strongly suggest to remove, or add references.	Noted: See references included on the officetel	Thibaud Voïta	IFRI	Germany
37233	8	27	8	27	What is officetel-schooling is not very clear. It needs to be elaborated a bit more.	Noted: See references included on the officetel	Arun kumar Nayak	Bhabha Atomic Research Centre Trombay Mumbai	India
30497	8	29	8	33	We are very much in support of such directions, i.e. to re-use / apply adaptive reuse to existing building stocks, rather than to over-supply with new buildings. We wish to note that the problem of abandoned old buildings is not confined to officetel-schooling triggered by COVID-19, but it has been prevalent for decades now (in developing countries). Hence, we wish that the AR6 could make a note that such re-purpose of existing buildings is not limited to COVID-19 related situation only, but could be a wide application in face of lowering buildings emissions.	Accepted: Text clarified	Kum Weng Yong	KW Yong Architect (Professional architect practice)	Malaysia
28301	8	30	8	30	the comma after "not" is not needed	Accepted	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
60563	8	32	8	32	the term 'officetel-schooling' could be replaced by 'remote-learning'.	Rejected: See references on officetel concept	Evyatar Erell	Ben-Gurion University of the Negev	Israel
37235	8	32	8	33	For many, the home itself may serve as a workplace. For instance, the IT enabled sector has hugely	Noted	Arun kumar Nayak	Bhabha Atomic Research Centre Trombay Mumbai	India
37237	8	32	8	33	moved from offices to homes of employees.	Noted	Arun kumar Nayak	Bhabha Atomic Research Centre Trombay Mumbai	India
56317	9	4	9	5	Authors state that "There are tight linkages between this chapter and Chapters 6, 7, 8, 10, and 11, which are sectoral sectors." What are "sectoral sectors"? Is there another way to state this that may be more clear to the reader?	Accepted: text revised	Government of United States of America	U.S. Department of State	United States of America
36981	9	10	14	13	Chapter 9.2 is too general; the information provided should be reduced.	Noted - This section was required by the IPCC instructions. The authors tried to do it as concise as necessary. Changes have been made as required by the reviewers and has been reduced as all the chapter.	Antonio Garcia-Martinez	Universidad de Sevilla	Spain
5007	9	10	61	9	NbS for buildings are not considered. I wold suggest to add a section about this topic	Noted - Nature based solutions (NbS) were included as a technology and everywhere needed. Due to extention restrictions for the chapter, a new section on this was not possible to be included.	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
56319	9	13	10	9	The chapter needs citations for the growth estimates earlier and discussion of the range of estimates that different studies present. Sahel (2021) is not in the list of references. Also, importantly, there is significant uncertainty in future energy use and emissions. A more traditional literature review would look holistically at both the IPCC AR6 scenario database regarding buildings as well as other literature on the topic. Recommend adding discussion of uncertainty and the range of projections, including additional graphics depicting a broader range of scenarios. This comment also refers to other parts of the chapter that only use Sahel (2021) as their reference for future projections.	Accepted: The report includes additional scenarios from additional models submitted to AR6 database and models. See alos Annex III, section 4 on the models and scenarios assessed by chapter 9	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
21977	9	14	9	31	Depending on the type of building, energy consumption, its cost (MacNaughton & al., 2015) and CO2 emissions (Hachem-Vermette & Singh, 2019) can vary considerably. Under the pressure of global warming, numerous studies have been carried out to contribute to the development of common international construction standards to reduce CO2 emissions (Nejat & al., 2015; Pérez-Lombard & al., 2016; Iwaro & Mwasha, 2010). This research in the extreme heterogeneity of the energy impacts of buildings, according to construction periods, architectural characteristics, regions, climatic zones, including within close geographical sectors (Csoknyai & al., 2016), or even a same country (Theodoridou & al., 2011). Beyond the diversity of energy consumption, most typologies agree to distinguish residential and non-residential buildings. Residential buildings are made up of housing when occupied by households, or rooms in the case of buildings intended for communities (nuns, students, homes, the elderly, etc.). Buildings occupied by households can be mobile (boats, caravans, mobile homes, etc.), removable and temporary (tiny houses, yurts, tents, etc.) or hard and durable (buildings). The typologies of residential buildings also involve the height of the building (number of floors), the number of dwellings or rooms they contain, the quality of the construction materials (concrete, wood, brick, cob, sheet metal, etc.) , the non-existence or existence of central or individual heating, the energy used (fuel oil, gas, electricity, wood). Solid buildings are also classified according to their date of construction (new or old), their single-family (houses) or collective characteristics (which include several apartments), and the financing of the construction (social or private). The density and location of these buildings (urban / rural; center / periphery) characterize types of neighborhoods (slums, adjoining suburban housing, of "standing", popular, old districts or recent) with urban heat islands fluctuating (Schoetter & al., 2019; Masson & al., 2020). These districts can also be classified according to the level and the lifestyle of the inhabitants (poor / rich, standing / popular...). Housing, and not buildings, can be distinguished according to their surface area (m^2), the number of rooms, sanitary comfort (bathroom, WC, hot water, etc.). The characteristics of the occupants are also involved in the classifications according to their occupation status (owners, tenants, free accommodation, squats), their social and economic position, their standard of living, which determine distinct energy practices according to the occupied housing (Bourgeois & al., 2017).	Editorial - changes incorporated when necessary	Government of France	Ministère de la Transition écologique et solidaire	France
43647	9	17	9	22	Neither the list of building types nor the list of actors involved is complete. Why is this even described if it is not referred to again later in the text?	Noted - the lists included were as complete as possible, understanding that there may be other ways of listing building types. The types are not listed again because they are considered in an aggregate manner.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
78183	9	17	9	22	A very important sub-sector of multifamily residences are highrises within gated communities. Cities in South Asian countries are experiencing Developer-led huge construction activities in this sub-sector. These are mammoth energy guzzlers. Special note should be taken of this from policy framing point of view.	Noted - this was considered in Section 9.9. Although lack of space did not allow to go in depth	SUCHANDRA BARDHAN	Jadavpur University	India
49651	9	17	9	31	Classification of buildings can be as per International Building Code (IBC), which is primarily categorized based on their usage. The following is based as per IBC, Group A includes Assembly (place used for gathering for entertainment, worship, eating and drinking) – restaurants, theatres, stadium etc. Group B includes Business (government buildings, banks etc.) Group E – Educational, Group F – factory, Group H – High hazard, Group I – Institutional, Group M – Mercantile, Group R – Residential and Group S – Storage.	Noted - Authors agree that there are many ways to classify buildings	Satyaprakas Das Das	Manipal Academy of Higher Education	India
56321	9	18	9	18	The classification seems based on mixed criteria: quality and occupancy. There may be a purpose, but it should be clarified.	Noted - Authors agree that there are many ways to classify buildings	Government of United States of America	U.S. Department of State	United States of America
64185	9	18	9	18	Classifying slums as buildings is a little problematic given the conditions of slums in developing countries. Most don't have proper walls or roofs to classify as buildings. Perhaps this can be mentioned in a separate sentence	Noted: literature agrees to include slums as building type	Minal Pathak	WGIII TSU, Ahmedabad University	India
76529	9	21	10	29	You do not manage to offer a crisp explanation of what sufficiency is. It would help if you offered some examples or enumerated ways to achieve sufficiency. I am not totally sure I like the term or find its use here prudent. In Chapter 5, which you refer to, sufficiency is defined as 'leading a life of moderation and prudence' (p.16 footnotes) or 'voluntary curtailment of consumption' (p.11 top). The mechanism by which such voluntary action could become successful are not quite clear. The industry chapter included 'demand management' as a complement to sufficiency aiming at the same outcome. In Norway, we find that residential floor space of primary residences decreasing as a result of urbanization and an increasing preference for multifamily homes over single-family homes. This trend leads to substantial reductions of both construction-related emissions and operational energy use and it at least in part due to zoning rules. The IRP 'Resource Efficiency and Climate Change' report (https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change)offers a quantification of the potential emissions savings from reducing floor space demand (either down from current levels in industrialized countries or compared to what it would grow to under standard SSP1/2 assumptions in developing countries). We also offer an analysis of how such a reduction can be achieved (larger houshold size, more multifamily living) and an analysis of policies and how they related to these issues.	Accepted: the text has been revised to ensure that the term "sufficiency" in the SER framework used in the chapter is clear	Edgar Hertwich	Norwegian University of Science and Technology	Norway
78185	9	23	9	31	It is important to have sub-classes based on occupancy period. For example, heathcare, hospitality and industrial segments (transport terminals) operate 24 x 7, calling for special policy/strategy interventions.	Rejected - Given the space available, it is impossible to reach this level of detail.	SUCHANDRA BARDHAN	Jadavpur University	India
9973	9	30		31	Agricultural building is not a part of industrial buildings, agricultural building is another type of non-residential building and differentiated into abattoir, barn, chicken coop or chickenhouse, cow-shed, farmhouse, greenhouse, silo, slaughterhouse, storm cellar, windmill, workshop, etc. There are other types of non-residential building not mentioned in this paragraph, i.e. infrastructure building and transportation buildings, which do not included within the classification of industrial buildings. (Sicola, Maria (March 2017). "Industrial Terminology")	Noted - Authors agree that there are many ways to classify buildings	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
64189	9	32	9	32	Building appears twice	Accepted: Text revised.	Minal Pathak	WGIII TSU, Ahmedabad University	India
37239	9	32	9	33	Is the data related to residential buildings growth simply linked to the population growth?	Accepted: clarified	Arun kumar Nayak	Bhabha Atomic Research Centre Trombay Mumbai	India
37241	9	32	9	33	If this is not so, then this violates sufficiency principle.	Noted	Arun kumar Nayak	Bhabha Atomic Research Centre Trombay Mumbai	India
56323	9	32	9	33	Global residential floor area grew by 191 billion m^2/yr in 2019? Or grew to 191 billion m^2 *by* 2019? 191 billion m^2 is about five times larger than the total U.S. residential floor area. Is that really an annual growth number? Figure 9.1 also might be mis-labeled.	Accepted: Text revised.	Government of United States of America	U.S. Department of State	United States of America
81995	9	32	9	33	The value 191.7 billion m2·yr-1 refers to an annual rate of floorspace, which I guess might be the annual inflow of floorspace from new construction. However this sentence refers to the building/floorspace stock, not inflows. Can you make these consistent, i.e. clarify whether you are referring to the size of the total building stock in 2019, or whether you are referring to the annual growth. Further, the percentages 46% and 60% do not have a clear basis, and it is unclear what they refer to. Does it mean the expected growth of floor space by 2030 and 2050 relative to 2005 levels, 2019 levels, or something else?	Accepted: Text revised	Berrill Peter	Yale University	United States of America
18443	9	32	9	41	Explanation of differences between regions in terms of key drivers would be helpful	Accepted: Text revised	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
49653	9	32	9	41	The global and regional building stock growth estimations and projection can be shown based on IBC classification of buildings. (the emissions and energy demands may hugely vary among the non-residential buildings).	Rejected - Data not available	Satyaprakas Das Das	Manipal Academy of Higher Education	India
56325	9	33	9	33	Is "billion m2 yr-1" correct. It seems should be "billion m2".	Accepted: Text revised	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
60565	9	33	9	33	Estimates of growth of the global building stock (46-60%) are supported by Figure 9.1a, which in turn is based on Saheb et al, 2021. I could not find this reference online. What is the methodology it is based on? The same source is later cited several more times: readers must have access to such a central resource.	Accepted - The methodology is explained in Box 9.1. The manuscript was not published by teh IPCC cut-off date	Evyatar Erell	Ben-Gurion University of the Negev	Israel
19153	9	34	9	34	A better descriptiom of the 3 scenarios of the figures should be given in the text	Accepted: See box 9.2	Paraskevi Dorizas	BPIE	Belgium
86623	9	35			"projections show that it will grow up to 40% in 2030 and up to 54% in 2050" - is this still true post covid? If we increase activites at home is this an increase in overall space or - following sufficiency- might there be less office and retail (in particular) and more residential space?	Noted: Scenarios assessed do not take intoc account Post-COVID changes	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
76531	9	38			Alcott has provided a quite well-informed argument for why sufficiency also is subject to the rebound effect, see 10.1016/j.ecolecon.2007.04.015.	Noted: Reboudn effect discussed in section 9.9	Edgar Hertwich	Norwegian University of Science and Technology	Norway
56327	9	39	9	41	Many studies show the commercial sector will experience the most growth. See, for example, Yu et al., 2014, in ERL: https://doi.org/10.1088/1748-9326/aaad84.	Noted: Non-residential buildings not included in the chapter	Government of United States of America	U.S. Department of State	United States of America
19913	9	42	12	20	This section should recognise the difference between naturally lit, heated, ventilated and cooled buildings and those built to PassivHaus and similar standards / approaches. Given the evidence from thermal comfort studies that occupants of the former are more tolerant to wider variations in temperature and other indoor conditions, with a potential for associated reductions in operational energy (albeit with positive or negative differences in embodied energy) there is a case for encouraging this building type where practical. I accept that the overall impact on global emissions from such a policy trajectory may be minimal in the wider scheme of things and the distinction is (sort of) made in the following section, but the potential is worth noting here as these are two very distinct approaches to building design and construction.	Noted - Section 9.2 only frames the chapter. The different technologies are discussed in Section 9.4 and behavioural aspects are discussed in Section 9.5.	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
2799	9	43	9	44	Quality control systems must be introduced on construction sites to avoid the so-called performance gap between building designs and actual buildings.	Noted and considered in Section 9.4	Leonardo Barreto	Head of center "EU&International"	Austria
16509	10	1			Please check the figure (a). I think that 3 graphs of scenario are same from 2020 to 2050.	Accepted: Figure revised	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17015	10	1			Please check the figure (a). I think that 3 graphs of scenario are same from 2020 to 2050.	Accepted - All figures and tables have been re-elaborated according to IPCC guidelines.	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
19155	10	1	10	1	The colours of the legends do not correspond to the colour patterns of the bars	Accepted - All figures have been modified	Paraskevi Dorizas	BPIE	Belgium
56329	10	1	10	1	In the bar chart at the upper right showing residential building stock growth, why is the "sustainable development scenario" building stock size by 2050 slightly higher than for the "current policies scenario" and "stated policies scenario" by 2050? Could the authors check the data. If correct as is, could the authors provide a footnote explaining why the "sustainable development scenario" by 2050 shows larger building stock size than in the other two scenarios by 2050? How is it assumed that this larger floor area will emit less GHGs (direct, indirect, embodied) and be "more sustainable"? It seems very important to address this in a footnote or somewhere in the text, and in all cases where graphs on page 9 show higher building stock size in "sustainable development scenarios" than in the other scenarios.	Noted: Final scenario selection revised.	Government of United States of America	U.S. Department of State	United States of America
64193	10	1	10	7	This figure and ohters refer to scenarios as Illusrative pathways. However these aren't the AR6 IPs from chapter 3. Wonder if you might consider labeling these as scenarios instead?	Accepted - All figures and tables have been re-elaborated according to IPCC guidelines. Illustrative pathways was replaced by Scenarios	Minal Pathak	WGIII TSU, Ahmedabad University	India
2285	10	1	10	9	Can the authors provide a map labeling the geographical classification of the countries. If shown in the earlier chapters can they provide an in-text reference to that figure/section	Noted: Geographical classification of countries is the one of the IPCC, the only difference is the grouping of Eurasia and Europe as noted in Box 9.2	Siddarth Durga	PNNL	United States of America
3595	10	1	10	9	It's not clear what the "scenarios" are in the figure, especially since the box describing them happens to fall on the next page. I suggest: (1) Either describing the scenarios briefly in the caption or simply mentioning that the scenarios are explained in Box 9.2, (2) plotting the three/four series so that the bars for corresponding decades are side-by-side and easy to compare.	Accepted - All figures and tables have been re-elaborated according to IPCC guidelines.	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
81997	10	1	10	9	Figure 9.1. Similar to the comment above; the y-axis text says "stock" but the unit of floor-space per year suggests a flow (perhaps inflow?) of floor area. Please clarify and amend.	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Berrill Peter	Yale University	United States of America
86625	10	2			Puzzled by the chart under (a) for residential buildings specifically in Asia-Pacific Developed. Why is the building stock likely to go down between 2019 and 2020, or is this a modelling glitch? (or is this IEA data?)	Noted: Figures updated	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
18445	10	3	10	3	Stronger colour difference between historical and current policies suggested	Accepted	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
56331	10	7			There are more scenarios for residential than non-residential buildings in Figure 9.1. Explain why.	Noted: Dissagregared data for non-residential buildings is unfortunately not available for all scenarios assessed, see box 9.2.	Government of United States of America	U.S. Department of State	United States of America
11925	11	1	11	1	• Suggested to compile data not on the basis of state of development but rather for identical geographical strata.	Rejected: We have to fellow IPCC regional grouping of countries	Anjali Sharma	Research, Projects and Collaborative initiatives, Delhi.	India
11927	11	2	11	4	Typically prior to working on mitigation measures it may be worthwhile to assimilated and documented Passive systems in our existing vernacular, heritage buildings/ precincts/ Cities as best practices for the respective geographical strata across the globe and explored for similar climatic conditions for traditional systems of natural ventilation, use of daylight, use of locally available building materials to reduce embodied energy substantially as with passive systems in place the energy requirements is often low validated such through research studies but for mitigation measures the baselines may be reviewed to optimise the energy use.	Rejected: comment not clear	Anjali Sharma	Research, Projects and Collaborative initiatives, Delhi.	India
10733	11	2	11	5	Admittedly this was IEA's responsbility to give to the 3rd scenario a name referring to the SDG. At the same time it is not quite correct, at least as far as SDG#5 is concerned. The objectives of SDG#5 concerning education and autonomy of girls and women, whenever thery are reached, have significant consequences on demography, in such a way that the population differ from UN projections. See eg Vollnet el al, 2020, doi.org/10.1016/S0140-6736(20)30677-2	Rejcted: Labels of scenarios used in the assessment are those provided by the scenarios' owners	Philippe Waldteufel	CNRS	France
27783	11	11	11	17	Use the official names of listed countries. Is there a country called officially "Macedonia"? Replace "Macedonia" with "Republic of North Macedonia".	Accepted - Corrected in the text	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
86043	11	19			National building classification standard exist, such as, ISO 12006-2:2015 Building construction — Organization of information about construction works — Part 2: Framework for classification; national standards of Table of Building Elements available i.e. NS 3451 - 2009 Other reference to explain the design process and how to organise data 1) Freja Nygaard Rasmussen, Tove Malmqvist, Alice Moncaster, Aoife Houlihan Wiberg, Harpa Birgisdóttir, Analysing methodological choices in calculations of embodied energy and GHG emissions from buildings, Energy and Buildings, Volume 158,2018,Pages 1487-1498,ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2017.11.013.) 2) H. Birgisdottir, A. Moncaster, A. Houlihan Wiberg, C. Chae, K. Yokoyama, M. Balouktsi, S. Seo, T. Oka, T. Lützkendorf, T. Malmqvist, IEA EBC annex 57 'evaluation of embodied energy and CO2eq for building construction', Energy and Buildings, Volume 154, 2017, Pages 72-80, ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2017.08.030. 3) Laurent Georges, Matthias Haase, Aoife Houlihan Wiberg, Torhildur Kristjansdottir & Birgit Risholt (2015) Life cycle emissions analysis of two nZEB concepts, Building Research & Information, 43:1, 82-93, DOI: 10.1080/09613218.2015.955755	Noted - The reviewer is right, but this classification done in the ISO 12006-2:2015 is too extended and not practical for readers worldwide. There is no consenscus in clasification since in literature there are BIM building components clasification, LCA, energy point of view	Aoife Houlihan Wiberg	The Belfast School of Architecture and the Built Environment, Ulster University, UK	United Kingdom (of Great Britain and Northern Ireland)
64191	11	21	11	23	Duplicates with line 45 on page 9	Accepted and corrected	Minal Pathak	WGIII TSU, Ahmedabad University	India
4269	11	21	11	26	Proposed change: substitute the text with a new one according to the proposed figure (comment 1). "There is not a global classification for the building components. Nevertheless, figure 9.2 tries to summarize the building components found in literature (Cavalliere et al. 2019) Building are primarily composed of building elements, and each one of them belongs to a different construction category: load bearing elements, namely structure (C); external envelope, namely façade, roof covering and windows, which usually feature the thermal insulation and the water proof elements (E,F); interior finishing, which have mainly an aesthetic function (G); building equipment, which provide the inhabitants with different services: conditioned air, hot water, electricity… (D). Building elements are grouped into building elements, each of which can have different components with different functions. For example, an exterior wall above ground is composed by three building components: The interior finishing, the exterior wall (load bearing element) and the external finishing. REASON: The readers may have a clearer idea on how the elements of a building are organized into building components. This classification is also in accordance with the latest developments in the BIM (Building Information Modelling) technology, and for that reason it might be more appealing to the readers who are more familiarized with these technologies.	Noted - but given the space available in the chapter the authors could not go into more detail.	Pulido Arcas Jesús Alberto	The University of Tokyo	Japan
60567	11	23	11	23	Building superstructure may include lightweight walls, too - not just heavyweight. I suggest replacing with the term 'walls'.	Rejected - In that specific case we are talking about structural elements, and lightweight walls are not structural. Although some buildings and construction methods have pilars as the structure and lightwalls	Evyatar Erell	Ben-Gurion University of the Negev	Israel
56333	11	24	11	24	Homes have curtain walls? Curtain walls are only used in commercial buildings with internal steel superstructures, i.e., the outer walls are not load bearing but rather hang from the steel skeleton like curtains.	Rejected - the paragraph relates to buildings in general, not only to "homes"	Government of United States of America	U.S. Department of State	United States of America
79675	11	27			The nomenclature for cost assessment has been extensively used for environmental calculation in various countries in Europe as well as is now promoted by the International Energy Agency, EBC Annex 72. Among references that are explaining this nomenclature and the interest it can have for environmental calculation one can cite, figure 2 in Cavalliere C., Habert G., Dell'Osso G.R., Hollberg A. 2019. Continuous BIM-based assessment of embodied environmental impacts throughout the design process. Journal of Cleaner Production, 211, 941-952. Other reference to explain the design process and how to organise data (C Llatas, B Soust-Verdaguer, A Passer. 2020. Implementing Life Cycle Sustainability Assessment during design stages in Building Information Modelling: From systematic literature review to a methodological approach - Building and Environment, doi.org/10.1016/j.buildenv.2020.107164); Soust-Verdaguer, B., García-Martínez, A., Llatas, C., Gómez de Cózar, J. C., Allacker, K., Trigaux, D., Alsema, E., Berg, B., Dowdell, D., Debacker, W., Frischknecht, R., Ramseier, L., Veselka, J., Volf, M., Hajek, P., Lupíšek, A., Malik, Z., Habert, G., Hollberg, A., … Passer, A. (2020). Implications of using systematic decomposition structures to organize building LCA information: A comparative analysis of national standards and guidelines- IEA EBC ANNEX 72. IOP Proceedings Earth and Environmental Science Journal. Obrecht, T. P., Röck, M., Hoxha, E., & Passer, A. (2020). The challenge of integrating Life Cycle Assessment in the building design process – a systematic literature review of BIM-LCA workflows. IOP Conference Series: Earth and Environmental Science, 588, 032024. https://doi.org/10.1088/1755-1315/588/3/032024 Potrč Obrecht, T., Röck, M., Hoxha, E., & Passer, A. (2020). BIM and LCA Integration: A Systematic Literature Review. Sustainability, 12(14), 5534. https://doi.org/10.3390/su12145534;Balouktsi, M., Lützkendorf, T., Röck, M., Passer, A., Reisinger, T., & Frischknecht, R. (2020). Survey results on acceptance and use of Life Cycle Assessment among designers in world regions: IEA EBC Annex 72. IOP Conference Series: Earth and Environmental Science, 588, 032023. https://doi.org/10.1088/1755-1315/588/3/032023	Noted - but given the space available in the chapter the authors could not go into more detail. Many different classifications are found in literature but there is still no agreement.	Alexander Passer	Graz University of Technology	Austria
19157	11	27	11	27	Misspelling of 'curtain wall' to curtian wall	Noted - there was an error, but the figure was deleted	Paraskevi Dorizas	BPIE	Belgium
19159	11	27	11	27	Misspelling of 'super-structure and sub-structure' to super-estructure and sub-estructure	Noted - there was an error, but the figure was deleted	Paraskevi Dorizas	BPIE	Belgium
56335	11	27	11	28	The term "curtain" in "curtain wall" is spelled wrong. The figure shows "curtian".	Noted - there was an error, but the figure was deleted	Government of United States of America	U.S. Department of State	United States of America
56337	11	27	11	28	Figure 9.2 does not do justice to the numerous types of foundations that may be found on homes or commercial buildings. The figure shows what appear to be pillars in a crawlspace, but could show slabs-on-grade, basements, or even cantilevered floors. The figure could be improved by perhaps showing multiple foundation types under this typical building, say a slab on grade under part of building and a basement under the rest of the building.	Rejected - Given the space available, it is impossible to reach this level of detail. Moreover, the figure was deleted	Government of United States of America	U.S. Department of State	United States of America
3665	11	27	11	30	The content of Figure 9.2 is quite simple. Please see if it is necessary	Acepted - figure 9.2 was deleted	Xinyan Yang	China Academy of Building Research	China
4267	11	27	11	30	Proposed change. Substitute figure 9.2 by figure 2 from this research paper: C Cavalliere et al 2019 IOP Conf. Ser.: Earth Environ. Sci. 323 012099. REASON: If the report is considering buildings from an energy perspective, it would be advisable to include a figure that makes a distinction between the external envelope of the building, the internal partitions and the building services in a clearer way.	Rejected - Given the space available, it is impossible to reach this level of detail. Moreover, the figure was deleted	Pulido Arcas Jesús Alberto	The University of Tokyo	Japan
43649	11	27	11	30	fig. 9.2: for the decomposition of buildings see: https://iopscience.iop.org/article/10.1088/1755-1315/588/2/022008/meta	Noted - but given the space available in the chapter the authors could not go into more detail. Many different classifications are found in literature but there is still no agreement.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
47779	11	27	11	32	The Swiss nomenclature for cost assessment has been extensively used for environmental calculation in Switzerland as well as in Europe and is now also promoted by the International Energy Agency, working group Annex 72. Among references that are explaining this nomenclature and the interest it can have for environmental calculation one can cite, figure 2 in Cavalliere C., Habert G., Dell'Osso G.R., Hollberg A. 2019. Continuous BIM-based assessment of embodied environmental impacts throughout the design process. Journal of Cleaner Production, 211, 941-952. Other reference to explain the design process and how to organise data (C Llatas, B Soust-Verdaguer, A Passer. 2020. Implementing Life Cycle Sustainability Assessment during design stages in Building Information Modelling: From systematic literature review to a methodological approach - Building and Environment, doi.org/10.1016/j.buildenv.2020.107164)	Noted - but given the space available in the chapter the authors could not go into more detail. Many different classifications are found in literature but there is still no agreement.	Guillaume Habert	ETH Zurich	Switzerland
10735	11	29	11	29	curtian (in figure 9.2)? Do you mean "curtain"?	Noted - there was an error, but the figure was deleted	Philippe Waldteufel	CNRS	France
43525	11	35	12	1	If possible, give information of different CO2 emission based on different types of building materials.	Rejected - Data not available	INTAN SUPRABA	Universitas Gadjah Mada	Indonesia
78187	11		11		Fig. 9.2 seems very basic and rudimentary. Modern buildings are also equipped with elevators and myriad of services that the chapter mentions later. Besides, single-family detached houses have become a rarity in fast growing cities.	Acepted - figure 9.2 was deleted becasuse given the space available, it is impossible to reach this level of detail	SUCHANDRA BARDHAN	Jadavpur University	India
4975	12	1	12	1	I would suggest to avoid using terms such as manmade but to opt for more inclusive terms such as humanmade or artificial (in this specific case)	Accepted: text revised	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
21979	12	1	12	2	In addition, traditional buildings can be made of clay (available in nature), or terracotta bricks (manmade material)	Rejected - This is not an exhaustive list. Materials used in buildings are discussed in Section 9.4.	Government of France	Ministère de la Transition écologique et solidaire	France
21981	12	2	12	2	Earth has been a very common material used for construction through the century. F. Pacheco-Torgal, Said Jalali, Earth construction: Lessons from the past for future eco-efficient construction, Construction and Building Materials, Volume 29, 2012, Pages 512-519, ISSN 0950-0618, https://doi.org/10.1016/j.conbuildmat.2011.10.054.	Rejected - This is not an exhaustive list. Materials used in buildings are discussed in Section 9.4.	Government of France	Ministère de la Transition écologique et solidaire	France
43011	12	2	12	2	We propose, to add plants and earth materials as natural building materials. Thank you.	Rejected - This is not an exhaustive list. Materials used in buildings are discussed in Section 9.4.	Doris Toe	Universiti Teknologi Malaysia	Malaysia
9975	12	3		4	This definition of on-site construction method differ to our understanding. On-site construction is one of construction methods in which all the works and construction activities are performed sequentially at the building site. If a construction project uses natural materials which manufactured somewhere else outside of the site, it can be called as off-site construction. The on-site and off-site construction is not differentiated only by the materials but also based on the objective and features of the construction project.	Accepted - Text revised - However, the authors wanted to explain the process from vernacular architecture to the industrial architecture.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
4271	12	6	12	6	Proposed change: Add the following sentence: “These industrialized materials brought new possibilities to the architectural design, but at the cost of considerable amount of energy necessary for its extraction, processing and delivery. In such way, vernacular architecture was substituted, built on-site, by a standardized architecture, built off site: REASON: This sentence may introduce the readers to the concept of carbon footprint from an historical perspective.	Rejected - The author's comment is interesting but due to space limitations in the chapter it is not possible to include it. Moreover, vernacular architecture was not substituted by a standardized architecture. In many regions, vernacular architecture is the unique way of construction. Moreover, I think that the sentence may confuse the readers talking about the historical footprint in that paragrah.	Pulido Arcas Jesús Alberto	The University of Tokyo	Japan
56339	12	6	12	6	Should be "steel-reinforced concrete".	Editorial - change included	Government of United States of America	U.S. Department of State	United States of America
86627	12	7		20	These lines probably over-emphasise the importance of 3D printing (unless the range of materials available chnages and composites become possible, but perhaps underemphasise the importance of offsite construction, which is likely to have an important role to play in developing buildings with much better airtightness, fewer thermal bridges and lower embodied carbon	Noted - we wanted just to mention new advances in technology and not opening a new discussion abou the avantatges between of-site construction and 3d printing, because 3d printing is still too new in the construction sector	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
78189	12	8			pre-engineered' synonym may also be added in the parenthesis.	Accepted - text was revised	SUCHANDRA BARDHAN	Jadavpur University	India
49655	12	9	12	11	Citation needed for the definition given for 'Prefabrication'. concept of PEB (Pre Engineered Building) along with prefabricated buildings can also be included.	Accepted - text was revised	Satyaprakas Das Das	Manipal Academy of Higher Education	India
86045	12	13			Other advances in technologies include parametric Life cycle assessment (LCA) which facilitates early phase feedback on the impact on emissions from operation and embodied emissions from materials. There are also advances in the use of visualisation and immersive technologies to engage diverse stakeholders in the design process. Useful references 1 Gabriele Lobaccaro, Aoife Houlihan Wiberg, Giulia Ceci, Mattia Manni, Nicola Lolli, Umberto Berardi, Parametric design to minimize the embodied GHG emissions in a ZEB, Energy and Buildings, Volume 167, 2018, Pages 106-123, ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2018.02.025. 2) Houlihan Wiberg A. A., Sondre Løvhaug, Mikael Mathisen, Benedikt Tschoerner, Eirik Resch, Marius Erdt, Ekaterina Prasolova-Førland (2021) Advanced Visualization of Neighborhood Carbon Metrics Using Virtual Reality: Improving Stakeholder Engagement. In: Augusto J.C. (eds) Handbook of Smart Cities. Springer, Cham. https://doi.org/10.1007/978-3-030-15145-4_64-1	Rejected - LCA is not a new technology in the building sector as it might be 3D printing, moreover, the authors do not consider a "technology" the LCA approach but a methodology methodology for assessing environmental impacts associated with all the stages of the life cycle of a l product, process, or service. The advances that you mentioned should be in another paragragh which is not the advances in technology	Aoife Houlihan Wiberg	The Belfast School of Architecture and the Built Environment, Ulster University, UK	United Kingdom (of Great Britain and Northern Ireland)
9977	12	13		20	Another advance in technology worth to mention is Building Information Modelling which brings designing and construction of buildings to be more efficient as it can detect errors among building elements for example.	Rejected - BIM was discussed in box 9.5	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
19161	12	13	12	13	Perhpas along with 3D printing, prefabricated solutions could be an alternative technology that allows to build faster, cheaper and more sustainably	Noted - the authors wanted to explain new technologies and we agree with the comments, but the discussion between methods was not the objective of the paragrah	Paraskevi Dorizas	BPIE	Belgium
47497	12	13	12	15	It is not clear how 3D printing may build faster, cheaper and more sustainable. There are many examples of industrialization processes in construction that did not bring more sustainability to the building sector. I suggest explaining the arguments to affirm this point in-depth.	Noted - due to space constraints it was not possible to expand the explanation. But two references were added to emphasise what was stated.	Gonzalo Sánchez	European Environmental Bureau	Belgium
47781	12	13	12	18	It is written “3d Printing allow to build faster, cheaper and more sustainably”. There are no ref. I don’t know ref showing the 3 at the same time. I know ref showing how 3d printing in construction can be cheaper: García de Soto B., Agustí-Juan I., Hunhevicz J., Joss S., Graser K., Habert G., Adey B.T. 2018. Productivity of digital fabrication in construction: cost and time analysis of a robotically built wall. Automation and construction, 92, 297-311 And I know ref showing it can be more sustainable: Agustí-Juan I., Müller F., Hack N., Wangler T., Habert G. 2017. Potential benefits of digital fabrication for complex structures: Environmental assessment of a robotically fabricated concrete wall. Journal of Cleaner Production. 154, 330-340.	Accepted - reference added to chapter	Guillaume Habert	ETH Zurich	Switzerland
37243	12	13	12	20	Though 3D printing is a great technology and indeed progressing fast, speaking of the sustainability	Noted - two references were added to accentuate the stated	Arun kumar Nayak	Bhabha Atomic Research Centre Trombay Mumbai	India
37245	12	13	12	20	with 3D printed homes might be too farfetched. Few reasons for calling 3D printed homes as sustainable should be given	Noted - two references were added to accentuate the stated	Arun kumar Nayak	Bhabha Atomic Research Centre Trombay Mumbai	India
56341	12	13	12	20	Do not call out 3D printing explicitly since it's not scalable. Plus, it often uses concrete which has obvious climate impacts. Instead, discuss new construction approaches (pre-fab or otherwise) using embodied carbon. This issue also shows up later in the document.	Accepted: text revised	Government of United States of America	U.S. Department of State	United States of America
56343	12	13	12	20	3-D printing can enable rapid construction for plug-and-play types of typologies such as housing clusters. 3-D printing does not require standardized molds, so it can be great for rapid but custom construction as well. New materials can be 3-D printed such as phase change materials that provide thermal energy storage embedded into the printed materials. R&D prototyping is underway at U.S. DOE National Labs.	Noted - two references were added to accentuate the stated	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
21983	12	15	12	15	3D printing won't operate with some vegetal materials at least modular ones (wood, straw ball). what is the risk of promoting new materials that would economical but not ecological ? Should this risk be mentionned ?	Accepted: text revised	Government of France	Ministère de la Transition écologique et solidaire	France
47783	12	17	12	18	It allows implementation of new processes and tools. There is no ref. I suggest. De Schutter G., Lesage K., Mechtcherine V., Naidu Nerella V., Habert G., Agusti-Juan I. 2018. Vision of 3D printing with concrete — Technical, economic and environmental potentials. Cement and Concrete Research, 112, 25-39.	Accepted - reference added to chapter	Guillaume Habert	ETH Zurich	Switzerland
43651	12	21	12	25	There seems to be a misunderstanding with "building services". On the one hand, the functions of a building are specified, e.g. shelter; on the other hand, this often refers to systems installed in buildings (technical equipment) in the literature. This can lead to misunderstandings. Essential functions should already be explained in the introduction.	Noted - Although building services have traditionally been categorised as building-installed systems. To the authors' knowledge, as the name implies, building services should contain all the services provided by a building, including shelter, for example.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
19919	12	21	15	11	Whilst I accept the need for clear structuring, this section appears to ignore the fact that building fabric can be / provide a 'service' in itself, in the form of thermal regulation. Higher thermal mass construction, along with some types of 'natural' insulation (sheepswool mixes, cellulose, etc) can work to flatten the daily and seasonal heating and cooling curves, and provide low tech solutions that negate the need for mechanical ventilation and cooling (and such approaches have been in use for millenia). The performance of high thermal mass can also be improved through the use of IR heaters and (as mentioned) ice cooling, both of which are relatively low tech. These can also be supplemented by installing temperature sensors within walls to optimise performance and enable remote control (e.g. by housing associations with elderly / vulnerable tenants or by building managers responsible for public and commercial buildings). One barrier, albeit a minor one, is changing occupant behaviour to switching heating systems off in the heating season (and vice versa for cooling) in countries where they have become used to setting heating systems around daily variations rather than seasonal ones. But the ideal heating and cooling system is one which involves as little human interaction as possible - as well as using as little energy as possible.	Noted - The author's comment is interesting but due to space limitations in the chapter it is not possible to include it.	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
56345	12	22	12	23	Building services also include access to open space, ventilation, and wellness / healthy conditions.	Noted - The authors agree with the comment, in fact all these services fall into the safety category in Figure 9.5.	Government of United States of America	U.S. Department of State	United States of America
78191	12	23			shelter' as building services appears vague as the whole building is a shelter. Common services for multi-family houses also include WTP, STP, elevators (escalaors in commercial buildings) etc. These consume significant energy. Need to be mentioned.	Noted - Although building services have traditionally been categorised as building-installed systems. To the authors' knowledge, as the name implies, building services should contain all the services provided by a building, including shelter, for example. Moreover, elevators was added to the document	SUCHANDRA BARDHAN	Jadavpur University	India
21985	12	28	12	28	« Figure 9.33 » should be replaced by Figure 9.3	Editorial - change included	Government of France	Ministère de la Transition écologique et solidaire	France
3667	12	28	12	32	It is Fig 9.3 instead of Fig 9.33	Editorial - change included	Xinyan Yang	China Academy of Building Research	China
9979	12	29		32	There's some "Error! Reference source not found". Please check the destination formulas.	Editorial - change included	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
3267	12	29	12	29	Note "Error! Reference source not found.."	Editorial - change included	Rachel Bannon-Godfrey	Stantec	United States of America
21987	12	29	12	29	« Error! Reference source not found » should be replaced by Figure 9.4	Editorial - change included	Government of France	Ministère de la Transition écologique et solidaire	France
60569	12	29	12	29	Error - reference not found.	Editorial - change included	Evyatar Erell	Ben-Gurion University of the Negev	Israel
16511	12	29	12	32	Revise the sentenses. "Error! Reference source not found."	Editorial - change included	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17017	12	29	12	32	Revise the sentenses. "Error! Reference source not found."	Editorial - change included	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
17083	12	29	12	32	Error in references!	Editorial - change included	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
19165	12	29	12	32	Error in references to figure	Editorial - change included	Paraskevi Dorizas	BPIE	Belgium
28303	12	29	12	32	there are two reference erros in these lines	Editorial - change included	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
64203	12	29	12	32	Error! Reference (link is not working)	Editorial - change included	Ova Candra Dewi	Universitas Indonesia	Indonesia
2235	12	29	12	33	Shows "Error! Reference source not found." Twice.	Editorial - change included	Stephen Wilkinson	University of Wollongong in Dubai	United Arab Emirates
3597	12	29	12	33	Paragraph is too generic to be useful. See comments on figures referenced in this paragraph.	Accepted - removed from the chapter	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
19915	12	29	12	33	References missing in this para.	Editorial - change included	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
20333	12	29	12	33	Series of "Error! Refernece source not found" in this paragraph	Editorial - change included	Thibaud Voïta	IFRI	Germany
27785	12	29	12	33	References to respective figures to be correctly presented.	Editorial - change included	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
49657	12	29	12	33	Citation given in the content of Building Services classification not matching with Fig 9.4. and Fig 9.5 citation.	Noted - the figures have been modified	Satyaprakas Das Das	Manipal Academy of Higher Education	India
52359	12	29	12	33	Two missing references/errors.	Editorial - change included	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
72049	12	29	12	33	There are 2 missing references in the text.	Editorial - change included	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
84827	12	29	12	33	There are multiple "Error! Reference source not found"s. This should be a simple edit.	Editorial - change included	Thomas Chen	U.S. Technology Policy Committee	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
18447	12	29	13	2	Figure 9.4: could the authors please clarify why the building service activity of water risk management action is not included in the box for CC but under comfort function as could be both and links to adaptation as well.	Noted - figure 9.4 was reworked to further emphasise these aspects. Now each building service is shown in the most relevant category but also has highlighted which other categories it influences.	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
3269	12	32	12	32	Note "Error! Reference source not found.."	Editorial - change included	Rachel Bannon-Godfrey	Stantec	United States of America
19163	12	32	12	32	Error in references!	Editorial - change included	Paraskevi Dorizas	BPIE	Belgium
21989	12	32	12	32	« Error! Reference source not found » should be replaced by Figure 9.5	Editorial - change included	Government of France	Ministère de la Transition écologique et solidaire	France
19917	12	33	12	33	Typo - 'today' should be 'today's'	Rejected - No saxon genitive used in scientific language	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
56347	12	36			For Figure 9.3, how does IEA population projection compare to UN and SSP projections?	Noted: IEA uses UN population projections	Government of United States of America	U.S. Department of State	United States of America
52361	13	0	13	1	The classification of building services by category in Figure 9.4 is odd. Building services on Page 12 Lines 22-24 are introduced as services such as shelter, nutrition, sanitation and thermal comfort. These building services fall under the top 2 categories in Figure 9.4 (Safety and Comfort). But in Figure 9.4 Efficiency and Climate Change are also included and appear to be separate categories. This will confuse readers. For example, how is "Embodied energy" which falls under the "Climate change" category an energy service?	Accepted - This entire section has been modified to improve consistency.	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
19167	13	1	13	1	Figure 9.4: Comfort: What is communication referring to?	Noted - communication refers to the communication networks installed in the building.	Paraskevi Dorizas	BPIE	Belgium
20335	13	1	13	1	On figure 9.4: Climate change should not be considered as a "building service"	Taken into account - combined with comment 52361	Thibaud Voïta	IFRI	Germany
30499	13	1	13	1	We propose, under comfort 'lighting' could be replaced with 'visual comfort' to be in line with thermal comfort and acoustic comfort.	Accepted - Figure 9.5 modified	Kum Weng Yong	KW Yong Architect (Professional architect practice)	Malaysia
56349	13	1	13	2	Figure 9.4 classifies building services into four categories of safety, comfort, efficiency, and climate change. However, water, drainage and plumbing, and air quality are really more ""health"" than ""comfort"". This is a referenced figure taken from a published document so authors may be constrained in adapting it, but not having a ""health"" category is a flaw. Another item that should be on this figure -- ideally under ""health"", but perhaps under ""comfort"" -- is radon. While radon mitigation is not a major building service, it is a very vital service for occupants.	Noted - the authors appreciate the comments. The health classification is interesting, but the authors decided not to use it because it covers building services in the safety category and the comfort category. Moreover, radon is included in the building service "Air quality".	Government of United States of America	U.S. Department of State	
56351	13	1	13	2	Facade engineering is a service the building provides? Communications networks are an efficiency service? Emissions/climate change are a building service? Very strange terminology.	Noted - Figure 9.5 modified	Government of United States of America	U.S. Department of State	United States of America
3599	13	1	13	3	The class "Climate Change", and services included therein, cannot reasonably be called "building services". Also "façade engineering" in "Energy Efficiency" is a strange inclusion.	Taken into account - combined with comment 52361	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
43653	13	1	13	3	The extent of misunderstandings becomes clear in the way Fig. 9.4 and 9.5 are represented. In Fig. 9.4, climate change is a building service; in Fig. 9.5, building energy services are shown as building technology elements. These do not fit together. It is advisable to either omit both figures or revise them.	Accepted - figure 9.6 has been removed, and figure 9.5 has been modified according to comments received.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
11929	13	2	13	2	Climate Change section may include Consumption of Resources for Safety n Comfort.	Noted - the authors believe that the suggestion to include Consumption of Resources for Safety n Comfort within climate change is interesting but due to space limitations it cannot be included in the chapter.	Anjali Sharma	Research, Projects and Collaborative initiatives, Delhi.	India
72051	13	2	13	2	This framework seems not to consider biodiversity in building services, in the climate change part. But buildings can also be biodiversity vectors, as green surfaces are part of the nature based solutions, even in urban areas.	Noted - Figure 9.4 was reworked to further emphasise these aspects. Now each building service is shown in the most relevant category but also has highlighted which other categories it influences. In this particular case we believe that biodiversity is included within the building service "facade engineering", which in the new figure 9.4 is in the Efficiency category but closely related to Climate Change.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
4273	13	3	13	5	Proposed change. Change figure 9.5 for figure 6(a) from this research manuscript: Yuekuan Zhou, Sunliang Cao, Jan L.M. Hensen, Peter D. Lund, Energy integration and interaction between buildings and vehicles: A state-of-the-art review, Renewable and Sustainable Energy Reviews, Volume 114, 2019, 109337, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2019.109337. (https://www.sciencedirect.com/science/article/pii/S1364032119305453). REASON: The current picture seems to be much centered on electricity consumption, and there are other sources of energy, such as gas, that are also part of the building energy services. The proposed diagram may depict this in a clearer way.	Noted - due to space constraints, figure 9.5 has been removed from the chapter.	Pulido Arcas Jesús Alberto	The University of Tokyo	Japan
56353	13	3	13	5	Figure 9.5 shows only building services served by electricity. Consider changing the title.	Taken into account - combined with comment 4273	Government of United States of America	U.S. Department of State	United States of America
56355	13	3	13	5	Figure 9.5 is a diagram of building energy services for what appears to be an all-electric home. While this may indeed be the ideal situation in the future, this is not a typical home by any means as it shows no use of fossil fuels for heating or hot water or cooking. This is a published figure so authors may be constrained in adapting it, but the implication is that the only building services of interest are electric. There should be more mention of natural gas and propane in this figure and in this chapter as a whole. If this figure is kept "as is", it should be labeled "building electrical energy services" to make it clear that it deals only with electrical services.	Taken into account - combined with comment 4273	Government of United States of America	U.S. Department of State	United States of America
3601	13	4	13	5	This is *one* example of how *some* building services may be delivered in a building. None of those systems are *essential* building services.	Taken into account - combined with comment 4273	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
77311	13	4	13	5	Figure 9.5 Schematic diagram of building energy services (Shcheklein et al. 2017)' seems to have not been referred in the body text.Moreover solar thermal collectors are conspicuously absent in the diagram. Either thermal collectors could be included or title can be modified to say electrical energy services	Taken into account - combined with comment 4273	Gajanana Hegde	UNFCCC (Climate Change Secretariat)	Germany
2287	13	5	13	5	The classification of buildings services (fig 9.4) does not explicitly include "building energy services" as a category and hence is not consistent with (fig 9.5)	Taken into account - combined with comment 4273	Siddarth Durga	PNNL	United States of America
2801	13	6	13	11	Smart buildings can play a leading role in transforming the energy landscape into a more decentralized, renewable-based, interconnected system that maximizes efficiency and ensures the optimal use of resources. A smart-ready built environment can enable energy-system-responsive buildings, which at the same time provide a better indoor environmental quality and comfort for the occupants.	Noted - figure 9.5 was reworked to further emphasise these aspects. Now each building service is shown in the most relevant category but also has highlighted which other categories it influences.	Leonardo Barreto	Head of center "EU&International"	Austria
2803	13	6	13	11	Artificial intelligence in Building Management Systems (BMS) can improve building operations. AI can contribute to make buildings more energy efficient, help them participate in energy markets, improve comfort control, and enable predictive maintenance (see e.g. IEA, 2019: Case Study: Artificial Intelligence for Building Energy Management Systems. https://www.iea.org/articles/case-study-artificial-intelligence-for-building-energy-management-systems)	Noted - Artificial intelligence, in the context mentioned in the commentary, is part of the building service "Building management systems". It is therefore already part of the chapter "Building management systems".	Leonardo Barreto	Head of center "EU&International"	Austria

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56357	13	6	13	11	Would suggest this section include something about electrification technologies and their high efficiency potential and opportunity to limit onsite combustion which is a heavy source of carbon emissions. NBI recently released a Building Electrification Technology Roadmap that describes scores of electrified products and their potential to reduce building energy demand. A number of these products also offer the opportunity to enhance building-grid integration. See the report at: https://newbuildings.org/resource/building-electrification-technology-roadmap/	Rejected - due to space limitations it cannot be included in the chapter.	Government of United States of America	U.S. Department of State	United States of America
21991	13	12	13	13	The statement " natural ventilation reduce energy consumption in buildings" should be completed to avoid misunderstanding. As regards to the nead of appropriate air renewal (sanitary regulations), in case of natural ventilation, extra sizing in order to take into account the variability of performance due to external conditions can induce extra consumption of energie for heating in cold or temperate regions. High exigences in french thermical regulation actually don't lead to use natural ventilation. On the other hand, thermal confort ventilation for tropical regions is effective, when appropriate, to provide air quality and air speed to improve comfort, thus reduce significantly climatisation need, and energy demand.	Noted - the paragraph on natural ventilation was improved to avoid misunderstandings.	Government of France	Ministère de la Transition écologique et solidaire	France
3271	13	12	13	14	As noted above, the increased frequency and severity of wildifres has rendered natural ventilation via operable windows unreliable as a means of delivering fresh air. The conflict between use of operable windows as a low-energy, healthy design solution, and the need to aggresively filter outdoor air during wildfires, is one that needs to be addressed more as the likelihood of fires increases.	Rejected - due to space limitations it cannot be included in the chapter.	Rachel Bannon-Godfrey	Stantec	United States of America
56359	13	12	13	14	This paragraph could be expanded to explain the connection between ventilation and public health (independently of energy considerations), particularly because of the historical trend towards greater building air tightness. The last sentence makes a critical point, and could be expanded to note that, in the reference cited, not only the public health benefits, but even just the productivity gains exceeded the energy costs involved.	Rejected - due to space limitations it cannot be included in the chapter.	Government of United States of America	U.S. Department of State	United States of America
60571	13	12	13	14	This short paragraph seems out of context. Adequate ventilation is of course important - as is control of infiltration.	Taken into account - combined with comment 56373	Evyatar Erell	Ben-Gurion University of the Negev	Israel
52363	13	13	13	14	The benefits of enhanced ventilation on public health should be measured and incorporated into any cost-benefit analysis of ventilation measures. There should be some estimates in the literature that could be quoted here.	Rejected - Although it is an interesting topic, no literature was found on the specified topic.	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
56361	13	15	13	15	AC use will grow not just with rising temperatures, but also with rising income and population.	Accepted	Government of United States of America	U.S. Department of State	United States of America
81999	13	15	13	15	Not only a rise in temperature, but also increased access to AC, especially in developing regions, will lead to higher energy consumption for cooling (https://www.iea.org/reports/the-future-of-cooling)	Accepted	Berrill Peter	Yale University	United States of America
52365	13	15	13	16	Not just the rise in temperatures. The demand for cooling is increasing mostly because of population growth, increases in building area, and most importantly, rising incomes across the world. There should be numerous papers and reports that the authors can look at that discuss this such as the IEA report on The Future of Cooling.	Accepted	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
56363	13	15	13	22	There should be more explicit discussion of heat pumps in this section. Though used primarily for heating in Europe, they are still an important technology for getting fossil fuels out of buildings with high heating loads. Plus, there are across the board efficiency gains.	Noted: Technlogies discussed in 9.4	Government of United States of America	U.S. Department of State	United States of America
72053	13	15	13	22	The use of night ventilation and passive cooling, also linked with natural ventilaion, is not mentioned as a way to decrease temperature, besides standard air conditioning services.	Noted: Passive solutions are discussed in 9.5	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
86629	13	15			"The use of air conditioning systems in buildings will increase with the experienced rise in temperature" the use of air con MAY increase - there is nothing inevitable about it	Noted	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
86633	13	15	15	3	This section on cooling (including all of box 9.3) feels out of place. It should be moved to a place where heating and other building energy services are discussed(eg after 9.3.3.2 Energy demand based on end-use). Also, the chapter discusses here the increased need for air conditioning with higher temperatures. Is there any balancing reduced need for heating with climate change?	Accepted: moved to the section on trends and drivers	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
52367	13	17	13	17	The adoption of energy efficient air conditioning is not "pertinent" when balancing thermal comfort and energy consumption.	Noted: text resvied	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
56365	13	18	13	19	What is "ice refrigeration"? Do authors mean "ice storage" (i.e., making ice at night when the weather is cooler and using it to cool during the day)? Also, integration of PV and HVAC is not a new advance in cooling.	Noted: see section on technologies	Government of United States of America	U.S. Department of State	United States of America
2289	13	18	13	22	Heat pumps should also be mentioned here, since they are one of the leading renewable heating and cooling technologies	Noted: see section on technologies	Siddarth Durga	PNNL	United States of America
56367	13	18	13	22	Consider including VRF (Variable Refrigerant Flow) systems which operate efficiently especially during part-load conditions and provide flexible zonal control to meet diverse personal cooling and heating needs (Hong et al., 2016). VRF systems have been widely adopted in small and medium-sized commercial buildings. See: T. Hong, K. Sun, R. Zhang, R. Hinokuma, S. Kasahara, Y. Yura. Development and Validation of a New Variable Refrigerant Flow System Model in EnergyPlus. Energy and Buildings, 2016.	Noted: see section on technologies	Government of United States of America	U.S. Department of State	United States of America
52327	13	19	13	20	It has been argued that PV for air conditioning is not the most efficient choice, from a macro perspective, given the low efficiency of PV technologies and high energy demand in AC.	Noted: see section on technologies	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
56369	13	20	13	22	Common thermal energy storage technologies do not necessarily minimize energy consumption. They minimize energy cost by allowing users to use off-peak energy to "charge their systems". By doing so they may also reduce greenhouse gas emissions. However, they may actually use slightly more energy as no system is 100% efficient.	Accepted: see section on technologies	Government of United States of America	U.S. Department of State	United States of America
329	13				In Fig. 9.4 under "comfort" I would specify "indoor air quality". Under "Climate": CO2 is a GHG, so it should not be mentioned twice. Also it is not clear what the term "pollution" means in this context. It is suggested to delete it.	Accepted - figure 9.4 was modified according to comments	Sandro Fuzzi	ISAC CNR	Italy
25031	13				Can include an electric car in figure 9.5. EVs are an integral part of future system integration/smart cities concepts which this section is addressing.	Rejected - The authors agree that electric cars are an integral part of future system integration/smart cities concepts. But these are not building services	Bassam AbuHijleh	The British University in Dubai	United Arab Emirates
78193	13				Fig. 9.4 has few items that overlap across groups, and some are also repetitve. The grouping and the group titles are a little ambiguous.	Taken into account - combined with comment 2801	SUCHANDRA BARDHAN	Jadavpur University	India
76533	14	2	15	2	There is something not coherent with the information provided here. The housing units permitted in the US in 2020 were 1.8 million, the completion was around 1.3 million, see https://www.census.gov/construction/nrc/pdf/newresconst.pdf. It is not clear what Fig 9.3 shows, you claim it is stocks, but that is clearly not true.	Accepted: Figure 9.3 removed because of space constraints	Edgar Hertwich	Norwegian University of Science and Technology	Norway
3273	14	4	14	13	Increasingly, architecture and engineering consultants carry out whole-bulding energy modeling during the design phase of a building project. This modeling provides information on the relationship, and relative influence, of all building services and systems in the total annual energy consumption of a building. So, there are situations where services are considered in more detail than "a very simplified way".	Accepted - the paragraph has been modified, adding that new technologies such as BIM have enabled the use of more complete models of buildings even at the design stage.	Rachel Bannon-Godfrey	Stantec	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56371	14	4	14	6	This sentence doesn't appear complete: "Lambertz et al. (2019) stated that when evaluating the environmental impact of buildings, building services are only considered in a very simplified way; this document considers building energy services and sanitary." Should it say "sanitary services"?	Rejected - Due to space limitations this paragraph was deleted from the chapter.	Government of United States of America	U.S. Department of State	United States of America
86631	14	4		13	the point being made in this paragraph is not clear. Are you describing the literature? Introducing us to buildings services? Telling us whats missing or what new? Im from a cold climate - nothing about heating? Infact heat loss is really important and there not a single reference to 'Passiv Haus' standards, and the very important idea of heating a building from solar gains, metabolic gains and lights and appliances gains.	Accepted - the building services section has been completely rewritten.	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
78195	14	6	14	11	hot water requirement?	Taken into account - combined with comment 56373	SUCHANDRA BARDHAN	Jadavpur University	India
10737	14	7	14	8	"ventilation related to computer simulation"? Please explain	Taken into account - combined with comment 56373	Philippe Waldteufel	CNRS	France
56373	14	7	14	8	What does "ventilation related to computer simulation" mean? The entire section on building services could use an edit. It is poorly written.	Accepted - the building services section has been completely rewritten.	Government of United States of America	U.S. Department of State	United States of America
61121	14	12	14	13	This sentence seems to miss a clear link to the rest of the previous text. Also, a clear definition of the term embodied energy (or emissions, or carbon...) would be welcome prior to its use. That would allow a clear identification by the non-expert reader as to how embodied energy is related to climate change aspects.	Accepted - text was revised	Marcella Saade	Graz University of Technology	Austria
44083	14	14	15	10	Given trends of global warming and the development of urban heat islands, Box 9.3 “Cooling demand in the building sector” I would suggest that you reference “Map of building energy codes by country, state, and province in 2017” [1], and seek rights to reproduce https://www.iea.org/terms/rights to illustrate the lack of regulation in the global south. I am currently preparing a manuscript that shows that most countries that enforce building energy codes coincidentally are located at high latitudes or high elevations such that their local climate does not objectively need air-conditioning if passive, fans, or direct evaporative cooling systems were integrated from the early of development. Within urban heat islands of megacities and in the unregulated countries of the global south AR6WG3 readers should be advised that passive design may not succeed without energy efficient active cooling powered by renewable energy, and that building codes from developed countries will not be locally appropriate. 1.IEA, 2019 Global status report for buildings and construction. Global Alliance for Buildings and Construction, International Energy Agency, and United Nations Environment Programme, 2019.	Noted: see section 9.9 on building energy codes	Eric Peterson	University of Leeds	United Kingdom (of Great Britain and Northern Ireland)
56375	14	14	15	10	Box 9.3 should also include discussion of district cooling, which is growing rapidly and allows for integration of novel new zero energy technologies.	Noted: reference is made to district networks in 9.4	Government of United States of America	U.S. Department of State	United States of America
20337	14	15	14	30	In Box 9.3 - cooling access should also be mentioned here. With temperatures increasing in different regions of the world, a challenge for climate change is to ensure that populations have access to low carbon cold chains for their houses, food, etc.	Noted: but no consolidated data available at teh time of drafting	Thibaud Voïta	IFRI	Germany
18449	14	15	15	10	Box 9.3 Figures and others like it are clear and helpful. Given scale differences justification of statement on pg. 15 line 2-3 and an explanation of what primary measures will be used under the sustainable development scenario would be helpful. The reason for fall in cooling demand in two regions is not explained nor why not expected to continue. A reorganisation of points made in the Box will strengthen structure of case.	Noted: References relted to the final selection of scenarios used included in box 9.2 and in Annex III, section 4	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
11931	14	19	14	19	Additionally the shape, areas, number/hierarchy of openings based on the floor-to-floor height of the building and proportion of solid to void fenestrations may be included.	Accepted: these interventions are described in 9.5	Anjali Sharma	Research, Projects and Collaborative initiatives, Delhi.	India
52329	14	20	14	20	openings, the wall area, the thermal properties, shading, and orientation, in fact, are cost factors. These can, with different levels, increase or decrease the cost of implementation, and material. For example, given the limited land space, changing the orientation of a building might not be a choice in many cases.	Accepted: interventions decsribed in the comment are discussed in 9.5	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
72055	14	23	13	27	Besides contributing to warmer temperatures through halocarbon, air conditioning also contributes at a local scale to warmer temperatures (urban heat islands) with the rejection of warm air. It could be mentioned.	Noted: Urban issues are discussed in Urban chapter	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
2291	14	27	14	28	The installation of both low GWP and ODP should be discussed, since some low GWP refrigerants tend to have high ODP. Also there isn't sufficient discussion around natural refrigerants and their implications on heatpumps and air conditioner usage and halocarbon emissions	Rejected: This is out of teh scope of teh building chapter	Siddarth Durga	PNNL	United States of America
21993	14	27	14	28	The reference to the Kigali amendment seems incorrect. The Kigali amendment is about phasing down the consumption (and production) of HFC - it doesn't require to "install" highly efficient technologies with low GWP. Some alternative technologies don't use refrigerants (or use natural refrigerants, with very low or zero GWP).	Accepted: Text revised	Government of France	Ministère de la Transition écologique et solidaire	France
18451	14	27	14	30	The relative contributions of efficient ACs, low GWP and solar make to reducing cooling demand is not provided, only that these are the 3 primary measures. If there are data on this it would be useful to include them.	Noted: No data available at the time of teh drafting	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
52369	14	28	14	28	Define acronym GWP where it first appears.	Accepted: spelled out	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
78197	14	29			Isnt it better to say renewable solutions instead of being solar specific? That will sound mor einclusive as wind and wind-solar hybrids might also be potential solutions.	Rejected: Solar solutions are those intgerated to buildings	SUCHANDRA BARDHAN	Jadavpur University	India
2293	14	29	14	30	Do the solar solutions mentioned here refer to renewable electricity usage for air conditioners or something else? Can be more specific	Accepted: Text revised	Siddarth Durga	PNNL	United States of America
52331	14	29	14	30	It is critical to evaluate the GHG emissions throughout the entire supply chain so we can end up with a recommendation to (or not to) adopt such technologies. In other words, adopting these tech. might not reduce the overall GHG emissions, due to their energy-intensity production and their low efficiency	Noted: The assessment provides GHG emissions for teh three scope of emissions. However, data on scope 3 emissions include only those relate dto teh production of cement and steel	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
60573	14	31	14	31	Cooling demand is very difficult to isolate from energy demand in general. The reference to 'IEA and WEO data' is (in my opinion) insufficient to support this estimate without further substantiation. Note: This is also the case for other estimates presented in this chapter.	Noted: New scenarios have been added	Evyatar Erell	Ben-Gurion University of the Negev	Israel

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
3669	14	39	14	40	Box 9.3 describes the impact of climate change on building cooling demand, which is also mentioned in Sector 9.7.1. Please make sure if the content is duplicate. The increase of the building cooling demand is related to the improvement of the economic level, the reduction of the price of cooling products, and also the climate change. It is suggested to change the sentence "The increased cooling demand can be partly explained by the increased ownership of room air conditioners per dwellings in all regions driven by the increased ambient temperatures driven by global warming."change to"Although economic development is the main driving factor of building energy demand(Zhang et al., 2020), the increase of building cooling demand can also be partly explained by the increased ownership of room air conditioners per dwellings in all regions driven by the increased ambient temperatures driven by global warming. Zhang, S., Xu, W., Wang, K., Feng, W., Athienitis, A., Hua, G., Okumiya, M., Yoon, G., Cho, D.W., Iyer-Raniga, U., Mazria, E., Lyu, Y., 2020. Scenarios of energy reduction potential of zero energy building promotion in the Asia-Pacific region to year 2050. Energy (Oxf) 213, 118792.	Noted: Duplicate removed and box 9.3 merged with teh section trends	Xinyan Yang	China Academy of Building Research	China
2295	14	39	14	41	Can the authors provide a citation for this statement?	Noted: text revised	Siddarth Durga	PNNL	United States of America
11933	14	39	14	41	The increased cooling demand can also be explained due to microclimate created due to urban design issues: densities, building form, building envelope etc; as the heat dissipated often trapped in the built morphology	Accepted	Anjali Sharma	Research, Projects and Collaborative initiatives, Delhi.	India
52333	14	39	14	41	This is a very strong statement. Link the ownership of room air conditioning to a strong, tangible, and measurable factors. Some of these factors are the increase in living standards, economic growths, change in welfare.	Accepted	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
52371	14	39	14	41	The rise in incomes has been a much bigger driver of the increased ownership of air-conditioners than the rise in ambient temperature.	Accepted	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
25033	14				In Box 9.3; cooling load is not the only thermal load that will increase. Heating demand in certain regions will also increase due to the greater spread in the seasonal temperature fluctuations due to changes in the climatic conditions. In many locations winters are becoming colder than usual while at the same time summers are becoming hotter than usual. Focusing only on the average annual temperature misses this point.	Accepted:	Bassam AbuHijleh	The British University in Dubai	United Arab Emirates
3603	15	4	15	5	Not clear how this cooling demand is calculated. Presumably the scenarios here are the same as those in Box 9.2? Even if that is clarified, a sentence or two on how changes in cooling demand were estimated would be appropriate here.	Accepted: Box 9,3 merged with the section on trends and scenarios	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
36983	15	12	23	15	Operational GHG emissions and embodied GHG emissions must be well differentiated. I suggest addressing operational and incorporated GHG emissions in different chapters	Noted: The assessment includes embodied emissions when data available	Antonio Garcia-Martinez	Universidad de Sevilla	Spain
17207	15	13	15	13	Another addition to this useful section would be a brief comparison of emissions estimates for the buildings sector, drawing from the main sources described here (EDGAR, IEA), but also any alternative databases and relevant publications, perhaps also for regions or large countries? One could also compare earlier years against AR5. This would be an important quality check on the results shown here and elsewhere. For info, Ch7 (AFOLU) does this for Agricultural and LULUCF emissions (see section 7.2.1).	Noted	William Lamb	Mercator Research Institute on Global Commons and Climate Change (MCC)	Germany
77313	15	15	15	15	the term carbonised electricity may be replaced with carbon intensive electricity	Accepted: text revised	Gajanana Hegde	UNFCCC (Climate Change Secretariat)	Germany
9955	15				BOX 9.3 The South Asia and South East Asia figure is located in the right bottom corner. The figure is in a very low pixel quality. Some of the letter are in bold mode, while the others aren't. It should be changed with a higher resolution figure too.	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
76537	16	3			Are there no smart buildings with slanted roofs?	Accepted: text revised	Edgar Hertwich	Norwegian University of Science and Technology	Norway
16513	16	4	16	6	CH4 and N2O have very high impact of GHG. I Think we must consider CH4 and N2O emission in building sector. GHG emissions should mean CO2e in building sector.	Noted: However, scenarios selected do not provide projections for CH4 and N2O	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17019	16	4	16	6	CH4 and N2O have very high impact of GHG. I Think we must consider CH4 and N2O emission in building sector. GHG emissions should mean CO2e in building sector.	Accepted: Text corrected	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
2297	16	6	16	6	Can the authors clarify whether the halocarbon and aerosol emissions are excluded from the emission plots? if so, can they provide a justification or a reasoning for the exclusion? (since they attribute to ~20% of the total building GHG emissions). In addition, the authors may choose to include it in their research gaps.	Accepted: Text clarified. Past data include halocarbons, aerosols have been excluded from teh analysis see Chapter 2. Scenarios include only CO2 emissions	Siddarth Durga	PNNL	United States of America
56377	16	7			"All buildings non-CO2 emissions" is included in legend but not shown in Figure 9.6.	Accepted - All figures and tables have been re-elaborated according to IPCC guidelines. Illustrat	Government of United States of America	U.S. Department of State	United States of America
47785	16	7	16	10	Ref is still not published. It's hard to check the validity of the source if it came from main lead authors but that it is actually not published in peer reviewed journal.	Accepted: reference removed bceause it did not meet the IPCC cut-off date	Guillaume Habert	ETH Zurich	Switzerland
48393	16	10	26	7	While the quantitative analyses are mainly derived from the IEA report, such as Fig9.6-9.9, scenario data from AR6 scenario database should be used here, like the transport chapter.	Accepted: Additional scenarios have been added	Ken Oshiro	Kyoto University	Japan
10739	16	12	16	12	It is difficult to understand figure 9.6, because colours used in the chart do not correspond to the colour code	Accepted: Colours changed	Philippe Waldteufel	CNRS	France
17205	16	12	16	12	This figure combines both historical data and future pathways. Would it not be better to separate these, as they have distinct drivers and trends, and also to ensure consistency across the sector chapters (all of which have historical figures)? Also, if this figure is based on the data provided by Ch2, the EDGAR database is missing as a source in the caption.	Rejected: not enough space	William Lamb	Mercator Research Institute on Global Commons and Climate Change (MCC)	Germany
60575	16	12	18	10	Subsection 9.3.1 provides numerous estimates of GHG emissions and projections based primarily on the WEO for 2020. Altough the detailed scenarios are described in that document, they should be summarized in brief here. Furthermore, the limitations of the data and the models must be acknowledged. There is inherent uncertainty in the findings, which is not referred to anywhere in this section.	Accepted: Additional scenarios and references included in the assessment	Evyatar Erell	Ben-Gurion University of the Negev	Israel
64205	16	17	16	17	As here its wirtten Figure 9.10 when in fact theres figure a and b. better recall this figure on the given exapmle as 9.10 (a) or 9.10 (b) in the text paraphraph	Accepted: Text updated	Ova Candra Dewi	Universitas Indonesia	Indonesia
56379	16	18	16	18	Figure cited (13.35Gt) does not match what is shown in Figure 9.6a. The expected value should be somewhere in the 15-16Gt range.	Accepted: Figures corrected	Government of United States of America	U.S. Department of State	United States of America
76535	17	2			This figure does not show energy services. It shows equipment.	Rejected: Unclear which figure it is refered to	Edgar Hertwich	Norwegian University of Science and Technology	Norway
21995	17	9	17	10	It seams that this paragraph deals with direct emissions only (cf Figure 9.6)	Rejected: Figure 9.6 includes both direct and indirect emissions	Government of France	Ministère de la Transition écologique et solidaire	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
82001	17	9	17	10	It appears that this paragraph deals only with direct emissions. If this is the case, the reference to indirect emissions could possibly be moved.	Rejected: Figure 9.6 includes both direct and indirect emissions	Berrill Peter	Yale University	United States of America
2299	17	9	17	11	Can the authors explain this trend	Noted: The US experienced a continous increase of the construction of new buildings and an increase of the floor area per capita	Siddarth Durga	PNNL	United States of America
82547	17	9	23	17	The sentence on lines 9-13 states that developed countries in Asia-Pacific experienced a decrease in indirect and direct emissions between 2010-18. These seems contrary to the Asia-Pacific indirect emissions increase points in lines 19-23. Suggest revising or clarifying.	Accepted: text revised	Constabile Kerry	Oxford University School of Geography	United States of America
56381	17	10	17	10	Any explanation for the increase in residential direct emissions in America?	Noted: The US experienced a continous increase of the construction of new buildings and an increase of the floor area per capita	Government of United States of America	U.S. Department of State	United States of America
56383	17	12	17	14	Is this due to electrification? If so, should be explained as such since it would be a transfer of emissions from one category to another, not a downright decline.	Noted, Later versions clarified this.	Government of United States of America	U.S. Department of State	United States of America
82003	17	17	17	19	Evidence that the decrease in (residential) building emissions was driven mainly by lower carbon electricity is illustrated in Berrill et al (https://doi.org/10.1088/1748-9326/abe325)	Noted	Berrill Peter	Yale University	United States of America
5451	17	18	17	19	The statement is true only for Great Britain, not for E.U. Germany and other E.U. Countries decrease in emissons is just symbolic. Please replace "Europe" by Great Britain.	Noted: The assessment is limited to regions	Michel SIMON	Retraité/ Pdt d'association	France
21997	17	27	17	27	The decrease in indirect non-residential emissions in Latin America (cf Figure 9.6) is not mentioned (if Latin America is effectively part of developping world), as well as the surprising gap between the values for 2018 and CSP 2020.	Accepted: Figures updated and text revised accordingly	Government of France	Ministère de la Transition écologique et solidaire	France
82005	17	30	17	36	Can you clarify the time frame the percentage increases in direct emissions refer to?	Accepted; text revised	Berrill Peter	Yale University	United States of America
21999	17	37	17	38	It is writtent « By 2050, the potential for GHG emission reduction in the developed world ranges from 17% in the SPS in North America to 93% in SDS in the same region ». To a better understanding, the year of reference should added.	Accepted: Text revised	Government of France	Ministère de la Transition écologique et solidaire	France
22001	18	4	18	4	omission : emissions reduction	Accepted	Government of France	Ministère de la Transition écologique et solidaire	France
72057	18	4	18	5	Do we mean potential for emissions reductions? The word "reductions" is missing then.	Accepted	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
52373	18	12	18	38	The Kaya Identity is easy to understand because of its simplicity. But one of the drawbacks is that it inherently assumes that doubling any of the factors (such as the population) will double GHG emissions. While some econometric studies may estimate this population elasticity to be equal to one, this may not necessarily be the case.	Noted	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
52375	18	12	18	38	The identity that the authors used for the decomposition fits the SER framework somewhat well, but it leaves out income as an important driver. For example, rising standards of living could lead households to purchase air conditioners, when they did not previously have access to space cooling. If we hold floor area fixed, then that implies an increase in energy use per floor area, which would be interpreted as inefficiency in the decomposition. Even if the household purchases the most efficient possible air conditioner, their energy use per floor area would increase because of a higher standard of living and access to a new energy service.	Noted: The identity used in Chapter 9 complements the one used in chapter 2. The latter looks to GDP increase while the former is building specific	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
28305	18	17	18	17	I think a lot more clarity (or at least a crystal-clear definition) is needed around the seemingly concept of floor area per capita. Some intend it as conditioned floor space, in line with the focus on the operational energy of the past decades. We know that this is not sufficient any longer to address embodied emissions and material stocks and flows but this is not immediately clear from a definition. Built-up area is the other extreme that also includes transport infrastructure and we don't want to cover that in the Buildings chapter but making sure that the "floor are" numbers in this chapter are univocally defined is crucial or wrong/misused numbers will be around for another five to ten years.	Accepted. A definition of floor area per capita has been included. Floor area as defined in the scenarios and histroical data presented here is total living floor aream including conditioned and unconditioned.	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
82007	18	18	18	22	An exception to the statement in this sentence is the same Berrill et al (2021) study, which which considers growth in conditioned floor area and reductions in household size (which together define increases in floor area per capita) as drivers of both residential energy and GHG emissions. https://doi.org/10.1088/1748-9326/abe325	Noted	Berrill Peter	Yale University	United States of America
2303	18	26	18	26	Please consider including the units in the kaya identity equation (even though it is discussed later in the text). Also It is unclear what the units of value added are. In addition, can the authors briefly describe what climate corrected final energy means?	Accepted: units included	Siddarth Durga	PNNL	United States of America
84829	18	26	18	31	I would recommend centering the "while…. follows" line for clarity.	Accepted	Thomas Chen	U.S. Technology Policy Committee	United States of America
52377	18	33	18	38	The authors state that floor area per capita reflects sufficiency. But there may be other things unrelated to sufficiency (such as changes in fertility rates and family sizes) that are driving changes in this factor. The authors need to at least discuss the other factors that affect this ratio that are unrelated to sufficiency.	Accepted: text clarified	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
52379	18	33	18	38	The authors state that climate corrected energy consumption per floor area reflects efficiency. But higher energy prices for consumers, for example, not only encourage greater investment in energy efficiency but also less wasteful behaviours. So behavioural changes and rising standards of living (as discussed in a previous comment) can influence this factor, not only energy efficiency. The authors should again discuss the other variables that affect this ratio. Also, are the authors accounting for this in their projections?	Noted: Behaviour is discussed in 9.5	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
5453	18	36	18	37	You state : "Carbon intensity reflects the renewables pillar of the SER framework" Carbon intensity can most surely be driven by mass production plants (Hydro or nuclear), whixh are not usually (you will surely agree!) in the center of the cities. This is a kind of bias which deconsider the Nagawatt report.	Noted: solar renewable solutions are integrated to buildings. This is not the case for nuclear en	Michel SIMON	Retraité/ Pdt d'association	France
22003	18	36	18	37	Carbon intensity reflects the renewables : What about Nuclear power ? Is It's évolution unsignificant at global level ?	Rejected: Solar reneawble solutions are integrated to buildings. See chapter 6 on the contribution of Nuclear to teh energy system	Government of France	Ministère de la Transition écologique et solidaire	France
6121	18	39			A recent study on residential electricity use (Liddle and Huntington 2021) considered how residential electricity demand responds to income, price, and weather by applying panel data that expanded the typical analysis by including maturing middle-income countries outside the OECD and comparing their results with those for the more developed high-income/OECD countries. Relative to the high-income/OECD countries, Liddle and Huntington found that the middle-income countries had a greater income elasticity that was not significantly different from unity (0.8 compared to 0.6), smaller price elasticity (-0.08 compared to 0.2), smaller heating elasticity (0.1 compared to 0.4), and larger cooling elasticity (0.3 compared to 0.01). Thus, Liddle and Huntington conclude that the combinations of (i) higher income and cooling long-run elasticities for middle-income countries; (ii) less temperate climates and more carbon-intensive electricity generation systems than the high-income economies within the OECD; and (iii) the facts that the middle-income economies outside the OECD are not only growing faster than the rest of the world, they are also becoming electrified very rapidly, will have important implications for both future electricity demand and climate change. Liddle, B. & Huntington, H. 2021. How Prices, Income, and Weather Shape Household Electricity Demand in High-Income and Middle-Income Countries Energy Economics, Vol. 95, 104995.	Noted	brantley liddle	independent consultant	United States of America
82009	18	39	18	43	This sentence tries to say too much and becomes difficult to comprehend. I think it would be easier to understand if it was split up and rephrased.	Accepted: Text revised	Berrill Peter	Yale University	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
52383	18	39	21	43	No mention of the role that a rising standard of living and income played in this section.	Noted: rising income as a driver is assessed in Chapter 2.	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
60577	18	46	19	1	The statement that dwelling size rather than occupant behaviour is the key driver of GHG emissions inresidential buildings is at best subject to much academic debate. It is certainly not a definite conclusion, as might be inferred from the text in the draft.	Accepted: Text revised	Evyatar Erell	Ben-Gurion University of the Negev	Israel
22005	18	46	19	4	The occupant behaviour seems to be underestimated to explain the energy consumption. Even if building characteristics are the main driver, other papers show the impact of occupant behaviour on energy consumption. For example, Salomé Bakaloglou and Dorothée Charlier, 2019 "Energy Consumption in the French Residential Sector: How Much do Individual Preferences Matter"? , Energy Journal, Vol.40 (3) Other than the size of dwellings and the household size, the income explain the ownership of appliances and the energy efficiency of these appliances. See Cayla, Jean-Michel, Maizi, Nadia, and Marchand, Christophe (2011), The role of income in energy consumption behaviour: Evidence from French households data, Energy Policy, 39 (12), 7874-83.	Noted: Behvaiour is discussed in 9.5	Government of France	Ministère de la Transition écologique et solidaire	France
60579	19	1	19	1	The citation should be Santin et al., not Guerra Santin et al.	Accepted	Evyatar Erell	Ben-Gurion University of the Negev	Israel
82011	19	2	19	2	Replace "combined to" with "combined with"	Accpted	Berrill Peter	Yale University	United States of America
78199	19	2	19	4	This relationship may not be so simple, as demand of air conditioned space will be less . Ambient temperature will also be less, further reducing the demand.	Noted	SUCHANDRA BARDHAN	Jadavpur University	India
82013	19	5	19	7	A report for UNEP/IRP demonstrates the relevance of residential floor area per capital for future global residential energy and emissions, by illustrating scenarios with different assumed trajectories of m2/cap https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change; 10.5281/zenodo.3542680	Noted: Reference added	Berrill Peter	Yale University	United States of America
56385	19	8	19	9	Energy/floor area makes it difficult to disentangle the two effects of smaller household sizes on energy use: larger floor area to heat/cool per capita, and larger number of appliances (specifically refrigerators which are always on) per capita. Maybe just add a callout that this effect will be dealt with in Section 9.4.3.2.	Noted; see section 9.4	Government of United States of America	U.S. Department of State	United States of America
86635	19	8			"Energy intensity expressed as climate corrected final energy per floor area" - how is climate being corrected - and is both heating and cooling being considered?? Needs unpacking	Accepted: Text revised and clarified	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
16515	19	10			Please check if it is 2010, not 2018.	Accepted	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17021	19	10			Please check if it is 2010, not 2018.	Accepted	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
52381	19	10	19	11	Still inefficient relative to what?	Accepted: text clarified	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
60581	19	10	19	11	The quoted improvements in efficiency are at best very coarse estimates, and should be acknowledged as such. There is enormous uncertainty in the underlying data, not to mention the difficulty of disentangling the effects of infrastructure from those of behaviour.	Accepted	Evyatar Erell	Ben-Gurion University of the Negev	Israel
63071	19	39	19	40	Replace “The increased cooling demand can be partly explained by the increased ownership of room airconditioners per dwellings in all regions driven by the increased ambient temperatures driven by globalwarming.”with“Although economic development is the main driving factor of building energy demand(Zhang et al., 2020), the increase of building cooling demand can also be partly explained by the increased ownership of room airconditioners per dwellings in all regions driven by the increased ambient temperatures driven by globalwarming.”	Accepted: Text revised	Changke WANG	National Climate Center, China Meteorological Administration	China
2305	20	1	20	1	Can the authors label the y-axis of the figures	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Siddarth Durga	PNNL	United States of America
3605	20	1	20	13	The y-axis needs a label, even if to say it is a dimensionless multiple.	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
3609	20	1	20	13	The figure is hard to interpret numerically. I think I understand the concept, and it's very cool, but the numbers are hard to interpret. E.g., in subfig (a) is it that Efficiency has made no change to energy use in 2018 compared to 1990, but "value added" has increased it by about 140% ?	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
3611	20	1	20	13	What is the baseline year for each graph? Are they the same?	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
47499	20	1	20	13	On this page there are significant figures about sufficiency statistics that provide a clear vision for the future. However, these figures are not self-explanatory. The format and the layout should be clarified so as to ensure a good understanding.	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Gonzalo Sánchez	European Environmental Bureau	Belgium
47787	20	1	20	5	Idem. Source is actually not published	Noted: Reference removed	Guillaume Habert	ETH Zurich	Switzerland
56387	20	1	20	7	Figure 9.7 (and this genre of graphic) is quite difficult to read and understand. Is the final CO2 impact the product of the four elements in the bar graph? That is a very counterintuitive interpretation of a bar graph.	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Government of United States of America	U.S. Department of State	United States of America
86639	20	1			The Y axid of these graphs is unlabelled. I assue they are a factor of improvement (so -1 means a 100% reduction?). The difficulty is they seem to use different base years, so to take the top graoh, Residential, from 1990-2015 the dots go up to a factor of 0.6, then under the sustainable Development Scenario these ar erebased at zero (I assume 2020) and indices go down to about 0.7? This combination of indices doesnt help with carbon It would be helpful to rebase all the Y axes in actual carbon emissions	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
22007	20	7	20	7	To a better understanding, the legend should be added to the y-axis	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Government of France	Ministère de la Transition écologique et solidaire	France
78201	20	10	20	12	This is interesting. However, it is not clear how the practical implications of 'floor area per capita' will fare as sufficiency measure in the non-residential sector. Secondly, is this floor area gross area or net airconditioned area? If this is gross, is this total built up area (including walls) or carpet area?	Noted: Floor area per capita is used as a sufficiency proxy for resident buildings only. A definition is included in the text.	SUCHANDRA BARDHAN	Jadavpur University	India
3607	20	10	20	13	The note accompanying the caption should declare the units of each metric.	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
86637	20	10		11	This should read "despite an efficiency improvement of 43% over the period 1990-2018 OF WHICH 17% WAS over the period 2010-2018". The word AND should not be used because they are not additional imrpvements	Accepted	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
82017	21	5	21	8	According to Figure 9.7a, for non-residential buildings, in the current policies scenario, emission reductions from efficiency and renewables are not enough to offset increases in value added, in a similar way that in some scenarios for residential buildings, improvements in efficiency/renewables are not enough to offset growth in floor area per capita. This is inconsitent with the content in the two sentences in lines 5-8.	Accepted: for consistency across scenarios and due to space constraints, data on non-residential are not included in the final report	Berrill Peter	Yale University	United States of America
82015	21	7	21	8	The final sentence of this paragraph does not work as a standalone sentence. It could be rephrased or combined with the previous sentence.	Accepted	Berrill Peter	Yale University	United States of America
86641	21	10		13	This sentence doesn't make sense. If an increase in carbon is due to new buildings then is it an intensity? Is it not just an increase in carbon emissions?	Accepted	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
72059	21	12	21	15	The author precises that the increase of carbon intensity is due to the development of new buildings in the South and the decarbonization of energy in Europe. But decarbonisation should be considered as a mitigation factor. The text can be misleading.	Accepted	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
72061	22	1	22	9	The author provides an initial status of energy vectors, biomass, electricity and specific focus on hydrogen but does not refer to gas, coal or thermal sources at this stage. Is it voluntary as hydrogen can be perceived as a future lever or was a specific research request for the report? If yes, it would be good to mention why we focus on hydrogen.	Accepted: the box on hydrogen has been removed and discussed on hydrogen has been merged with the one on other fuels	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
49659	22	3	22	4	The statement requires more explanation on the specific percentages mentioned on CPS,SPS,SDS,which would be more clear.	Accepted: Text revised	Satyaprakas Das Das	Manipal Academy of Higher Education	India
78203	22	4	22	42	Is there enough evidence to 'biomass being the dominant energy source'?	Noted: Past data are those provided by the IEA, which is considered as reliable source	SUCHANDRA BARDHAN	Jadavpur University	India
17931	22	4	22	5	There should be a differentiation between developing and developed countries for the statement that "global level, biomass was the most used energy carrier in residential buildings" and the statement needs quantification. Is this number of buildings, (as I suspect) or rather total energy use? Developing countries may have the most biomass use in terms of household numbers, but energy consumption from other sources is much higher in developed countries than biomass.	Accepted: Text revised	Robert Brecha	Climate Analytics	Germany
82019	22	7	22	7	I suggest adding reference to space heating here too, e.g. "end uses such as space and water heating"	Accepted	Berrill Peter	Yale University	United States of America
7835	22	11	22	30	According to the UK Government Response to the Committee on Climate Change's 2020 Progress Report to Parliament dated Octovber 2020, decarbonization plan in building sector still hold both hydrogen and heat pump as a future choice.One of the reason to keep hydrogen as an option is to avoid shortage of electricity in cold winter nights. It would be better to cite UK's case here.	Noted: References included in teh assessment are mainly from teh UK	Mitsutsune Yamaguchi	Research Institute for the Innovative Technology for the Earth (RITE)	Japan
14697	22	11	22	30	For a recent analysis, see Fraunhofer study: https://www.iee.fraunhofer.de/content/dam/iee/energiesystemtechnik/en/documents/Studies-Reports/FraunhoferIEE_Study_H2_Heat_in_Buildings_final_EN_20200619.pdf	Noted: Reference added	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
19921	22	11	22	30	There is a growing consensus around a hierarchy for the use of hydrogen, with heating buildings invariably coming out last (e.g. https://energy-cities.eu/where-should-green-hydrogen-fit-in-your-city/ https://energypost.eu/which-sectors-need-hydrogen-which-dont-transport-heating-electricity-storage-industry/ https://www.al-monitor.com/pulse/originals/2021/02/gulf-states-quest-new-oil-hydrogen-green-energy-solar-wind.html https://100percentrenewableuk.org/100-ruk-hydrogen-position-statement - disclosure: I am an Associate of 100% Renewable UK and lead author of the H2 position statement). Hydrogen is the lightest element, the smallest atomic size, and has a very low energy density, meaning it is highly inefficient as a source of heat (where alternatives are practical) and can easily escape from existing infrastructure. As a rule of thumb, existing gas networks (in the UK at least) can cope with mixes of up to 30% hydrogen without requiring replacement, which would come at significant costs in terms of both the necessary investment and the time needed to do so. Ultimately, all existing gas boilers will need to be replaced with alternative heating systems. A combination of strategies including maximising energy efficiency and the installation of heat pumps, solar thermal and photovoltaic panels, and non-fossil-fuelled district heating systems would be a major national priority in the short and medium term. Given the small nascent capacity for producing 'green' hydrogen and the other preferable uses for it, along with the need to eliminate the extraction of fossil fuels at a rate commensurate with meeting our emissions targets and the other disadvantages mentioned in this box, I would re-word this section to be far more cautious (and indeed recommend against) the deployment of hydrogen heating systems.	Noted	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
28307	22	11	22	30	referencing in the box is not impeccable, an easy fix.	Accepted	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
86643	22	11			Box 9.4 Hydrogen in the building sector. I broadly agree with this. Two important additional perspectives suggests there could be significant regional variation depending on industrial as well as gas network infrastructure. See: - LETI (London Energy Transition Initiative) concludes it is unlikely that zero carbon hydrogen supplied via a re-purposed gas mains network will be available for the vast majority of buildings, for the foreseeable future. https://b80d7a04-1c28-45e2-b904-e0715cface93.filesusr.com/ugd/252d09_54035c0c27684afca52c7634709b86ec.pdf - H21 North of England Report, – 70% of all UK meter points could be supplied by 2050 using a six-phase regional roll out strategy www.h21.green/wp-content/uploads/2019/01/H21-NoE-PRINT-PDF-FINAL-1.pdf	Noted	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
45527	22	15	22	18	There is an interesting study from Imperial College. That study confirms that full hydrogen is indeed more expensive than a heat pump pathway, but that hybrid solutions (use biogas or hydrogen only for peak heat demand) may be the most cost-effective. This is the report: G. Strbac, D. Pudjianto, R. Sansom, P. Djapic, H. Ameli, N. Shah, N. Brandon, A. Hawkes, "Analysis of Alternative UK Heat Decarbonisation Pathways" (August 2018), Imperial College, UK	Noted: Reference added	Kornelis Blok	Delft University of Technology	Netherlands
5455	22	19	22	19	Delete "renewable". The statement is true even if the source of energy is not renewabe	Rejected: The reference to renewables is from the authors of the study not from the IPCC authors	Michel SIMON	Retraité/ Pdt d'association	France
74217	22	19	22	19	Strike "renewable energy" and insert "carbon free generation" so as not to discriminate against other methods of producting green hydrogen such as nuclear and hydroelectric.	Rejected: The reference to renewables is from the authors of the study not from the IPCC authors	Jeffrey Merrifield	Pillsbury Law Firm	United States of America
45525	22	22	22	25	A report made for the Netherlands energy distribution companies says that hydrogen can without problems be used in existing networks. The network material will play a role, e.g. PVC and PE may be less problematic than cast iron. Here is the report (in Dutch): https://www.netbeheernederland.nl/_upload/Files/Toekomstbestendige_gasdistributienetten_133.pdf?UA-142619432-2 and here is a summry in English: https://www.netbeheernederland.nl/_upload/Files/Waterstof_56_8ad725a5d3.pdf	Noted	Kornelis Blok	Delft University of Technology	Netherlands
76539	23	1			What happend to cooking from year 2000 on?	Accepted: Text revised	Edgar Hertwich	Norwegian University of Science and Technology	Norway
86645	23	11		12	I agree with the statement that "Over the period 2020-2050, electricity is projected to become the main energy source used in non-residential buildings in all three scenarios", however, in terms of projecting trends and when it comes to AR7, looking back at trends, how is it proposed to disaggregate EV charging from both domestic and non-domestic buildings? in most cases (but not all) the electricity will go through the same metres for different end uses. Validation of data will get very difficult.	Noted: EV is out of the scope of the building chapter	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56389	24	2			In Figure 9.8a, there is still a significant share of biomass used in Africa towards mid-century. It would be useful to explain why fuel switching is relatively slow in this region.	Noted: section on biomass revised	Government of United States of America	U.S. Department of State	United States of America
10741	24	7	24	7	When inspecting figure 9.8, there appears a strong "catch up" trend from developing regions (this is best seen on the SDS scenario projections). Furthermore, it is clear that this processus is still well under way in 2050. Hence one is unable to see clearly which kind of stationary situation one is likely to reach. For this reason, it would be highly desirable to carry on the projections under the 3 scenarios until 2100.	Rejected: Projections under the scenarios used are available until 2050 only	Philippe Waldteufel	CNRS	France
52337	25	1	25	1	Need to focuse on the impact of living patterns on energy driving energy consumption and peak demand especially in high-populated areas.	Noted: See section 9.5	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
77315	25	2	25	28	under the 'energy demand for end use', water heating and cooking are mentioned as priorities next only to space heating, however section does not detail the trends in these areas unlike space heating. 2020 edition of Tracking SDG 7: The Energy Progress Report' available from https://www.irena.org/publications/2020/May/Tracking-SDG7-The-Energy-Progress-Report-2020 may be referred on recent statitstics on biomass use, particularly since it is mentioned that biomass is the largest source of energy in developing countries. Or alterantively reference can be made to page 62 lines 21-22 where the issue is discussed to some extent. Furthermore while discussing mitigation opportunities in this sector, tiers of performance including both emissions and health impacts developed under the joint work of ISO, WHO, Clean cooking alliance may be referred (https://www.cleancookingalliance.org/about/news/10-16-2018-voluntary-performance-targets.html	Noted: text and figures updated based on data available for the scenarios included in the assessment	Gajanana Hegde	UNFCCC (Climate Change Secretariat)	Germany
22009	25	3	25	4	To a better understanding, the period of time should be indicated (between 1990 and 2018?)	Accepted: Text revised	Government of France	Ministère de la Transition écologique et solidaire	France
25035	25	9			There is a substantial demand for space heating in some countries in the Middle East. The ME is more than the gulf countries which traditionally had little demand for space heating. Countries like Syria & Lebanon as well as the northern regions of Iraq & Iran have very cold winters and thus have a significant heating demand.	Noted: The assessment is based on existing scenarios. The IPCC does not develop its own scenarios	Bassam AbuHijleh	The British University in Dubai	United Arab Emirates
22011	25	18	25	18	To avoid misinterpretation, « Energy demand » should be replaced by « the share of energy demand »	Accepted	Government of France	Ministère de la Transition écologique et solidaire	France
47667	25	30	36	17	The section title has the terms "...strategies towards zero carbon buildings" in it, but I fail to see this bieng explored at a level which would bring out some of the potentials, barriers, and dynamics of the decaonization of this sector. The text does a good job on the embodied energy and emissions of materials (9.4.2), and a very thorough literature review for appliances and lighting (9.4.3.2). However it presents virtually nothing on heating and cooling technologies, which as showed infigure 9.9, are currenty (and expected to remain) the major sources of residential energy demand. Concerning heating technologies, given that they currently mostly depend o nthe combustion of fossil fuels, technology developments there are extremely important in the quest for "zero carbon buildings". I emplore the authors to dedicate more text there. In following comments I propose literature from the modelling/simulation community which provide pathways towards net zero buildings.	Reject - due to space restrictions no more text can be added. Moreover, most of what is asked for here can be found in the Supplementarly material.	Vassilis Daioglou	Utrecht University	Netherlands
47669	25	30	36	17	This section can benefit from a forthcoming publicaton from Daioglou et al., currenty under review in "Energy". They have used the IMAGE integrated assessment model to investigate decarbonization pathways of the residential sector. Specifically they Investigate the interaction between (i) Evolving building stock and demand for residential energy services, (ii) Investments in insulation (in new buildings as well as retrofits), (iv) Investments in energy efficiency in cooling/heating, (v) Investments in rooftop PV. The study hilights that strategies for each of the above vary across climate and socioecnomic contexts, and indicates situation where buildings can become "energy positive". The forthcoming paper is expected to be called "Efficiency improvement and technology choice for energy and emission reductions of the residential sector" The study improves and uses the TIMER-REMG residential sector model: https://www.sciencedirect.com/science/article/abs/pii/S0360544211007110	Reject - This section does not study decarbonization pathways, where can be found in Section 9.3.	Vassilis Daioglou	Utrecht University	Netherlands
47671	25	30	36	17	A 2019 paper from Knobloch et al., investigates strategies for the decarbonization of residential heating. they use a technologically rich simulation model to look at the impact of different policy measures on the rate and cost of decarbonization, globally and across multiple world regions. Knobloch, F., Pollitt, H., Chewpreecha, U., Daioglou, V., & Mercure, J. F. (2019). Simulating the deep decarbonisation of residential heating for limiting global warming to 1.5 C. Energy Efficiency, 12(2), 521-550. https://link.springer.com/content/pdf/10.1007/s12053-018-9710-0.pdf	Accepted - considered in Section 9.4	Vassilis Daioglou	Utrecht University	Netherlands
36985	25	30	36	9	I suggest operational and embodied mitigation technologies being explained in different Chapters.	Reject - Chapter sections were given by IPCC secretariat. Due to space constraints, text cannot be extended	Antonio Garcia-Martinez	Universidad de Sevilla	Spain
86047	25	32			Pleaase consider reference to current IEA Annex 72 research on definitions for (net) zero GHG emissions and typologies. Suggestions include: 1) Lützkendorf, T., & Frischknecht, R. (2020). (Net-) zero-emission buildings: a typology of terms and definitions. Buildings and Cities, 1(1), 662–675. DOI: http://doi.org/10.5334/bc.66 2) D. Satola, M. Balouktsi, T. Lützkendorf, A. Houlihan Wiberg, A. Gustavsen, How to define (net) zero greenhouse gas emissions buildings: The results of an international survey as part of IEA EBC annex 72, Building and Environment, Volume 192, 2021, 107619, ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2021.107619.	Noted - This reference was already considered when drafting this section.	Aoife Houlihan Wiberg	The Belfast School of Architecture and the Built Environment, Ulster University, UK	United Kingdom (of Great Britain and Northern Ireland)
6021	25	32	25	34	The report incorrectly says "most studies and reviews do not relate themselves to climate change mitigation, therefore there is a clear gap in reporting the mitigation potential of the different technologies." In the past decade hundreds of studies have appeared in peer reviewed journals and buildings trade journals describing the climate mitigating potential of new building materials and techniques. See, e,g.: Royal Society 2018, Greenhouse Gas Removal Report ISBN: 978-1-78252-349-9. Section 2.12 Low-carbon Concrete; Q. Hu, J. Jung, D. Chen, et al., Biochar industry to circular economy, Science of the Total Environment, https://doi.org/ 10.1016/j.scitotenv.2020.143820	Reject - The detailed systematic review done to draft this section has clearly shown that the statement is correct. The reviewer gives some of the very few examples that would be the exception.	Albert Bates	Global Village Institute	United States of America
10743	25	32	25	35	I have difficulties understanding this paragraph. This report is concerned with technological issues which have a potential mitigation impact, whether such an impact is indicated by the literature or if it is pointed out by the report authors!	Acceptec: text was revised	Philippe Waldteufel	CNRS	France
84831	25	32	25	39	Explain further why "most studies and reviews do not relate themselves to climate change mitigation." This seems a bit contradictory. In other words, I would recommend including some information regarding what the literature directly relates to, if it is NOT climate mitigation.	Noted - The entire building services section has been edited.	Thomas Chen	U.S. Technology Policy Committee	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
47789	25	34	25	36	"It should be highlighted that when assessing the literature, it is clear that a lot of new research is focussed on the improvement of control systems, including the use of artificial intelligence or internet of things (IoT)." There is no references. Usually improved control, IoT and AI are interesting to reduce operation energy of buildings. Embodied emissions are less impacted by such development. I think it shows a confusion between Zero carbon, Zero energy, net zero energy buildings. There is actually very clear definition of terms and clear diagram. It can be found in: Lützkendorf, T., & Frischknecht, R. (2020). (Net-) zero-emission buildings: a typology of terms and definitions. Buildings and Cities, 1(1), 662–675. DOI: http://doi.org/10.5334/bc.66	Noted - The entire building services section has been edited.	Guillaume Habert	ETH Zurich	Switzerland
22013	25	35	25	36	It would be interesting to present also the reaserch on the so-called "low technology" options as it prove to be very effective in differents contexts. for instance : Khalil, Ayah-Allah & Abdeaal, Waled. (2018). High technology or low technology for buildings envelopes in residential buildings in Egypt. Alexandria Engineering Journal. 57. 10.1016/j.aej.2018.11.001.	Reject - This concept is already included. See also Suplementary material	Government of France	Ministère de la Transition écologique et solidaire	France
56391	25	45	25	46	While the design of buildings has been historically linear, Integrated Design practices have largely shifted building design away from a linear process. Authors should note Integrated Design in the text. See related U.S. comment on page 53, line 2.	Noted - This paragrah summarises AR5 key findings. Later in the chapter (e.g. Section 9.5) considers integrated design and circular economy	Government of United States of America	U.S. Department of State	United States of America
10745	25	45	2725	45	"the conventional process of designing and constructing buildings and its systems is largely linear": while this seems a quite interesting clue, the text does not indicate where in this chapter are discussed possible non linear processes.	Noted - This paragrah summarises AR5 key findings. Later in the chapter (e.g. Section 9.5) considers integrated design and circular economy	Philippe Waldteufel	CNRS	France
4977	26	1	26	4	A ")" is missing	Accepted - Corrected in the text	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
22015	26	1	26	4	The second part of the parenthesis is missing « electricity source). »	Accepted - Corrected in the text	Government of France	Ministère de la Transition écologique et solidaire	France
37247	26	1	26	4	Some mention may be made for Small/micro nuclear reactors which could power districts or communities.	Noted - That's interesting but there is not enough data on the literature to make any conclusions yet	Arun kumar Nayak	Bhabha Atomic Research Centre Trombay Mumbai	India
37249	26	1	26	4	This could lead to significant reduction in GHG emissions	Noted - That's interesting but there is not enough data on the literature to make any conclusions yet	Arun kumar Nayak	Bhabha Atomic Research Centre Trombay Mumbai	India
22017	26	9	26	9	The legend of the y-axis « Energy shares (%) » should be added on the figure (a)	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Government of France	Ministère de la Transition écologique et solidaire	France
86647	26	9		10	Figure 9.9 is not related to the section in which it sits. The section is entiled "9.4.1 Key points from AR5 and special reports". The chart is neither, and is a reference to a 2021 report. There is no commentary on the chart. Very confusing!	Accepted: Figure moved	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
86049	26	11			Please consider the following references which emphasise the increased importance of embodied emissions materials compared to operational emissions in net zero buildings. Please see 1) Thomas Lützkendorf, Greg Foliente, Maria Balouktsi & Aoife Houlihan Wiberg (2015) Net-zero buildings: incorporating embodied impacts, Building Research & Information, 43:1, 62-81, DOI: 10.1080/09613218.2014.935575 2) H. Birgisdottir, A. Moncaster, A. Houlihan Wiberg, C. Chae, K. Yokoyama, M. Balouktsi, S. Seo, T. Oka, T. Lützkendorf, T. Malmqvist, IEA EBC annex 57 'evaluation of embodied energy and CO2eq for building construction', Energy and Buildings, Volume 154, 2017, Pages 72-80, ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2017.08.030.	Noted - This reference was already considered when drafting this section.	Aoife Houlihan Wiberg	The Belfast School of Architecture and the Built Environment, Ulster University, UK	United Kingdom (of Great Britain and Northern Ireland)
61123	26	12			This section is surprisingly short, and does not reflect state-of-the-art knowledge in the field of embodied emissions in buildings. The depiction of embodied GHG emissions and embodied energy of different materials per unit of mass or volume is a source of concern - it might mislead the reader into immediately positioning one material as "always better", which is something that specialists in LCA have strived to avoid for decades now.	Reject - due to space restrictions no more text can be added. Moreover, the text is based on a very recent extensive published review.	Marcella Saade	Graz University of Technology	Austria
77121	26	12	26	17	What nonsense suggesting of buildings of rammed earth and bamboo – does IPCC seriously advocate that the world reverts to primitive living conditions?	Reject - Diversity in worldwide conditions should be included and assessed in any IPCC report.	Jim O'Brien	Expert Reviewer AR6 SOD WG1	Ireland
28309	26	12	27	25	This section really needs to be brought up to the standard of the literature and discourse in this field. The whole Net Zero movement acknowledges the fundamental role played by embodied energy and embodied carbon, and the WGBC 'Bringing Embodied Carbon Upfront' has given it global visibility. There is also a whole Annex of the IEA (Annex 57) concluded around this topic and an ongoing Annex (Annex 72) which has already produced significant results in this space. In addition, there have been academics in the past 5-10 years who greatly advanced the field and this section in its current form is worryingly scarce. Some useful sources and elements to consider are as follows. (1) extensive discussion on the variability on the embodied carbon of building materials, with potential explanations and methodological issues that cause it [https://doi.org/10.1016/j.rser.2017.06.049], (2) the need not to compare embodied energy and carbon per unit mass of materials since this is misleading because materials are not used in identical quantities [https://doi.org/10.1021/es202190r; https://doi.org/10.1016/j.jobe.2020.101426], (3) the still many open questions remaining on any scalability of timber solutions globally in addition to Churkina already cited who provides an exceptionally optmisitic estimate [https://doi.org/10.1016/j.oneear.2020.07.018; https://doi.org/10.3390/su12083473], (4) the potential offered by composite frames/hybrid structures at a global scale [https://doi.org/10.1016/j.jclepro.2020.123487], (5) the significant role that embodied carbon plays in a net/near zero mindset and the even greater role that it will play going forward as grids across the globe are progressively decarbonised [https://doi.org/10.1016/j.apenergy.2019.114107], (6) the significance of embodied water in construction and the little correlation it seems to have with embodied energy and carbon [https://doi.org/10.1016/j.watres.2021.116935], and (7) a much deeper and more meaningful discussion on carbon storage and sequestration in the built environment [https://doi.org/10.1016/j.spc.2021.02.028]. In general, I am quite worried that embodied impacts deserve such a small and narrative section without any significant advancement of their understanding and mitigation options. I believe this section should be brought up one level and significantly expanded, potentially with each of the points above representing a sub-section on their own.	Reject - due to space restrictions no more text can be added. Moreover, the text is based on a very recent extensive published review.	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
28331	26	12	27	25	It would seem appropriate in the "Buildings" chapter to emphasise the key role played by whole-life thinking and life cycle assessment and offer a clear understanding of the different life cycle stages of a building's life, for instance through the ubiquitous EN 15978 diagram. Missing the opportunity to push governments and key decision makers to adopt a life-cycle based thinking would be a disgrace. London will soon start requiring mandatory whole-life carbon assessments for certain projects, and California passed the Buy Clean Act last year (which does the same). These have resulted out of incredible efforts from leading academics, inspired professionals and motivated industries. The IPCC would add a very authoritative voice to support such transition and accelerate it.	Noted - This is the aim of the chapter, but lack of enough literature has not allowed to push this concept further.	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
43655	26	12	28	6	The section on embodied energy and embodied carbon is completely isolated and taken out of context. It does not make sense to discuss embodied energy/carbon on the level of construction products without discussing embodied energy/carbon on the level of buildings - see e.g. Embodied GHG emissions of buildings - The hidden challenge for effective climate change mitigation: Martin Röck, Marcella Ruschi Mendes Saade, Maria Balouktsi, Freja Nygaard Rasmussen, Harpa Birgisdottir, Rolf Frischknecht, Guillaume Habert, Thomas Lützkendorf, Alexander Passer. https://www.sciencedirect.com/science/article/pii/S0306261919317945?via%3Dihub	Reject - due to space restrictions no more text can be added. Moreover, the text is based on a very recent extensive published review.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
43657	26	12	28	6	Figure 9.10: It does not make sense to compare embodied energy/carbon on the level of building products per kg. Comparisons are only permitted if the functional equivalent is identical. This is the case when comparing building components (e.g. windows) or whole buildings. It should be stated which life cycle stages were taken into account when collecting the data (without/with end-of-life).	Noted - The figure is based on an extensive review that only included studies with the same funcional unit and equivalent LCA stages.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
70095	26	12	28	6	Page 9.26 Why only envelope materials? HVAC systems, light bulbs, electronics can have significant embodied impacts and energy as well	Reject - Lack of space and lack of literature on the topic do not allow to include this suggestion.	Cellura Maurizio	University of Palermo	Italy
79677	26	13			The decrease in operational energy demand in buildings is highlighting the importance of embodied energy and embodied GHG emissions in building materials (Ürge-Vorsatz et al. 2020). This fact should be further highlighted as it is actually a hidden challenge of buildings. Concerning about this is not so much the fact that due to decrease in energy demand, the embodied energy becomes predominant, but it is also that no significant progress has been achieved yet in reduction of embodied emissions. Röck M., Mendes Saade M.R., Balouktsi M., Nygaard Rasmussen F., Birgisdottird H., Frischknecht R., Habert G., Lützkendorf T., Passer A. 2020. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy. 258, 114107. DOI: 10.1016/j.apenergy.2019.114107	Noted - This concept is highlighted in Section 9.1.	Alexander Passer	Graz University of Technology	Austria
47791	26	13	26	13	The decrease in energy demand in buildings is highlighting the importance of embodied energy and embodied carbon in building materials (Ürge-Vorsatz et al. 2020). This point should be highlighted. It is actually the hidden challenge of buildings. What is concerning is not so much the fact that due to decrease in energy demand, the embodied energy becomes predominant. It is also that no significant progress has been achieved in reduction of embodied emissions. Röck M., Mendes Saade M.R., Balouktsi M., Nygaard Rasmussen F., Birgisdottird H., Frischknecht R., Habert G., Lützkendorf T., Passer A. 2020. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy. 258, 114107. DOI: 10.1016/j.apenergy.2019.114107	Noted - This concept is highlighted in Section 9.1.	Guillaume Habert	ETH Zurich	Switzerland
47793	26	13	26	13	This chapter is mainly treating building operation and disconnecting operation from construction while the 2 are extremely linked. Using biobased insulation materials can for instance reduce instantaneous radiative forcing and at the same reduce long term energy demand of building. Pittau F., Lumia G., Heeren N., Iannaccone G., Habert G. 2019. Retrofit as a carbon sink: the carbon storage potentials of the EU housing stock. Journal of Cleaner Production, 214, 365-376.	Reject - The chapter considers this issue. Moreover, the section on embodied energy considers most life-cycle stages.	Guillaume Habert	ETH Zurich	Switzerland
56393	26	13	26	13	The wording of this sentence "decrease in energy demand" is a bit confusing given that Figure 9.8 (page 24) shows no decrease in building energy demand. Consider re-wording to: "... as building energy demand is decreased, the importance of embodied carbon ..."	Accepted - Corrected in the text	Government of United States of America	U.S. Department of State	United States of America
79421	26	13	26	13	"The decrease in energy demand in buildings is highlighting the importance of embodied energy and embodied carbon in building materials (Ürge-Vorsatz et al. 2020)". This point should be emphasized, supported by additional references (e.g. Röck et al 2020, see the following) and expanded upon as embodied GHG emissions represent a hidden challenge for effective climate mitigation in buildings. A recent meta-study by Röck et al. collected and analysed more than 600 building life cycle assessment case studies and found embodied GHG emissions to be increasing, in both relative and absolute terms. The study shows that embodied GHG emissions have been increasing in absolute terms - especially for new and complex, advanced building concepts - and that embodied emissions from initial building production are in fact dominating the timeframe relevant for effective climate change mitigation. See: Röck M., Mendes Saade M.R., Balouktsi M., Nygaard Rasmussen F., Birgisdottird H., Frischknecht R., Habert G., Lützkendorf T., Passer A. 2020. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy. 258, 114107. DOI: 10.1016/j.apenergy.2019.114107.	Noted - The text is base in a very comprehensive review that already includes other literature like the one cited here.	Martin Röck	KU Leuven	Austria
16517	26	13	26	14	Compare this sentence (the decrease in energy demand in buildings) with the first sentence jof 9.3.3.1 section (21page, 46 line).	Accepted - The text has been reworded	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17023	26	13	26	14	Compare this sentence (the decrease in energy demand in buildings) with the first sentence jof 9.3.3.1 section (21page, 46 line).	Accepted - The text has been reworded	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
16495	26	13	27	17	In the point of LCA, the amount of GHG emission of construction material production process is described. However, it is necessary to clarify that the importance of ecological and eco-friendly aspects should be taken into account in terms of production of building materials.	Rejected - Production of buildings materials is included in the Industry chapter.	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
16519	26	13	27	25	Building materials can have many differences depending on regional conditions (country and region), so it is necessary to specify this point in this section.	Noted - The differences in materials and technologies based on regional conditions could not be included with too much detail due to limist in chapter space and due to lack of literature; but those aspects are included as much as possible in Section 9.2, 9.4, and 9.5.	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17025	26	13	27	25	Building materials can have many differences depending on regional conditions (country and region), so it is necessary to specify this point in this section.	Noted - The differences in materials and technologies based on regional conditions could not be included with too much detail due to limist in chapter space and due to lack of literature; but those aspects are included as much as possible in Section 9.2, 9.4, and 9.5.	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
62099	26	13	27	25	Reducing embodied GHG emissions should not lead to increasing energy use. Therefore mitigation measures should be studied and assessed using both life cycle assessment and energy calculation (Roux et al., 2016), (Peuportier et al., 2013). For instance wood is a low carbon material but its low thermal mass reduces the possibility to store energy : the use of solar gains or demand management is thus limited. A higher thermal mass also improves the resilience of buildings to heat waves. Depending on climatic conditions, it may therefore be needed to complement wood with thermal mass, preferably using earth or low carbon concrete. Roux C., Schalbart P., Assoumou E. and Peuportier B., Integrating climate change and energy mix scenarios in LCA of buildings and districts, Applied Energy 184 (2016), pp. 619-629 Peuportier, B., Thiers, S. and Guiavarch, A., Eco-design of buildings using thermal simulation and life cycle assessment, Journal of cleaner production, Volume 39, Pages 73-78, January 2013	Noted - Technologies are detailed in the Supplementary material.	Bruno Peuportier	MINES ParisTech	France
56395	26	13	28	6	Essential low-embodied carbon building materials should include strategies such as: 1. Locally-sourced culture and resource-sensitive/renewable materials 2. Potential of buildings to being not just ZNE but carbon-negative through the use of biogenic materials that sequester carbon. Buildings can store gigatons of carbon (e.g., by injecting CO2 into concrete, and the use of biogenic building materials such as purpose grown crops or from agro-waste, rice husk ash, sugarcane bagasse ash). These biogenic building materials are biodegradable and rapidly renewable, and can be both sourced then utilized regionally, thus shortening the supply chain and reducing embodied carbon. Examples include, e.g., mushroom (mycelium-strengthened) bricks, luffa gourd strengthened wall panels, coconut fiber wall insulation, etc. 3. Circularity in materials, e.g., re-use of construction and demolition waste, re-use of obsolete PV panels as building materials, and embedding plastic as a main component in infrastructural services (non-load bearing partitions, bricks, sheds, roof tiles, tiles, terracing and landscape, furniture, asphalt development).	Reject - This is too much detail for the space available for the chapter.	Government of United States of America	U.S. Department of State	United States of America
79679	26	14			See also: Pittau F., Lumia G., Heeren N., Iannaccone G., Habert G. 2019. Retrofit as a carbon sink: the carbon storage potentials of the EU housing stock. Journal of Cleaner Production, 214, 365-376.	Noted - The reference was already considered.	Alexander Passer	Graz University of Technology	Austria

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
47795	26	16	26	16	"but other building frames should be considered to include worldwide building construction practice, such as rammed earth and bamboo (Cabeza et al. 2021)." It is not clear what is meant here. One estimate that 30% of humanity is leaving in earth or bamboo house. And this has indeed very low environmental footprint. But these are usually vernacular or very temporary and informal housings. New formal and contemporary buildings with earth or bamboo are representing a very small proportion of buildings so no need to add these constructive frames. I feel the question is bigger than the problem of having rammed earth as new construction possibilities in models. It is more, how construction technologies in informal settlements are considered in models. And here, yes, it is usually badly evaluated. One example of quantification of emissions in South Africa building stock including informal settlements as well as the consequences of policy to remove them (and transform into subsidised housing with different construction technologies) is evaluated in Göswein et al. Göswein V., Krones J., Celentano G., Fernández J.E., Habert G. 2017. Embodied GHG in a fast growing city – Looking at the evolution of a dwelling stock using structural elements breakdown and policy scenarios. Journal of industrial ecology. DOI: 10.1111/jiec.12700	Noted - In the IPCC context it is important to consider all worlwide situations.	Guillaume Habert	ETH Zurich	Switzerland
47797	26	16	26	16	Many other construction technique should be considered. In general, focus is only on structural materials But façade systems are composed of insulation materials. Heeren showed that insulation materials will represent the major embodied emissions in European context where renovation of existing stock will gradually become the main construction activity. Study is for Switzerland but can be extrapolated to Europe. (Heeren, N. and Hellweg, S. 2018. Tracking Construction Material over Space and Time: Prospective and Geo-referenced Modeling of Building Stocks and Construction Material Flows. Journal of Industrial ecology. https://doi.org/10.1111/jiec.12739). Pittau then showed that using biobased insulation instead of usualy fossil based insulation materials could completely invert this tendency and rather reduce GWP compared to increase it. (Pittau F., Krause F., Lumia G., Habert G. 2018. Fast-growing bio-based materials as an opportunity for storing carbon in exterior walls. Building and Environment, 129, 117-129.)	Reject - The literature is very scarce and disperse, so here an effort to compile it was done. The authors agree that this should be extended to other building parts, but this was not possible with the space available and the timeframe of the report.	Guillaume Habert	ETH Zurich	Switzerland
4567	26	17	26	17	Add importance of 'Vernacular Design'	Accept - Corrected in the text.	Alka Bharat	Maulana Azad National Institute of Technology (An Institute of National importance), Bhopal	India
56397	26	17	26	17	Bamboo is a kind of wood.	Noted - Agreed, but the literature differentiated between them both since they are used in very different building types and regions of the world.	Government of United States of America	U.S. Department of State	United States of America
37251	26		26		Space heating is certainly a big consumer in developed northern hemisphere countries.	Accepted - text revised	Arun kumar Nayak	Bhabha Atomic Research Centre Trombay Mumbai	India
37253	26		26		It is not quite clear as to why it is so in Africa which has a predominantly tropical climate.	Accepted - text revised	Arun kumar Nayak	Bhabha Atomic Research Centre Trombay Mumbai	India
4979	27	2	27	2	As in the comment at line 38	Rejected - comment not clear	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
61125	27	4	27	4	The statement that steel is the "strongest building material" seems too strong, and should be backed up with scientific evidence	Reject - The literature cited back up this statement.	Marcella Saade	Graz University of Technology	Austria
60583	27	4	27	5	Steel reinforcement is essential to all concrete construction. It is thus present in all buildings with a concrete structure, including residential ones. Steel is, in fact, the primary contributor to embodied energy in concrete buildings.	Noted - This is already included in the text.	Evyatar Erell	Ben-Gurion University of the Negev	Israel
78205	27	6	27	7	Fly ash bricks must be included, as thermal power stations producing huge amount of flyash must be considered in totality. It may also have low embodied energy due to the trade-off.	Reject - This would be just one case that adds too many details not possible with the space constraints.	SUCHANDRA BARDHAN	Jadavpur University	India
47799	27	7	27	7	The treatment of bamboo compared to wood seem to show a Eurocentric approach of construction. It is written "Wood has been used for many centuries for the construction of buildings and other structures in the built environment; and it remains as an important construction material today.". But for bamboo it is written "Bamboo is a traditional building material throughout the world tropical and sub-tropical regions." I think Bamboo remains an important construction material today too.. There are important engineer association supporting it's use: INBAR. There are impressive contemporary construction made out of bamboo (See for instance Bamboo bridges for cars designed by Jorg Stamm engineer and Lucas Zollinger as architect). There are also very high tech development of laminated bamboo products. EZ Escamilla, H Archilla, DA Nuramo, D Trujillo. Bamboo: An engineered alternative for buildings in the global South. Bioclimatic Architecture in Warm Climates, 397-414	Reject - The statements are based on literature and with wide consideration on worldwide regions. The fact that bamboo is included is a sign of this, as other reviewers are asking to even broaden this perspective.	Guillaume Habert	ETH Zurich	Switzerland
61127	27	7	27	8	I'm afraid this is too generalist. Bamboo wouldn't necessarily be considered as traditional building material throughout the world tropical and sub-tropical regions. In Latin America, e.g. its use is not so widespread. A reference here would be welcome.	Reject - The literature cited back up this statement.	Marcella Saade	Graz University of Technology	Austria
47801	27	8	27	8	Rammed earth can be considered to be included in masonry construction, but it is a structure very much used in developing countries that are finding new interest in developed ones. Rammed earth is only one construction technique with earth. Structural design of rammed earth is really not based on masonery. It is more soil mechanic related. But other earth construction techniques such as adobe or CEB are indeed masonery construction. Again, I feel the vision on earth is as simplistic as the vision on bamboo. Ref: QB Bui, JC Morel, S Hans, N Meunier. 2009. Compression behaviour of non-industrial materials in civil engineering by three scale experiments: the case of rammed earth Materials and structures 42 (8), 1101-1116	Reject - The statements are based on literature and with wide consideration on worldwide regions. The fact that bamboo is included is a sign of this, as other reviewers are asking to even broaden this perspective.	Guillaume Habert	ETH Zurich	Switzerland
47803	27	8	27	8	30% of humanity lives in earth construction, including adobe, rammed earth, cob, wattle and daub… Very few new construction are done in rammed earth in what is called developing countries. What I would rather refer to emerging countries or Global South. In Global South, main earth construction technique is a mix of wattle and daub and adobe but these construction are mainly for poor housing in rural area or informal settlements. Important discussion on earth construction is it's stabilization. Stabilized earth construction is usually done with cement which then relates very much to concrete masonery construction. Van Damme H., Houben H. 2018. Earth concrete. Stabilization revisited. Cement and concrete research, 114, 90-102. https://doi.org/10.1016/j.cemconres.2017.02.035	Reject - The statements are based on literature and with wide consideration on worldwide regions. The fact that bamboo is included is a sign of this, as other reviewers are asking to even broaden this perspective.	Guillaume Habert	ETH Zurich	Switzerland
22019	27	8	27	9	Sentence not clear : developping countries find new interest in rammed earth ?	Accepted - Text corrected.	Government of France	Ministère de la Transition écologique et solidaire	France
56399	27	8	27	9	This sentence needs editing. A simple change of the word "are" to "is" may suffice, but reference to rammed earth as a "structure" probably needs changing as well. Here, the word "technology" may be appropriate.	Accepted - Text corrected.	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
86051	27	11			There is a considerable body of research published from the IEA Annex 57 presenting important lessons from the international case studies and which could be useful in this section. 1) Tove Malmqvist, Marie Nehasilova, Alice Moncaster, Harpa Birgisdottir, Freja Nygaard Rasmussen, Aoife Houlihan Wiberg, José Potting, Design and construction strategies for reducing embodied impacts from buildings – Case study analysis, Energy and Buildings, Volume 166, 2018, Pages 35-47, ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2018.01.033.1) 2) Freja Nygaard Rasmussen, Tove Malmqvist, Alice Moncaster, Aoife Houlihan Wiberg, Harpa Birgisdóttir, Analysing methodological choices in calculations of embodied energy and GHG emissions from buildings, Energy and Buildings, Volume 158, 2018, Pages 1487-1498, ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2017.11.013.	Noted - This reference was already considered when drafting this section.	Aoife Houlihan Wiberg	The Belfast School of Architecture and the Built Environment, Ulster University, UK	United Kingdom (of Great Britain and Northern Ireland)
47805	27	11	27	12	"The literature evaluating the embodied energy in building materials is extensive, but that considering embodied carbon is much more scarce." There has been massive effort to quantify embodied emissions from buildings. See ref. Röck M., Mendes Saade M.R., Balouktsi M., Nygaard Rasmussen F., Birgisdottird H., Frischknecht R., Habert G., Lützkendorf T., Passer A. 2020. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy. 258, 114107. DOI: 10.1016/j.apenergy.2019.114107	Reject - Eventhoug authors agree that there is more and more literature on embodied carbon, it is still very scarced compared to that related to embodied energy.	Guillaume Habert	ETH Zurich	Switzerland
47807	27	11	27	12	For the building materials, this statement is very surprising as there exist environmental database which quantify the environmental impact of all building materials. The most common one is Ecoinvent. The ökoBaudat is the german database gathering embodied carbon of all materials used in Germany. KBOB is the swiss free to use excel file which gather embodied energy as well as GHG emisions and ecological scarcity values.	Reject - Eventhoug authors agree that there is more and more literature on embodied carbon, it is still very scarced compared to that related to embodied energy.	Guillaume Habert	ETH Zurich	Switzerland
79423	27	11	27	12	"The literature evaluating the embodied energy in building materials is extensive, but that considering embodied carbon is much more scarce." This is overlooking the massive effort made by Röck et al. to systematically review and analyse the scientific literature on embodied GHG emissions across the life cycle of buildings, which should be referred to here. The study analysed hundreds of building LCA case studies and shows the increasing importance of embodied GHG emissions ("embodied carbon") as these have increased in both relative and absolute terms and are in fact dominating the timeframe for effective climate change mitigation - See ref: Röck M., Mendes Saade M.R., Balouktsi M., Nygaard Rasmussen F., Birgisdottird H., Frischknecht R., Habert G., Lützkendorf T., Passer A. 2020. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy. 258, 114107. DOI: 10.1016/j.apenergy.2019.114107.	Noted - No literature has been not considered, and those papers were already evaluated.	Martin Röck	KU Leuven	Austria
79681	27	11	27	12	"The literature evaluating the embodied energy in building materials is extensive, but that considering embodied carbon is much more scarce." Recent literature shows massive efforts to quantify embodied emissions from buildings. See ref. Röck M., Mendes Saade M.R., Balouktsi M., Nygaard Rasmussen F., Birgisdottird H., Frischknecht R., Habert G., Lützkendorf T., Passer A. 2020. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy. 258, 114107. DOI: 10.1016/j.apenergy.2019.114107.	Noted - No literature has been not considered, and those papers were already evaluated.	Alexander Passer	Graz University of Technology	Austria
79683	27	11	27	12	For the construction materials, this statement is very surprising as there are standards and environmental database which quantify the environmental impacts - i.e. Ecoinvent, ökoBaudat KBOB and others.	Reject - Eventhoug authors agree that there is more and more literature on embodied carbon, it is still very scarced compared to that related to embodied energy.	Alexander Passer	Graz University of Technology	Austria
79685	27	11	27	12	see also: Passer, A., Lasvaux, S., Allacker, K., De Lathauwer, D., Spirinckx, C., Wittstock, B., Kellenberger, D., Gschösser, F., Wall, J., & Wallbaum, H. (2015). Environmental product declarations entering the building sector: critical reflections based on 5 to 10 years experience in different European countries. The International Journal of Life Cycle Assessment, 20(9), 1199–1212. https://doi.org/10.1007/s11367-015-0926-3	Noted - No literature has been not considered, and those papers were already evaluated.	Alexander Passer	Graz University of Technology	Austria
47809	27	11	27	15	"The literature evaluating the embodied energy in building materials is extensive, but that considering embodied carbon is much more scarce (Cabeza et al. 2021). Recently this evaluation is done using the methodology life cycle assessment (LCA), but since the boundaries used in those studies are different, varying for example, in the consideration of cradle to grave, cradle to gate, or cradle to cradle, the comparison is very difficult (Moncaster et al. 2019)." The argument is not correct. It seems there is no problem of system boundaries with embodied energy while there are problems with embodied carbon. Questions of system boundaries are common to all environmental impact indicators calculation. Furthermore, it's not that comparison is difficult, it's that comparison between materials in MJ/kg or kgCO2eq/kg makes no sense as we should compare material for the same function. LCA is a method that has been applied to building materials since 20 years. All data are available. And yes there is variability within one material. See Ref: Passer, A., Lasvaux, S., Allacker, K., De Lathauwer, D., Spirinckx, C., Wittstock, B., Kellenberger, D., Gschösser, F., Wall, J., & Wallbaum, H. (2015). Environmental product declarations entering the building sector: critical reflections based on 5 to 10 years experience in different European countries. The International Journal of Life Cycle Assessment, 20(9), 1199–1212. https://doi.org/10.1007/s11367-015-0926-3. What seems important to point out is that considering difference between database and uncertainties due to production process, there is actually a performance gap between the average environmental impact of materials and the real effective one that will be emitted by the construction project. Ref: Pomponi, Francesco & Moncaster, Alice, 2018. "Scrutinising embodied carbon in buildings: The next performance gap made manifest," Renewable and Sustainable Energy Reviews, Elsevier, vol. 81(P2), pages 2431-2442	Reject - Eventhoug authors agree that there is more and more literature on embodied carbon, it is still very scarced compared to that related to embodied energy.	Guillaume Habert	ETH Zurich	Switzerland
2307	27	11	27	25	The discussion around embodied carbon and embodied energy is very interesting, but some background definitions of these terms will be helpful for readers	Noted - Definitions are in the glossary of the report.	Siddarth Durga	PNNL	United States of America
10747	27	12	27	15	According to figures 8 & 9 in (Moncaster et al, 2019), the "cradle to gate" part seems strongly dominant in considered cases; hence errors due to various boundaries should not be major ones.	Noted - This was due to the fact that most literature was based on this life-cycle stage, and was the only considered in the reference to have comparable results.	Philippe Waldteufel	CNRS	France
72063	27	12	28	25	Embodied emissions for each material are assessed and the main differences between materials are provided. But there is no assessment of the mitigation potential of shifts from high carbon materials to low carbon materials, and its possible contribution to GHG reduction for the building sectors.	Noted - This was due to the lact of literature.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
61129	27	15	27	16	A clear statement shall be made mentioning the fact that, even among studies adopting identical system boundaries, many differences arise from different methodological approaches, which implicates in very different values being found for the same building material, hindering the robustness of the information depicted in the figure	Noted - This is very clear in the reference of the figure.	Marcella Saade	Graz University of Technology	Austria
3505	27	16	27	16	Reference (Cabeza et al. 2021) is missing in the references list.	Accept - Incluced now.	Miguel Angel Sanjuán	IECA	Spain
10395	27	16	27	16	Reference (Cabeza et al. 2021) is missing in the references list.	Accept - Incluced now.	Aniceto Zaragoza	Oficemen	Spain
11551	27	16	27	16	Reference (Cabeza et al. 2021) is missing in the references list.	Accept - Incluced now.	PEDRO MORA PERIS	UNIVERSITY	Spain
47811	27	19	27	21	"Steel represents the materials with higher embodied energy, 32-35 19MJ·kg-1; embodied energy in masonry is higher than in concrete and earth materials, but surprisingly, wood has the highest embodied energy." This sentence is embarrassing. It's not surprising, it's the LCA calculation method that will count as embodied energy, that energy that will be released when burning the wood. Again comparing material per kg makes no sense. We need to compare material for a same function. Like one m2 of beam in order to support a given load. See the paper where we show that although one material has higher impact per m3, the final bridge has less impact. This is extremely classic. Habert G., Arribe D., Dehove T., Espinasse L., Le Roy R. 2012. Reducing environmental impact by increasing the strength of concrete: quantification of the improvement to concrete bridges. Journal of Cleaner Production, 35, 250-262	Noted - No literature has been not considered, and those papers were already evaluated.	Guillaume Habert	ETH Zurich	Switzerland

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
72065	27	19	27	21	It is interesting to focus on the fact that wood has the highest embodied energy and it would be good to explain shortly why. Is it because of the industrial process, or the embodied energy as wood is also an energy vector?	Noted - It depends on both and it would be too long to be included in the text.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
3613	27	19	27	22	The discussion of embodied energy and carbon in different building materials is confusing. Wood has the highest embodied energy but the lowest embodied carbon.	Noted - Many reviewers state that the section is clear and important.	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
25055	27	19	27	25	"The concept of buildings as carbon sinks raise from the idea that wood stores considerable quantities of carbon with a relatively small ratio of carbon emissions to material volume and concrete has substantial embodied carbon emissions with minimal carbon storage capacity (Churkina et al. 2020a; Sanjuán et al. 2019)." Only selective extracts from Churkina have been used. For balance add: "However without improvements in using lignin-based adhesive technologies or mechanical lamination techniques there will be a massive increase in the production of synthetic glues and adhesives and their potentially harmful chemical residues in wood waste at the end of a building's life. (Churkina et al 2020). In addition, more and more research papers are questioning the concept of buildings as carbon sinks in carbon accounting and this should be acknowledged here. We recommend insist adding a reference to the following paper "Based on a typical LCA study, it is possible to test the overall LCA impacts of wood building construction against a concrete building, controlling for the GHG impacts of three different forest management scenarios: a silvicultural success rate of 90 per cent, a net permanent loss of soil carbon attributed to a clear-cut harvest and carbon losses from the conversion of primary forest to secondary managed forest.1 Compared to a baseline that assumes biogenic carbon emissions are zero over the building life cycle, cradle-to-gate life-cycle emissions for wood buildings increased between 5 and 72 per cent depending on the scenario. Aggregating these impacts suggests that a wood building could have greater embodied emissions than a concrete building (see Figures ES1 and ES2). [Emission Omissions: Carbon accounting gaps in the built environment, Life-cycle assessment (LCA) studies are the best tool we have to measure the carbon footprints of building products at each phase of their lifespan, but they have some flaws by Seton Stiebert, Daniella Echeverría, Philip Gass, Lucy Kitson on April 1, 2019]	Noted - No literature has been not considered, and those papers were already evaluated.	|Claude Lorea	GCCA	Belgium
1197	27	20	27	20	To avoid confustion, I suggest adding to the end of this line as follows, "…but surprisingly, other than steel…"	Accepted - There was an error on the sentence	Reid Miner	Private Consultant	United States of America
56401	27	20	27	21	Wood has higher embodied energy than steel and concrete? What is the explanation for this? Is sunlight counted as energy here? Is this the energy required to saw wood into building lumber?	Accepted - There was an error on the sentence. The whole sentence was rewritten.	Government of United States of America	U.S. Department of State	United States of America
11935	27	20	27	22	Contradicting statement about embodied energy of wood in the same sentence.	Accepted - There was an error on the sentence. The whole sentence was rewritten.	Anjali Sharma	Research, Projects and Collaborative initiatives, Delhi.	India
1199	27	21	27	21	For purposes of helping the reader understand the reasons behing the observations in this sentence, I suggest a parenthetical be added, as follows. "…,wood has the highest embodied energy (most of it from biomass),…"	Noted - also there was an error on the whole sentence	Reid Miner	Private Consultant	United States of America
43659	27	21	27	21	A general statement on embodied energy/carbon of wood does not make sense. A distinction must be made between embodied energy, non renewable; embodied energy, renewable; calorific value; GWP fossil; GWP biogenic, carbon content. It is suggested to address the special features of a life cycle assessment of wood (0/0 versus -1/1).	Rejected - there was not enough data on literature to study that	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
60585	27	21	27	21	Wood does NOT have the highest embodied energy, even according to the data in this section	Accepted - There was an error on the sentence	Evyatar Erell	Ben-Gurion University of the Negev	Israel
70089	27	21	27	21	The results on wood are a bit surprising and should be a bit more discussed with some more context	Accepted - Explanations were enlarged	Cellura Maurizio	University of Palermo	Italy
47813	27	21	27	22	On the other hand, earth materials and wood have the lowest 21embodied carbon, with less than 0.01 kg CO2per kg of material(Cabeza et al. 2021). Calculation used for wood can be discussed. To have negative impact, one need to consider only cradle to gate and to include biogenic calculation in contribution to climate change. Usually, GWP100 only include fossil emissions and biogenic methane. When biogenic CO2 is considered then cradle to grave approach is recommended (-1/+1). Finally, recently dynamic LCA calculation emerged which allow to show the interest of biobased materials. But then the growth rate of species count and timber construction is therefore less negative. It seems these values do not use appropriate calculation methods. Ref: Hoxha E., Passer A., Ruschi Mendes Saade M., Trigaux D., Shuttleworth A., Pittau F., Allacker K., Habert G. 2020. Biogenic carbon in buildings: a critical overview of LCA methods. Buildings and Cities. 1(1), 504–524. DOI: http://doi.org/10.5334/bc.46. Or such ref : Levasseur, A., Lesage, P., Margni, M., Deschênes, L., & Samson, R. (2010). Considering time in LCA: Dynamic LCA and its application to global warming impact assessments. Environmental Science & Technology, 44(8), 3169–3174. DOI: https://doi.org/10.1021/es9030003. Finally this ref: Guest, G., Cherubini, F., & Strømman, A. H. (2013). Global warming potential of carbon dioxide emissions from biomass stored in the anthroposphere and used for bioenergy at end of life. Journal of Industrial Ecology, 17, 20–30. DOI: https://doi.org/10.1111/j.1530-9290.2012.00507.x	Noted - But, the selected values are the ones reported in the literature. no calculation was carried out in this study	Guillaume Habert	ETH Zurich	Switzerland
78207	27	21	27	22	Contradiction- wood having both high and low embodied energy? Failed to understand this.	Accepted - There was an error on the sentence	SUCHANDRA BARDHAN	Jadavpur University	India
79687	27	21	27	22	According to the existing standards (EN 15804:A2) the full life clycle needs to be adresses (modules A-C and D); In the calculations, it seems these values do not use appropriate calculation methods. See: Hoxha, E., Passer, A., Saade, M. R. M., Trigaux, D., Shuttleworth, A., Pittau, F., Allacker, K., & Habert, G. (2020). Biogenic carbon in buildings: a critical overview of LCA methods. Buildings and Cities, 1(1), 504–524. https://doi.org/10.5334/bc.46.; Levasseur, A., Lesage, P., Margni, M., Deschênes, L., & Samson, R. (2010). Considering time in LCA: Dynamic LCA and its application to global warming impact assessments. Environmental Science & Technology, 44(8), 3169–3174. DOI: https://doi.org/10.1021/es9030003. Finally this ref: Guest, G., Cherubini, F., & Strømman, A. H. (2013). Global warming potential of carbon dioxide emissions from biomass stored in the anthroposphere and used for bioenergy at end of life. Journal of Industrial Ecology, 17, 20–30. DOI: https://doi.org/10.1111/j.1530-9290.2012.00507.x	Noted - But, the selected values are the ones reported in the literature. no calculation was carried out in this study	Alexander Passer	Graz University of Technology	Austria
5137	27	21	27	25	Further explain the difference between biogenic carbon and fossile carbon to avoid misconceptions around what type of embodied carbon that is stored in wood (it says 0.01 in the report but in reality its much more if you count biogenic + fossile carbon) and how one can say that the ration of carbon emissions to material volume is relatively small.	Reject - Definitions are included in the glossary of the report	Jonas Persson	Malmö Stad	Sweden
70099	27	21	27	25	7. "The concept of buildings as carbon sinks raise from the idea that wood stores considerable quantities of carbon with relatively small ratio of carbon emissions to material volume and concrete has substantial embodied carbon emissions with minimal carbon storage capacity" This sentence in page 9.27 should be put a bit more into context, it seems too general.	Noted - Given the space available, it is impossible to reach this level of detail. However, in the paper (Cabeza et al. 2021) this context is discussed more in depth.	Cellura Maurizio	University of Palermo	Italy
3507	27	22	27	22	Reference (Cabeza et al. 2021) is missing in the references list.	Accept - This reference is added now	Miguel Angel Sanjuán	IECA	Spain
10397	27	22	27	22	Reference (Cabeza et al. 2021) is missing in the references list.	Accept - This reference is added now	Aniceto Zaragoza	Oficemen	Spain
11553	27	22	27	22	Reference (Cabeza et al. 2021) is missing in the references list.	Accept - This reference is added now	PEDRO MORA PERIS	UNIVERSITY	Spain
6023	27	23	27	25	The chapter says, "The concept of buildings as carbon sinks raise from the idea that wood stores considerable quantities of carbon with a relatively small ratio of carbon emissions to material volume and concrete has substantial embodied carbon emissions with minimal carbon storage capacity (Churkina et al. 2020a; Sanjuán et al. 2019)." The chapter astonishingly overlooks a large volume of published literature on carbon-capturing materials and composites.	Accepted - text revised	Albert Bates	Global Village Institute	United States of America
56403	27	25	27	25	The idea that wood can store carbon depends significantly on how the wood is harvested. If it is not harvested in a sustainable way (e.g., clearcutting), it can produce significant emissions from soil carbon.	Noted - this explained in depth in the cited document (Cabeza et al. 2021)	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
3503	27	26	27	26	Please, add the following paragraph: "Some new concrete mix designs will be able to absorb a significant amount of carbon dioxide by a chemical process known as carbonation (Wang 2019; Sanjuán et al 2018; Sanjuán et al 2018). In particular, the type of cement will influence the carbon dioxide uptake potential (Goñi et al 2002). Carbonation rate is higher in blended cements (Andrade, 2020; Argiz et al 2014; Argiz et al 2017; Sanjuán et al 2019)." Wang, X.-Y. Impact of Climate Change on the Optimization of Mixture Design of Low-CO2 Concrete Containing Fly Ash and Slag. Sustainability 2019, 11, 3394. https://doi.org/10.3390/su11123394 Miguel Ángel Sanjuán, Esteban Estévez, Cristina Argiz, Daniel del Barrio. Effect of curing time on granulated blast-furnace slag cement mortars carbonation. Cement and Concrete Composites 90 (2018) 257–265. https://doi.org/10.1016/j.cemconcomp.2018.04.006 Sanjuán, M.Á.; Estévez, E.; Argiz, C. Carbon Dioxide Absorption by Blast-Furnace Slag Mortars in Function of the Curing Intensity. Energies 2019, 12(12), 2346; https://doi.org/10.3390/en12122346 Cristina Argiz; Miguel Ángel Sanjuán; Esperanza Menéndez. Coal Bottom Ash for Portland Cement Production. Advances in Materials Science and Engineering /Volume 2017 (2017), Article ID 6068286, 7 pages https://doi.org/10.1155/2017/6068286 C. Argiz, E. Menéndez, A. Moragues, M. A. Sanjuán. "Recent advances in coal bottom ash use as a new common Portland cement constituent". SEI - STRUCTURAL ENGINEERING INTERNATIONAL, 2014. Vol 24 Nº 4, pp. 503-508. http://dx.doi.org/10.2749/101686613X13768348400518 Sanjuán, M.A.; Argiz, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake in the Roadmap 2050 of the Spanish Cement Industry. Energies 2020, 13, 3452. https://doi.org/10.3390/en13133452	Accepted - Changes were made in the document	Miguel Angel Sanjuán	IECA	Spain
10393	27	26	27	26	Please, add the following paragraph: "Some new concrete mix designs will be able to absorb a significant amount of carbon dioxide by a chemical process known as carbonation (Wang 2019; Sanjuán et al 2018; Sanjuán et al 2018). In particular, the type of cement will influence the carbon dioxide uptake potential (Goñi et al 2002). Carbonation rate is higher in blended cements (Andrade, 2020; Argiz et al 2014; Argiz et al 2017; Sanjuán et al 2019)." Wang, X.-Y. Impact of Climate Change on the Optimization of Mixture Design of Low-CO2 Concrete Containing Fly Ash and Slag. Sustainability 2019, 11, 3394. https://doi.org/10.3390/su11123394 Miguel Ángel Sanjuán, Esteban Estévez, Cristina Argiz, Daniel del Barrio. Effect of curing time on granulated blast-furnace slag cement mortars carbonation. Cement and Concrete Composites 90 (2018) 257–265. https://doi.org/10.1016/j.cemconcomp.2018.04.006 Sanjuán, M.Á.; Estévez, E.; Argiz, C. Carbon Dioxide Absorption by Blast-Furnace Slag Mortars in Function of the Curing Intensity. Energies 2019, 12(12), 2346; https://doi.org/10.3390/en12122346 Cristina Argiz; Miguel Ángel Sanjuán; Esperanza Menéndez. Coal Bottom Ash for Portland Cement Production. Advances in Materials Science and Engineering /Volume 2017 (2017), Article ID 6068286, 7 pages https://doi.org/10.1155/2017/6068286 C. Argiz, E. Menéndez, A. Moragues, M. A. Sanjuán. "Recent advances in coal bottom ash use as a new common Portland cement constituent". SEI - STRUCTURAL ENGINEERING INTERNATIONAL, 2014. Vol 24 Nº 4, pp. 503-508. http://dx.doi.org/10.2749/101686613X13768348400518 Sanjuán, M.A.; Argiz, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake in the Roadmap 2050 of the Spanish Cement Industry. Energies 2020, 13, 3452. https://doi.org/10.3390/en13133452	Accepted - text revised	Aniceto Zaragoza	Oficemen	Spain
11549	27	26	27	26	Please, add the following paragraph: "Some new concrete mix designs will be able to absorb a significant amount of carbon dioxide by a chemical process known as carbonation (Wang 2019; Sanjuán et al 2018; Sanjuán et al 2018). In particular, the type of cement will influence the carbon dioxide uptake potential (Goñi et al 2002). Carbonation rate is higher in blended cements (Andrade, 2020; Argiz et al 2014; Argiz et al 2017; Sanjuán et al 2019)." Wang, X.-Y. Impact of Climate Change on the Optimization of Mixture Design of Low-CO2 Concrete Containing Fly Ash and Slag. Sustainability 2019, 11, 3394. https://doi.org/10.3390/su11123394 Miguel Ángel Sanjuán, Esteban Estévez, Cristina Argiz, Daniel del Barrio. Effect of curing time on granulated blast-furnace slag cement mortars carbonation. Cement and Concrete Composites 90 (2018) 257–265. https://doi.org/10.1016/j.cemconcomp.2018.04.006 Sanjuán, M.Á.; Estévez, E.; Argiz, C. Carbon Dioxide Absorption by Blast-Furnace Slag Mortars in Function of the Curing Intensity. Energies 2019, 12(12), 2346; https://doi.org/10.3390/en12122346 Cristina Argiz; Miguel Ángel Sanjuán; Esperanza Menéndez. Coal Bottom Ash for Portland Cement Production. Advances in Materials Science and Engineering /Volume 2017 (2017), Article ID 6068286, 7 pages https://doi.org/10.1155/2017/6068286 C. Argiz, E. Menéndez, A. Moragues, M. A. Sanjuán. "Recent advances in coal bottom ash use as a new common Portland cement constituent". SEI - STRUCTURAL ENGINEERING INTERNATIONAL, 2014. Vol 24 Nº 4, pp. 503-508. http://dx.doi.org/10.2749/101686613X13768348400518 Sanjuán, M.A.; Argiz, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake in the Roadmap 2050 of the Spanish Cement Industry. Energies 2020, 13, 3452. https://doi.org/10.3390/en13133452	Accepted - Changes were made in the document	PEDRO MORA PERIS	UNIVERSITY	Spain
28311	28	1	28	6	current wording and framing of Figure 9.10 would suggest embodied energy and embodied carbon as related to cradle to gate system boundaries (A1-A3 of EN 15978) which is not correct in my view and surely not representative of what the majority of scholars agree on. This highlights the worryingly little weight that embodied impacts receive in this chapter, when such impacts are incurred now on carbon-intensive energy grids thus locking in emissions for decades to come in our atmosphere.	Reject - This figure is a review based on the literature available and that could be compared in teh same life-span: cradle to gate	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
29645	28	1	28	6	Shows embodied energy and carbon. Please consider to include the quantities of carbon (HWP) stored as well. Please also include headlines for the figure and for panel A and B.	Rejected - Given the space available, it is impossible to reach this level of detail. The authors wanted to show the embodied enegy and carbon reported in the literature	Government of Norway	Norwegian Environment Agency	Norway
72067	28	1	28	6	Very clear illustrations and tables, easy to understand and which shows the main facts in an effective manner.	Noted - thanks for the comment	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
5139	28	3	28	4	Embodied carbon for Concrete in the grey box almost looks like it could related to the green masonry materials. Move them a bit further down in the figure to avoid misconceptions.	Rejected - Concrete (brown) and masonry materials (red) are coloured different to avoid misconceptions	Jonas Persson	Malmö Stad	Sweden
22021	28	6	28	6	"concrete block": The diagram presents concrete blocks, i.e. cinder blocks, as having a carbon footprint in a very wide range, from 0.10 Kg CO2/Kg to 1.26, which is a very high upper bound. If it is indeed a question of qualifying prefabricated concrete blocks, whether solid or hollow, their constitution (same ingredients as for concrete, but less cement and more aggregates) does not leave much room for variation in terms of carbon footprint. The lower part of the range seems consistent. This comment is based on the values in the French INIES database, and on the logic associated with the constituents of the product. The high values do not seem consistent. Concrete blocks filled with a particular filler material and acting as insulation? In this case the comparison with materials that only perform the structural or framing function may not be relevant. Is it a balance of concrete blocks transported over long distances if this happens (their production is generally well distributed over the territory)?	Noted - Authors know that there is a high variability among the embodied carbon. However, if supplementary cementitious materials are added as partial replacement of cement, the emdied carbon can decrease. The reported results are the ones found in the literature and the higher amount of Porland cement leads to higher embodied carbon, while blended cements contribute to decrease it.	Government of France	Ministère de la Transition écologique et solidaire	France
56405	28	6	28	6	Figure numbering is askew.	Editorial - change included	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
69739	29	1	29	7	The most important technological development since AR5 potentially affecting the GHG emissions from the building sector, while outside this very sector, is the sharp decrease in the cost of electricity-generating renewable energy technologies, notably solar PV and wind power. Whether off grid, on grid or in mini-grids, this change has deep implications on the ways decarbonising the building sector can be done, and put a much stronger impetus on electrification of heating and cooking (and lighting), but is also relevant on already-electrified services such as cooling (air-conditioning and coolilng in warehouses, shops, etc.	Noted - considered in Section 9.6	Cédric PHILIBERT	Institut Français des Relations Internationales	France
3663	29	1	31	25	This sector is talking about “Technological developments since”. However, it only consists “9.4.3.2 Appliances and lighting”. It suggested to delate the title of 9.4.3.1 and 9.4.3.2.	Accepted - text revised	Xinyan Yang	China Academy of Building Research	China
86053	29	5			There is a considerable body of research on technologies and strategies for net zero GHG emission buildings as illustrated in the Norwegian pilot buildings. Please see: 1) Zero Emission Buildings Edited by Anne Grete Hestnes and Nancy Lea Eik-NesFagbokforlaget,5068 Bergen, Norway; 2017; ISBN 9788245020557 2) Marianne Kjendseth Wiik, Selamawit Mamo Fufa, Torhildur Kristjansdottir, Inger Andresen, Lessons learnt from embodied GHG emission calculations in zero emission buildings (ZEBs) from the Norwegian ZEB research centre, Energy and Buildings, Volume 165, 2018, Pages 25-34, ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2018.01.025. 3) Aoife Houlihan Wiberg, Laurent Georges, Tor Helge Dokka, Matthias Haase, Berit Time, Anne G. Lien, Sofie Mellegård, Mette Maltha, A net zero emission concept analysis of a single-family house, Energy and Buildings, Volume 74, 2014, Pages 101-110, ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2014.01.037.	Noted - But the authors wanted to summarize some technologies. The body of knowledge is very wide and we tried to summarize.	Aoife Houlihan Wiberg	The Belfast School of Architecture and the Built Environment, Ulster University, UK	United Kingdom (of Great Britain and Northern Ireland)
72069	29	8	29		The information is very clear on the labelling and the increase in the number of appliances, but information on the replacement frequency of appliances would be interesting to consider as the evolution of their average lifetime is also key for the evolution of the manufacturing emissions (in particular for the appliances with electronics)	Rejected: Data not available on the replacement rates	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
3275	29	8	29	8	It would be helpful to provide a graphic showing the percentage of total building energy use that plug loads (appliances) accounts for, to emphasise how important this topic is. Our energy modeling of various building types shows plug loads now represent 40-50% of energy use, due to both increased appliance use and intensity, and increased efficiency of HVAC and lighting which means plug loads are a greater share of overall energy use. This has become a significant issue when design teams are asked to achieve energy savings but the majority of operational energy use is beyond our control and instead determined by occupant use and behaviour.	Rejected: Data not available for different regions at the time of drafting	Rachel Bannon-Godfrey	Stantec	United States of America
56407	29	8	31	25	Section 9.4.3.2 seems to have little or no mention of fossil fuel using appliances. This may be because the authors assume that fossil fuels just need to be eliminated, but it is a true statement that fossil fuels are used in many countries for heating, cooking, and water heating. "Cleaner" fossil fuels like natural gas may be needed to help transition countries from traditional biomass or coal usage as well, before those countries can make the switch to an all-electric future. While there is undoubtedly great enthusiasm among the authors for electrification, ignoring the reality of fossil fuel usage is a shortcoming of this section.	Accepted - text revised	Government of United States of America	U.S. Department of State	United States of America
56409	29	9	29	21	There is no mention of how Smart Building and IoT appliances impact energy use. This is addressed in Box 5 and it would be helpful to have a cross-reference pointing the reader to that discussion.	Accepted - paragraph amended, added a sentence referring to the IoT	Government of United States of America	U.S. Department of State	United States of America
43661	29	9	29	9	It is not always common practice to attribute household electricity consumption to the building. A module B 6.3 was introduced in the European standards with respect the to life cycle assessment of buildings (i.e. EN 15978) in order to be able to do this transparently. This should be explained here.	Rejected: The attribution of electricity consumption to buildings is not done by IPCC authors. It is done by teh owners of the data projected in the report	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
44085	29	21	29	26	Change the efficiency measure “Evaporative Condensers” to “Adiabatic/Evaporative Condensers” in Figure 9.11 Energy savings potential of technology strategies for climate change mitigation in buildings. Refer to comments and references in response to Table SM 9.2 Page 159 lines 1 to 4. At this point perhaps summarise that “adiabatic condensers” have pre-coolers that draw ambient air through spray mist or porous humidification pads. Adiabatic evaporation of water in the entering airstream boosts the cooling capacity of direct expansion vapour-compression refrigeration, or reduces work load of the compressor.	Accepted - figure 9.11 modified	Eric Peterson	University of Leeds	United Kingdom (of Great Britain and Northern Ireland)
4275	29	22	29	23	Proposed change: Change the explanation for sufficiency to “Sufficiency include those measures that do not require energy during their operation” REASON: Those measures actually require energy to be implemented (They need to be fabricated, processed and transported to the construction site), and the current version of the text could lead to confusion. The new version also accords with the approach in the previous sections, which makes emphasis on the LCA assessment.	Accepted: See definition of sufficiency provided in Box 9.1	Pulido Arcas Jesús Alberto	The University of Tokyo	Japan
29939	29	22	29	23	If I understand the figure correctly, mitigation measures such as green roofs, cool ponds and vertical greenery systems are categorised here as "Sufficiency" measures. In WGII SOD Chapter 6 these and similar measures seems to fall under the label of "nature-based solutions" (referring to WGII chapter 6.3.3.1. Temperature Regulation, page 52, line 6 to 20). However the term "nature-based" seems not to be used to describe these (seemingly very similar) concepts in Chapter 9 Buildings in WGIII. They are highlighted in WGII Ch. 6 as a solution combining mitigation and adaptation, specifically contributing to lowering temperature and energy cost. If relevant, it would be an advantage to refer to the same terms/concepts where possible, across adaptation and mitigation. Is it relevant to refer to some of the measures listed as "sufficiency" in chapter 9 as "nature-based solutions" as featured in chapter 9 in the adaptation report? E.g. "some of these sufficiency measures are also known as nature-based solutions, due to...[definition/explanation]". We also note that it seems like some of these measures are referred to as nature-based solutions in the SPM (p 23, line 10). Please ensure consistency throughout this chapter, Technical Summary and SPM, and if appropriate across all relevant chapters and Working groups. You might consider making a cross-working group Box on Nature-based solutions? Finally, we ask you to consider including some of the nature-based solutions measures in the Executive Summary of this chapter (e.g. paragraph on page 4 line 25-35).	Noted: consistency checked	Government of Norway	Norwegian Environment Agency	Norway
45529	29	22	29	23	I think the use of the term "sufficiency" is not used consistently across the chapter. In Box 9.1 it is defined as the reduction of the use of energy services (e.g. reduce m2). But in this figure insulation and other technical measures are categorized as sufficiency, whereas these typically would count as efficiency in the Box 9.1 definition.	Accepted: see box 9.1 on the definition of sufficiency. It includes all the measures that do not consumme energy in the use phase	Kornelis Blok	Delft University of Technology	Netherlands
56411	29	22	29	24	This does not align with the previous definition of sufficiency. That definition had more to do with people learning to accept smaller homes and fewer "luxuries" than efficiency measures like insulation.	Accepted: see box 9.1 on the definition of sufficiency. It includes all the measures that do not consumme energy in the use phase	Government of United States of America	U.S. Department of State	United States of America
56413	29	22	29	26	It seems like this should also mention district energy as well as efficient windows. Likewise, shading is a major passive technology, and in developing (hot) countries, water elements on the lowest level of the building are more common than roof ponds.	Noted - District level is considered in the Chapter on Cities	Government of United States of America	U.S. Department of State	United States of America
72071	29	22	29	26	The definition of "sufficiency measures" given in the figure 9.11 might not be fully consistent with the definitions of "sufficiency" provided in Box 9.1 - Fig 1. In Fig 9.11, it seems that sufficiency is associated with insulation measures (building envelop) whereas in Box 1.1 sufficiency seems to be associated with reduction of the demand for material and energy and has a lot to do with organisational aspects and behaviour. In page 73, energy efficiency is also discussed in a way which is more close to behaviour aspects.	Accepted: see box 9.1 on the definition of sufficiency. It includes all the measures that do not consumme energy in the use phase	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
86649	29	22			Figure 9.11 needs placing somewhere else. Its in a section on appliances and lighting and talks about things like Trombe Walls and Green roofs!	Editorial - Figure 9.11 is called in "Section 9.4.3.1 - Overview of technological developments"	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
22023	29	24	29	24	Please not that the legend does not seem to appropriately represent the potentials, at least for the items using greenery, as the sources refered to are very different. (SM9.1) Greenery efficacity relies on the climate : it's efficient in hot climate, and on non insulated buildings. It's a litte hazardous to display efficiency level without mention of the areas of application. The difference between the result for green wall and for green roof is surprising, it seams to be the consequence of the few particular examples taken in reference in SM9.1.	Rejected - The reviewer is right, but the table and the potencial is written for every climate studied and found in the literature. The areas of aplication are considered as climate zones.	Government of France	Ministère de la Transition écologique et solidaire	France
2309	29	24	29	25	Figure 9.11 does not include air source heat pumps in the renewable energy category. Also ground source heat pumps and deep geothermal should be investigated separately, since they are different technologies with varying operation and performance	Noted - considered when revising figures and text	Siddarth Durga	PNNL	United States of America
82021	29	24	29	26	Another literature (which is already cited elsewhere in this chapter) which can be informative here is Langevin et al (2019) https://doi.org/10.1016/j.joule.2019.07.013	Accept - Reference added	Berrill Peter	Yale University	United States of America
78209	29				Fig. 9.11: certain sufficiency measures like vertical green, green roof will also have water requirement. The water-energy nexus may be interesting to study.	Noted - Due to space restrictions, this was not included	SUCHANDRA BARDHAN	Jadavpur University	India
72953	29		29		table 9.11 may need to be updated as several aspects do not look right eg Solar PV and Solar Thermal difference are now less than shown - perhaps data needs to be updated? Need to add 'airtigntness' to Sufficiency (Table SM9.1)	Accepted - table was redone	David Gale	Gale & Snowden Architedcts Ltd	United Kingdom (of Great Britain and Northern Ireland)
74967	29		29		Consider including MEPS development process and approved appliances in Kenya as well as lighting options and programs including LED lighting and Government interventions in switching	The authors thank the suggestion, but have not found scientific literature to cite on the subject.	Government of Kenya	Kenya Meteorological Service	Kenya
79127	29		57		Naturally, technology marches on. For example, Swiss low-lift miniature high-speed heat pumps delivering 6–15 units of domestic hot water per unit of electricity (for 13–31K lift) have entered the EU market, while the Maravić (also Swiss) electric cooktop with smart controls and vacuum-insulated pots has also been validated by California Energy Commission and German tests to save 2.5–4+x compared with induction. In April 2021, the India-centered Global Cooling Prize will announce the winners of its contest to develop affordable window air conditioners with ≥5x lower climate impact; two of the finalists, both major manufacturers of air conditioners, seem to have achieved >10x. Perhaps the most important missing item in Fig 9.11 is the 2019 (published 1 Sep 2020 by PNAS) demonstration of purely radiative comfort cooling in tropical climates: Teitelbaum et al 2020 (doi:10.1073/pnas.2001678117) showed outdoor comfort in Singapore, without fans or breezes, by radiant cooling panels (separated from humid air by airgapped polyethylene film 82% transmissive of far-IR radiation from the body) at, say, 25-27 ˚C in 32˚C ambient air with 80% RH. This 5–7K cooling could be provided passively by several kinds of mainly Stanford-developed passive radiators, rejecting >100 W/m^2 even in direct sunlight so they remain cool to the touch. That in turn implies the feasibility of passive cooling indoors (and in vehicles), plausibly retrofittable onto masonry interior walls, using no electricity, even in the most severe hot/humid climates. This seems especially important to sections like 9.7.1 that focus on space cooling. I'm not sure where such innovations belong in this chapter--probably in text, maybe in 9.6.3, not this specific Figure—but I suggest they be offered as important examples of rather dramatic continuing improvements that represent an important downward intensity trend, often with improved service quality and attractive economics.	Accepted - considered in Section 9.4	Amory B. Lovins	Rocky Mountain Institute; also Adjunct Professor of Environmental & Civil Engineering, Stanford University	United States of America
56415	30	17	30	17	Is "brown appliances" a term of art?	Noted - "brown applicances" is a term widly used in the literature	Government of United States of America	U.S. Department of State	United States of America
49661	30	17	30	18	"An instresting point to be highlighted is the relation between water consumption and appliances energy efficiency" -The sentence needs explanation regarding what is the relation acheived? Reference for the above needs to be stated.	Noted - thank you for your comment, but due to space limitations, we are unable to include the recommended point.	Satyaprakas Das Das	Manipal Academy of Higher Education	India
82023	30	17	30	18	It is unclear what is the relationship being referred to here, and how it relates to Figure 9.12?	Noted - text was revised	Berrill Peter	Yale University	United States of America
19923	30	21	30	28	I think it's worth noting the differences between energy labels here. Whilst early labels (i.e. EnergyStar) work on a relative basis (i.e. most efficient models within an appliance category), the most globally dominant are those that adopt the Minimum Energy Performance Standard (MEPS) approach. Greater harmonisation of energy labelling around the MEPS approach shows the greatest potential for driving increased appliance energy efficiency.	Noted - thank you for your comment, but due to space limitations, we are unable to include the recommended point.	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
86651	30	21			This section would be better in the description fo policy instruments later. There is much to learn from the 'market transformation' achieved through a combination of policies. The evidence in appliances allowed the development (in the EU) of the Energy Performance certificate for buildings. There could be an important cross-reference to market transformation in chapter 16 on innovation. But there are significant factual errors here. US labels first appeared in the 1970s. EU labels followed in the 1990s AFTER the Danes and Dutch wanted to introduce national programmes based on the US model. There was CONSIDERABLE research prior to intorduction of a label both in the US and in the EU (though not necessarily in the academic literature it was in the government policy domain). There was also post-introduction research on effectiveness. There is a huge literature in this. See for instance https://www.sciencedirect.com/science/article/abs/pii/S0378778896010134 which was written shortly after the EU labels and for a wider more up to date review of appliance programmes See https://www.osti.gov/servlets/purl/836221. I dont know why the chart in 9.12 starts in 2000, there is research going back to the 1970s oil crisis in the US, and to the 1990s in Europe.	Noted - the section was modified .	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
2311	30	31	30	31	The authors can consider using contrasting colors for the figure labels. It is difficult to parse the different shades of blue - which show important results	Editorial - figures will be re-formatted during the production phase of the report to be in line with IPCC visual guidance	Siddarth Durga	PNNL	United States of America
10749	30	31	30	31	On figure 9.12 colours are too close to allow unambiguous discrimination. You might combine colour and shape codes.	Editorial - figures will be re-formatted during the production phase of the report to be in line with IPCC visual guidance	Philippe Waldteufel	CNRS	France
22025	30	31	30	31	Please note that the colour shades are not always identifiable which can lead to confusion.	Editorial - figures will be re-formatted during the production phase of the report to be in line with IPCC visual guidance	Government of France	Ministère de la Transition écologique et solidaire	France
14707	30	54	61	9	For an overview and quantification of multiple benefits of investing in energy efficiency please see BPIE (2018): Building 4 people: Quantifying the benefits of energy renovation investments in schools, offices and hospitals. https://www.bpie.eu/wp-content/uploads/2018/12/BPIE_methodology_031218.pdf	Accepted - reference added to chapter	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
78211	30				Fig. 9.12: water pumps may be included.	Rejected - Water pumps are not in the scope of the study carried out for Figure 9.13.	SUCHANDRA BARDHAN	Jadavpur University	India
56417	31	1	31	25	There are several major areas of technology development that are not included. These include smart meters and controls, grid-integrated buildings, storage technologies, and EV connections in buildings. These also need some degree of discussion. In addition, there is a growing effort to do remote inspections of buildings, including using drones, robotics, and advanced computing, in order to assess buildings for code compliance, for operational performance, and options for energy efficient retrofits.	Taken into account - combined with other comment 43663	Government of United States of America	U.S. Department of State	United States of America
60587	31	2	31	2	Lighting does not account for 19% of global electricity consumption. The figure is apparently from a 2006 IEA report, and are at least 15 years out of date. The 3 sources cited either do not provide this figure at all, or they are secondary.	Accepted - data was updated	Evyatar Erell	Ben-Gurion University of the Negev	Israel
43663	31	16	31	16	Table 9.1: In Germany, the English translation of VDI 3807 - Part 4 contains reference values for lighting in W/m² and kWh/m²	Accepted - data was updated	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
56419	31	22	31	23	GIS and LIDAR are used in *appliance* monitoring? This entire sentence does not belong here. This is a section about appliances.	Accepted - sentence deleted	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56421	31	25	31	25	Suggested new or additional content for Section 9.4.3, perhaps as 9.4.3.3: ""Complementing equipment focused gains, advanced controls and continuous analytics technologies offer tremendous opportunity for zero carbon buildings. Leveraging cloud-based software, smart meter data, and traditional as well as IoT sensing, SHEMS (smart home energy management systems), and commercial building EMIS (energy management and information systems) reveal otherwise hidden operational waste in buildings. For example, users of continuous fault detection and diagnostics software have been documented to save 9% in whole-building level energy use, with 2-year payback; users of smart meter analytics were documented to save 3% also with a 2-year payback (Kramer et al., 2020). Additionally, these technologies enable analysis and visualization of temporal (sub hourly) and seasonal dimensions of energy consumption, which are critical to ensuring and quantifying zero carbon operational performance."" Reference: Kramer, H., Lin, G., Curtin, C., Crowe, E., and Granderson, J. Proving the Business Case for Building Analytics. Lawrence Berkeley National Laboratory, October 2020. https://doi.org/10.20357/B7G022	Noted - thanks for the comment. A sentence on this was added to section 9.4.3.2 but due to space limitations, we are unable to create a new section.	Government of United States of America	U.S. Department of State	United States of America
56423	31	25	31	26	Include a new section about Advanced Control: ""Improved control of commercial buildings can reduce site energy by appromxately 29% for a representative range of commercial buildings in the United States (Fernandez, 2017). With the recent need of buildings to also provide load flexibility to electric grids, the need for control methods that are adaptive and predictive are increasing. Among these methods, Automated Demand Response, enabled by the OpenADR Standard (IEC 62746-10-1:2018), uses two-way communication to send price or event signals from grid/market operators to loads. Customers typically employ pre-programmed rules to respond to these signals by reducing loads for time scales from seconds to hours. Another promising control method that is not yet widely deployed is Model Predictive Control (MPC) (Drgona et al., 2020). MPC incorporates forecasts of weather, occupancy, and building performance into deciding how to best respond to price signals. In doing so, MPC can direct operation towards various control objectives, such as minimizing total operating cost or peak demand, and account for operating constraints, such as building temperature, energy system capacity, and needs for load curtailment."" References: Fernandez, Nick, Katipamula, Srinivas, Wang, Weimin, Xie, Yulong, and Zhao, Mingjie. Energy savings potential from improved building controls for the US commercial building sector. United States: N. p., 2017. Web. doi:10.1007/s12053-017-9569-5. Drgona, Javier Arroyo, Iago Cupeiro Figueroa, David Blum, Krzysztof Arendt, Donghun Kim, Enric Perarnau Olla, Juraj Oravec, Michael Wetter, Draguna L. Vrabie, Lieve Helsen. All you need to know about model predictive control for buildings. Annual Reviews in Control, 2020. https://doi.org/10.1016/j.arcontrol.2020.09.001	Rejected - due to lack of space	Government of United States of America	U.S. Department of State	United States of America
47815	31	26	31	26	The case studies presented here are incomplete and very strangely chosen. They don't cover the building stock: Warehouse, historic and heritage buildings, positive energy buildings, district energy network. Somehow they probably miss the largest part of the buildings: the existing but not historic (1945 to 2020) residential and non-residential. And the new construction which are not net positive… What is the aim of this case study part? If objective is to gather understanding of current situation then Röck et al, gathered 400 building and calculated with coherent and comparable system boundaries operation and embodied emissions.They clearly show that the hidden challenge lies on the embodied emissions which have not improved over time. Ref: Röck M., Mendes Saade M.R., Balouktsi M., Nygaard Rasmussen F., Birgisdottird H., Frischknecht R., Habert G., Lützkendorf T., Passer A. 2020. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy. 258, 114107. DOI: 10.1016/j.apenergy.2019.114107	Noted - These cases studies were added to highlight the progress on the state of the art since AR5. Embodied energy is considered earlier.	Guillaume Habert	ETH Zurich	Switzerland
79425	31	26	31	26	The cases chosen here do not seem to be representative for the building stock, as they do not include residential and non-residential buildings of the 1945-2020 period, which will represent the majority of buildings in buildings stocks in most countries. complete and very strangely chosen. This section may want to refer to Röck et al 2020, who gathered more than 600 building LCA case studies to analyse the development of operational and embodied emissions across buildings' life cycle.The study shows that embodied GHG emissions present a hidden challenge for effective climate change mitigation, in particular as the "carbon spike" from new building production dominates the timeframeof mitigation until 2050. - see: Röck M., Mendes Saade M.R., Balouktsi M., Nygaard Rasmussen F., Birgisdottird H., Frischknecht R., Habert G., Lützkendorf T., Passer A. 2020. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy. 258, 114107. DOI: 10.1016/j.apenergy.2019.114107	Noted - These cases studies were added to highlight the progress on the state of the art since AR5. Embodied energy is considered earlier.	Martin Röck	KU Leuven	Austria
56425	31	26	32	34	What are these "case studies" of? What are they supposed to demonstrate?	Noted - These cases studies were added to highlight the progress on the state of the art since AR5. Embodied energy is considered earlier.	Government of United States of America	U.S. Department of State	United States of America
4277	31	28	31	28	Proposed change: Add the following text. Although warehouses are not specifically designed to provide their inhabitants with comfort because they are mainly unoccupied, the impact of their activities in the global GHG emissions is remarkable REASON: Just to make it clear that, contrary to the majority of buildings, whose main purpose is to provide their inhabitants with comfort, in those buildings the major purpose is to store goods and deliver them.	Accepted - Text added	Pulido Arcas Jesús Alberto	The University of Tokyo	Japan
49663	31	31	31	32	The assumption made about the warehouses logistic activities need to have relevant citation.	Noted - A reference is already there	Satyaprakas Das Das	Manipal Academy of Higher Education	India
30501	32	4	32	15	We propose, there shall be coverage of historical and heritage buildings other than European countries. Such building stock is too important to be overlooked in the world regions.	Noted - Literature is scarce, specially that related to CO2 emissions	Kum Weng Yong	KW Yong Architect (Professional architect practice)	Malaysia
44091	32	4	32	15	Case studies 9.4.4.2 Historical and heritage buildings. English Heritage has listed early exemplars of the Brutalist movement that are now 50 years old [4] – already a quarter of century later than 1945 threshold. Retrofitting required some very creative attention to building envelope boundaries in this case study, where I was lead author. It is a wicked problem that renovation of heritage buildings is a taboo subject, because the thermal mass of ancient stone buildings would serve as thermal energy storage reservoirs if transparent insulation or Trombe glazing could clad over existing stone walls. 4.Peterson, E., et al., Transition Engineering urban canyons - Roger Stevens Cooling Pond, Leeds, in Fourth International SEEDS Conference, L. Scott and C. Gorse, Editors. 2018, Leeds Sustainability Institute: Dublin Institute of Technology, Dublin, Ireland. p. 110-121 https://datamillnorth.org/download/urban-canyons/1359ffbf-13bb-4d5f-b8ec-3c44a673cb5a/Peterson_et_al_2018.pdf	Noted - References with specific case studies cannot be added, as there would be too many	Eric Peterson	University of Leeds	United Kingdom (of Great Britain and Northern Ireland)
78213	32	4	32	15	This is a bit tricky. Historical buildings are more often than not found to be built in harmony with the local climate, thus making these more thermally comfortable without energy appliances. Repurposing these could be more advantageous with favourable policy attention (like incentives) unless these are of poor structural health.	Noted - References on this issue are not available	SUCHANDRA BARDHAN	Jadavpur University	India
22027	32	5	32	6	There is big differences in terms of energy need for space heating between well-maintened historical buildings and historical building in poor state. In France and in part of Europe, buildings built in 1955-1975 usually need more energy for space heating than historical building. R. Cantin, J. Burgholzer, G. Guarracino, B. Moujalled, S. Tamelikecht, B.G. Royet, Field assessment of thermal behaviour of historical dwellings in France, Building and Environment, Volume 45, Issue 2, 2010, Pages 473-484, ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2009.07.010.	Noted - The need of good maintenance of buildings is considered in another section	Government of France	Ministère de la Transition écologique et solidaire	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
19925	32	5	32	7	I'm far from convinced that this statement is true, and the use of the term 'historic' is potentially misleading as it brings to mind images of castles and other buildings of historic value where improvements may be limited by their protected status. Here in Scotland we have large numbers of traditional tenements (~30% of the domestic stock) which can exhibit high levels of energy performance if they are maintained and upgraded with basic energy efficiency measures. I recommend amending this section to distinguish between 'historic' and 'traditional' buildings, and to note the impact of (lack of) maintenance in figures for their energy performance. I don't know if similar situations exist in other countries where traditional buildings are still common but this could be clarified.	Noted - This nomenclature is widly accepted	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
43013	32	5	32	7	In our humble opinion, this Section content is quite limited to the context of European region. Hence, it could not represent the vastness of historical and heritage buildings worldwide. For evidence, we have conducted field measurements of thermal performance in historical buildings in Malaysia and they are actually superior to modern buildings. Hence, it is too simplistic to generalize that these are low-performance buildings. The context in tropical climate and cooling by natural ventilation is much different from the space heating in Europe. We propose, to include different world regions in this Section. Since tropical region is a dominant region on the world map, it deserves some mention or review in this section in the AR6.	Noted - Literature is scarce, specially that related to CO2 emissions	Doris Toe	Universiti Teknologi Malaysia	Malaysia
9981	32	7			The definition of historical buildings in this paragraph needs to be elaborated as it does not only determined by the age but also significant historical values. In Indonesian case, historical buildings built by the Dutch prior to 1945 tend to be in contrary to this paragraph as most of them still have good structures as well as large window openings and high ceilings which allow for cross ventilation, sufficient indoor daylight, and comfortable indoor temperature.	Noted - This nomenclature is widly accepted	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
22029	32	13	32	15	A European standart aims to give a method for retrofitting project when an historical building is concerned : EN 16883:2017 standard, Conservation of cultural heritage	Noted - not relevant here	Government of France	Ministère de la Transition écologique et solidaire	France
49665	32	13	32	15	The statement can have more clarity with inclusive of intergration of multiple renewable energy.	Rejected - why only with multiple RES?	Satyaprakas Das Das	Manipal Academy of Higher Education	India
47817	32	14	32	14	Considering uncertainties in LCA modelling, it is possible to show that robust renovation scenario should focus in priority on heating systems and do not necessarily have the priority of reducing energy demand. Galimshina A., Moustapha M., Hollberg A., Padey P., Lasvaux S., Sudret B., Habert G. 2020. Statistical method to identify robust building renovation choices for environmental and economic performance. Building and environment, 183, 107143. DOI: 10.1016/j.buildenv.2020.107143	Noted - The impact of renovation in costs is included in Section 9.6	Guillaume Habert	ETH Zurich	Switzerland
16521	32	16			I suggest that you change 'Positive energy or energy plus buildings' to 'Intergration of renewables in buildings'.	Rejected - The concept is different	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17027	32	16			I suggest that you change 'Positive energy or energy plus buildings' to 'Intergration of renewables in buildings'.	Rejected - The concept is different	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
4279	32	16	32	16	Proposed change: Change the title of this section to “Low energy buildings, zero energy buildings and positive energy buildings” REASON: Positive energy buildings are, surely, a state-of-the-art standard, but it should be advisable to explain also other standards which are more realistic in the current state of affairs. Positive buildings are still a dream for underdeveloped and many developed countries.	Rejected - The overall chapter concept is to be ambitious and to aim at positive energy buildings	Pulido Arcas Jesús Alberto	The University of Tokyo	Japan
43665	32	16	32	16	It is proposed to also present buildings that achieve (net) zero GHG emissions in the use stage. The discussion of the corresponding definitions should also be considered. See, among others, https://journal-buildingscities.org/article/10.5334/bc.66/ and https://www.sciencedirect.com/science/article/pii/S0360132321000329	Noted - Definitions are in the glossary of the report.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
56427	32	16	32	26	Section 9.4.4.3 refers to "positive energy" and "energy plus buildings". While the term "energy plus buildings" may actually be used in some publications, this is very unfortunate terminology for readers from the U.S. There is a whole building energy simulation tool developed by the U.S. Department of Energy with the name of "EnergyPlus" and the opportunities for confusion between a building simulated with EnergyPlus and an "energy plus building" are great. See https://energyplus.net/ for reference to the simulation tool. Perhaps the solution would be a footnote advising the reader not to confuse these "energy plus buildings" with "EnergyPlus".	Noted - Definitions are in the glossary of the report.	Government of United States of America	U.S. Department of State	United States of America
56429	32	16	32	26	Not sure why these case study types were selected, but would hope to see some other options including multi-family. In particular on the section about positive buildings, would suggest adding a reference to the potential for battery-backed onsite renewables to help shift load and shave peak demand from the grid.	Accepted - added in the text	Government of United States of America	U.S. Department of State	United States of America
4281	32	17	32	17	Proposed change: Add the following text at the beginning of the section. One of the main trends that has emerged in the last years in the possibility of ultra-efficient buildings, which demand a very small amount of energy, combined with on-site generation. In this context, low-energy building can be defined as ultra-efficient buildings that demand very little energy in comparison with a standard building. The limit to consider a building as “low-energy”: varies depending on the country, but as a reference the EPBD (Energy Building Performance Directive) of the EU sets a limit between 12.5 and 45 kWh/m2 for new buildings depending on the climate zone. A step further considers that this small demand can be covered by onsite generation of renewable energy, so the net demand is zero, that is, a net zero energy building (nZEB). Finally, if the net balance is positive, the building is classified as a positive energy building”. (Reference: Towards nearly zero-energy buildings Definition of common principles under the EPBD. Final report - Executive Summary.) REASON: The reason accords with the reason provided for comment 7. Besides, the concept nZEB is mentioned several times across the text, so it would be advisable to have a proper definition at this point.	Noted - The term "ultra-low energy building" is not defined in the report. The concept defined here is the same that it is in the text.	Pulido Arcas Jesús Alberto	The University of Tokyo	Japan
2805	32	17	32	26	Beyong positive energy buildings, positive energ districts (PED) can be implemented. A district scale RES approach allows for the optimisation of a wider area than an individual building approach. minimum energy performance requirements imposed by energy efficiency building codes can also be applied to a cluster of buildings in a specific district	Noted - District level is considered in the Chapter on Cities	Leonardo Barreto	Head of center "EU&International"	Austria
62101	32	17	32	26	Integrating renewable energy systems increases embodied GHG emissions, but applying life cycle assessment shows that total life cycle emissions are decreased (Thiers et al., 2012). Thiers S. and Peuportier B., Energy and environmental assessment of two high energy performance residential buildings, Building and Environment, Volume 51, May 2012, Pages 276–284	Noted - both the concept and the reference are already in the text.	Bruno Peuportier	MINES ParisTech	France
78215	32	17	32	26	Other renewbales may also be discussed.	Noted - Technologies are detailed in the Supplementary material	SUCHANDRA BARDHAN	Jadavpur University	India
5457	32	18	32	20	I strongly recommend that you make clear that the highest priority is to reduce the energy consumption. The use of renewable to supply the necessary energy is a possibility but is not necessarily the optimal solution.	Noted - This is included in all the chapter with the frame around SER (see Box 9.1)	Michel SIMON	Retraité/ Pdt d'association	France
10751	32	18	32	22	why "Integration of renewables in buildings should always come after maximising the reduction in the demand for energy services"? Is this established and how? Hints of ideology are detected…	Noted - The chapter is framed around the SER concept (see Box 9.1)	Philippe Waldteufel	CNRS	France
2807	32	21	32	22	Prosumers enable new business models. For example, they can provide demand response services to the grid, for example by shifting their energy consumption to off-peak hours with lower tariffs, including through aggregators as well as storage services through batteries and, in the future, possibly electric vehicles, and energy conservation	Noted - Business models are discussed in Section 9.9	Leonardo Barreto	Head of center "EU&International"	Austria
72073	32	22	32	24	Eventually use photovoltaics instead of "PV"	Noted - Acronyms are well defined in the chapter	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
2321	32	24	32	26	Heat pumps (ASHP and GSHP) should be included as options in this section, as well as in district energy networks, where they are a vital system component.	Noted - Technologies are detailed in the Supplementary material	Siddarth Durga	PNNL	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
79689	32	25			see Low- and net-zero energy buildings – exemplary buildings; see also Passer, A., Habert, G., Kromp-Kolb, H., Lützkendorf, T., & Monsberger, M. (2019). Transition Towards a Net Zero Carbon Built Environment. The International Journal of Life Cycle Assessment, 24(2), 362–363. https://doi.org/10.1007/s11367-018-1550-9 Frischknecht, R., Balouktsi, M., Lützkendorf, T., Aumann, A., Birgisdottir, H., Ruse, E. G., Hollberg, A., Kuittinen, M., Lavagna, M., Lupišek, A., Passer, A., Peuportier, B., Ramseier, L., Röck, M., Trigaux, D., & Vancso, D. (2019). Environmental benchmarks for buildings: needs, challenges and solutions—71st LCA forum, Swiss Federal Institute of Technology, Zürich, 18 June 2019. The International Journal of Life Cycle Assessment. https://doi.org/10.1007/s11367-019-01690-y Passer, A., Balouktsi, M., Lützkendorf, T., Hinterbrandner, A., & Kreiner, H. (2017). Generating and Providing Embodied Energy and Global Warming Potential Related Information: Recommendations for Construction Product Manufacturers. World Sustainable Built Environment Conference 2017, 989–995. Frischknecht, R., Birgisdottir, H., Chae, C.-U., Lützkendorf, T., Passer, A., Alsema, E., Balouktsi, M., Berg, B., Dowdell, D., García Martínez, A., Habert, G., Hollberg, A., König, H., Lasvaux, S., Llatas, C., Nygaard Rasmussen, F., Peuportier, B., Ramseier, L., Röck, M., … Yang, W. (2019). Comparison of the environmental assessment of an identical office building with national methods. IOP Conference Series: Earth and Environmental Science, 323, 012037. https://doi.org/10.1088/1755-1315/323/1/012037 Frischknecht, R., Ramseier, L., Yang, W., Birgisdottir, H., Chae, C. U., Lützkendorf, T., Passer, A., Balouktsi, M., Berg, B., Bragança, L., Butler, J., Cellura, M., Dixit, M., Dowdell, D., Francart, N., García Martínez, A., Gomes, V., Gomes Da Silva, M., Guimaraes, G., … Zara, O. (2020). Comparison of the greenhouse gas emissions of a high-rise residential building assessed with different national LCA approaches – IEA EBC Annex 72. IOP Conference Series: Earth and Environmental Science, 588, 022029. https://doi.org/10.1088/1755-1315/588/2/022029	Accepted - table was revised. Due to lack of space, no more examples were added	Alexander Passer	Graz University of Technology	Austria
2323	32	27	32	34	This section could include different generations of district energy networks and their advances in a structured and more comprehensive format. The current discussion here is very preliminary.	Noted - Due to space restrictions and that districts are also included in the chapter on cities, this was not more elaborated	Siddarth Durga	PNNL	United States of America
56431	32	27	32	34	Some district heating systems have seen a drop in energy use compared to gas boilers of closer to 100%, with 100% use of waste energy or renewables. For example, Stockholm receives a large share of its heat from waste heat recovery from buildings (such as supermarkets). District cooling is smaller than district heating but it is growing rapidly. It exists in some form in almost all major cities (for example, supplying certain districts or campus facilities).	Accepted - modified paragraph	Government of United States of America	U.S. Department of State	United States of America
64345	32	27	32	34	Lastest work on district heating is towards 5th generation heat networks that operate at lower temperatures to minimise heat loss and better integrate renewables and waste heat sources, i.e., use the least amount electricity in heat pump operation both in terms of annual volument and peak demand. This does require building codes to ensure heat emitters will operate with low supply temperatures. Buidling heating design therefore needs to be considered as part of the overall energy supply system.	Accepted - modified paragraph	Peter North	Imperial College (part-time PhD student) /Calorem Ltd	United Kingdom (of Great Britain and Northern Ireland)
2809	32	28	32	34	The description of the role of district heating and cooling could be expanded. District heating could play an important role for the decarbonisation of heating and cooling. For instance, renewable-based efficient district heating can replace natural gas heating technologies. Different heat generation technologies such as solar thermal, geothermal, biomass and biogas can be integrated in the district heating network as well as heat storage technologies. District heating can also integrate waste heat, for example coming from data centers and industry The integration of renewable sources and waste heat in district heating networks requires new approaches, such as innovative network configurations and advanced "intelligent" network controllers.	Accepted - modified paragraph	Leonardo Barreto	Head of center "EU&International"	Austria
2811	32	28	32	34	Comprehenisve assessments of energy efficiency and renewable eenergy potentials and costs can facilitate the planning of district heating systems. Furthermore, cooperation between national and local authorities is required to advance planning and implementation of investment projects.	Taken into account. Thank you for your comment. Indeed, when the switch to heat pumps+RE i	Leonardo Barreto	Head of center "EU&International"	Austria
56433	32	28	32	34	There is no mention of low temperature thermal energy districts that are being developed throughout the United States to support the shift away form natural gas to heat pumps. See https://heet.org/geomicrodistrict/. This is notably absent throughout the entire chapter and deserves at least a mention since decarbonization using heat pumps is so widely discussed.	Accepted - modified paragraph	Government of United States of America	U.S. Department of State	United States of America
63753	32	28	32	34	Alternate text suggested for this paragraph: "District heating networks have evolved from systems where heat was produced by coal or waste and storage was in the form of steam, to much higher energy efficiency networks with water or glycol as the energy carrier and fuelled by a wide range of renewable and low carbon fuels. Common low carbon fuels for district energy systems include biomass, other renewables (i.e. geothermal, PV, and large solar thermal), industry surplus heat or power-to-heat concepts, and heat storage including seasonal heat storage (Lund et al. 2018). District energy infrastructure opens opportunities for integration of several heat and power sources and is 'future proof' in the sense that the energy source can easily be converted or upgraded in the future, with heat distributed through the existing district energy network."	Accepted - modified paragraph	Government of Canada	Environment and Climate Change Canada	Canada
74219	32	28	32	34	This section should be amended to include nuclear as one of the methods of providing district heating. This technology has been widely adopted in eastern europe, Finland and Russia. https://www.world-nuclear-news.org/Articles/Haiyang-begins-commercial-scale-district-heat-supp https://www.world-nuclear.org/information-library/non-power-nuclear-applications/industry/nuclear-process-heat-for-industry.aspx	Noted - Any energy production technology could be listed here. The ones included now are those descentralized	Jeffrey Merrifield	Pillsbury Law Firm	United States of America
82025	32	28	32	34	GHG reductions from energy cogeneration or trigeneration (of electricity, heat, and cooling) are contingent on the relative system efficiencies, and relative demand for different energy services (electricity, heating, cooling). When district energy systems are fuelled by natural gas, if the competing electricity has sufficiently low GHG intensity, it can be preferable to simply use grid electricity and generate heat independently, even if that heat is generated by combusting natural gas. (https://doi.org/10.1016/j.enbuild.2012.06.014; https://doi.org/10.1016/j.enbuild.2018.05.020) If there exists simultaneous demand for heating and cooling, or when there is capacity for thermal energy storage, cogeneration of heating and cooling in electric-powered heat recovery chillers can be highly efficient. (https://doi.org/10.1016/j.enbuild.2018.05.020)	Noted - thank you very much for your feedback. Due to space restrictions we cannot add it to the chapter.	Berrill Peter	Yale University	United States of America
19927	32	31	32	31	Seasonal' should be 'inter-seasonal'.	Rejected - "Seasonal energy storage" is the common terminology used in the literature	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
3277	32	34	32	34	incomplete sentence " District cooling networks are more novel technology less widespread"	Accepted - modified paragraph	Rachel Bannon-Godfrey	Stantec	United States of America
47819	32	35	32	35	9.4.5Low-and net-zero energy buildings –exemplary building. This section covers only operation energy of building. This is confusing to have within the general chapter of Zero carbon building, one section on embodied carbon and then examples which do not consider embodied carbon to only focus on operation energy. There might be needed a clear definition of what zero carbon /zero energy net zero energy means. Lützkendorf, T., & Frischknecht, R. (2020). (Net-) zero-emission buildings: a typology of terms and definitions. Buildings and Cities, 1(1), 662–675. DOI: http://doi.org/10.5334/bc.66	The table focusses on illustative examples of low carbon buildings and net zero energy buildings without getting into the definiteional differences between zero carbon/zero energy. These are discussed in the broader chapter.	Guillaume Habert	ETH Zurich	Switzerland

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
79427	32	35	32	35	9.4.5 Low-and net-zero energy buildings –exemplary building.There seems to be a need for a clear definition terms (zero carbo, zero energy, net zero energy). See e.g.: Lützkendorf, T., & Frischknecht, R. (2020). (Net-) zero-emission buildings: a typology of terms and definitions. Buildings and Cities, 1(1), 662–675. DOI: http://doi.org/10.5334/bc.66	The table focusses on illustative examples of low carbon buildings and net zero energy buildings without getting into the definiteional differences between zero carbon/zero energy. These are discussed in the broader chapter.	Martin Röck	KU Leuven	Austria
44089	32	35	33	3	Chapter 9 Figure 9.13 (after Ürge-Vorsatz et al. 2020) is dramatic in terms of the lack of Passive Houses in outside of Europe, North America, North east Asia, Australia and NZ. Their article points out that the demand for cooling and dehumidification in the Global South likely requires air-conditioning and cannot be met with passive house standards. They point out the coincident opportunity of photovoltaic (PV) to provide the demand for cooling and particularly dehumidification. Consequently, AR6WG3 section "9.4.5 Low- and net zero energy buildings - exemplary buildings" is unsubstantiated in claiming the nearly zero energy (NZE) buildings are practical in all climate zones. Bioclimatic analysis [2] shows there are over 100 countries where passive, forced ventilation, or direct evaporative cooling designs may not be suffice during extreme heat and humidity. Air-conditioning is desirable in 34% of the global network of WMO and WBAN stations, and access to air-conditioned shelters during heat waves is recommended in at least 9% of locations [3] (due to be submitted for publication https://doi.org/10.5518/967). Certainly Passive House standard of 15 kWh/m2 is proven to be appropriate at higher latitude and higher elevations of temperature climates, but it is most certainly no assured that sustainable development goals can be accommodated in low elevation tropical and sub-tropical climates without complementary rooftop PV electricity generation as well as on-site energy storage for the time after sunset when cooling loads persist. 2.Peterson, E., Transition Engineering the water-electricity nexus operating in building services and urban heat islands – Concept Design – is air-conditioning really necessary?, in ASHRAE 3rd International Conference on Efficient Building Design. 2018, ASHRAE: American University, Beirut. https://www.techstreet.com/standards/transition-engineering-the-water-electricity-nexus-operating-in-building-services-and-urban-heat-islands-concept-design-is-air-conditioning-really-necessary?product_id=2025561#product 3.Peterson, E., Data associated with "Considering alternatives, is air-conditioning necessary?". [Dataset]. , S.o.B. Visiting Research Fellow, University of Leeds, Editor. 2021: Leeds, West Yorkshire, United Kingdom. https://doi.org/10.5518/967 (active upon publication)	Accpeted - Figure has been updated	Eric Peterson	University of Leeds	United Kingdom (of Great Britain and Northern Ireland)
56435	32	35	33	41	This section references Figure 9.13, which is very limited at least in terms of the North American projects. NBI had verified 140 commercial buidings in the U.S. and Canada alone that have achieved zero energy performance. Would like to see a more complete list included. See https://newbuildings.org/resource/getting-to-zero-database	Accepted - Figure 9.14 Modified	Government of United States of America	U.S. Department of State	United States of America
63073	32	35	33	5	Taiwan is a province of China. Please change "Taiwan" into "Taiwan, China"	Editorial - Changed	Changke WANG	National Climate Center, China Meteorological Administration	China
16523	32	35	34	1	9.4.5 -> 9.4.4.5	Rejected - The section numbering is correct	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17029	32	35	34	1	9.4.5 -> 9.4.4.5	Rejected - The section numbering is correct	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
3279	32	36	32	36	In the building industry, NZE is the standard acronym for net zero energy building. To avoid confusion, I recommend this report uses a different acronym for nearly net zero (which is not a term used widely).	Noted - Definitions are in the glossary of the report.	Rachel Bannon-Godfrey	Stantec	United States of America
82027	32	36	32	37	Regarding policies, the European Energy Performance in Buildings Directive requires all new buildings from 2021 to be NZE https://ec.europa.eu/energy/content/nzeb-24_en	Accpeted - see Section 9.9	Berrill Peter	Yale University	United States of America
2813	32	36	32	38	Nearly-zero energy buildings are still expensive. The considerably higher investment costs are one of the main barriers to the application of the NZEB concept. Cost reductions are still required and could be achieved in the medium term through innovative combinations of building envelope technologies, services systems for heating, domestic hot water, ventilation and cooling and renewable energy systems. More research and demonstration projects are required	Noted - Costs are considered in Section 9.6	Leonardo Barreto	Head of center "EU&International"	Austria
19929	32	39	32	39	Passive house' should be 'Passivhaus™' or 'passivhaus' if not refering specifically to the standard. Comment also applies to the table on page 33.	Rejected - This terminology was discussed with the Passive House association	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
17051	32	39	32	40	It is not clear whether the energy demand decrease of 75-95% refers to new buildings or retrofitted buildings.	Noted - to all buildings	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
49667	32	39	32	41	A significant point have been highlighted decrease of energy demand with passive techniques .The statement can elaborate how energy demand is decreased in passive technique with one example and relevant citation for statement.	Noted - This is already elaborated in this section and in the Supplementing material	Satyaprakas Das Das	Manipal Academy of Higher Education	India
22031	32	41	32	41	New buildings represent only a small part of the existing stocks so it is important to achieve low and NZE buildings. The IEA SHC Task 59 Renovating Historic buildings towards Zero Energy has produced a website with several exemplary low and NZE buildings in the case of global retrofitting projects with special care to architecture preservation : https://www.hiberatlas.com/fr/home-1.html	Noted - This reference was already considered when drafting this section.	Government of France	Ministère de la Transition écologique et solidaire	France
74969	32		32		Consider green buildings and net zero buildings program within the region especially in South Africa, consider also the Kenya Green buiildng Strategy	Noted - Policies are considered in Section 9.9	Government of Kenya	Kenya Meteorological Service	Kenya
15275	33	1	33	1	In Figure 9.13, the East Section and West Section of China-India Border are wrongly drawn and the Taiwan island, the Dotted Line of South China Sea, Nanhai Zhudao, Diaoyu Dao and its affiliated islands of China are missing. It is suggested to use a color block map, delete the national boundary lines, and mark the island points. As for the East Section and West Section of China-India Border, it is suggested to use a color block map or mark the line as claimed by the two sides in the disputed area.	Accepted - Map replaced by one without borders	Government of China	China Meteorological Administration	China
16497	33	1	33	1	The contents below needes to be added.	Noted - Not clear which content this comment relates to	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
3615	33	1	33	3	The key is confusing - small dots represent 1 building and larger dots represent 10 or 22?	Noted - The key shows clearly how the size of the dots gives qualitative indication of the number of buidings	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
56437	33	1	33	3	Recommend checking this site as it appears that net-zero buildings in North America are undercounted: https://newbuildings.org/nbi-releases-zero-energy-building-count-and-trends-for-2019/. There are about 600 net-zero buildings in the U.S. and Canada, which this map does not appear to capture.	Noted - This reference was already considered when drafting this section.	Government of United States of America	U.S. Department of State	United States of America
22033	33	2	33	2	The legend should be clarified. What does « buildings reported in literature » mean? What is the « passive house database » ?	Noted - All this information is very much detailed in the reference source used	Government of France	Ministère de la Transition écologique et solidaire	France
2315	33	4	33	4	The row-wise information in the Energy efficiency and renewable energy column can be categorized based on common attributes (such as building envelope, passive design features, renewables etc.). Currently, the facts in this column do not have consistency across projects.	The table provides illustrative examples and is not meant for a measure by measure comparison across cases	Siddarth Durga	PNNL	United States of America
15277	33	4	33	5	Taiwan is a province of China, not an independent country. The statement in Figure 9.2 is seriously wrong. Please change "Taiwan" to "Taiwan, Province of China".	Editorial - Corrected	Government of China	China Meteorological Administration	China

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56439	33	4	33	5	Table 9.2 references the NREL research facility as a sample project. This building is wonderful, but not representative of a typical, cost-effective project. NBI has a set of Zero Energy and Exemplary building case studies that represent common use cases. Case studies include: - Schools: https://gettingtozeroforum.org/schools/ - Multi-family: https://gettingtozeroforum.org/multifamily/ - Other commercial: https://gettingtozeroforum.org/commercial/ Residential case studies can also be found on this site.	These are useful suggestions of additional literature, including from NREL buildings, however, this table is a selection of a handfull of examples and it is beyond the scope of the table and the chapter to include all exisiting examples.	Government of United States of America	U.S. Department of State	United States of America
56441	33	4	34	1	Recommend checking that the buildings are compared with similar metrics. It looks like some of the buildings are showing reduced energy use because of onsite renewables and some are not. Would be helpful to clarify that for each example so that they can be compared apples-to-apples.	The EPIs of the buildings use the same metrics. The table is a set of illustrative examples that use both onsite RE (when listed) and/or not but without the intention of direct comparison.	Government of United States of America	U.S. Department of State	United States of America
14699	33	4	34	5	It would be useful to include more examples from develoing countries and emerging economies, as they are e.g. available on https://www.construction21.org/case-studies/#page1:local	These are useful suggestions of additional literature, however, this table is a selection of a handfull of examples and it is beyond the scope of the table and the chapter to include all exisiting examples	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
3671	33	5	33	5	1. In table 9.2 Taiwan should be Chinese Taipei 2. 2. Table 9.2 consist two buildings from Asia. During last decades, China has developed 10 million m2 nearly zero energy building. It is suggested to include the first NZEB in China, e.g. Li et al. (2021). Building name: CABR Nearly Zero Energy Building Location: China Energy efficiency and renewable energy features: Roof U-value=0.17W/m2K Exterior wall U-value=0.24 W/m2K Windows U-value=1.2 W/m2K Underground borehole and solar collectors are used in the geothermal heat pumps absorption chiller with cold storage tank Measured energy performance heating, cooling and lighting < 25 kWh/(m2 a) Maximum cooling load= 40.1 W/m2 Maximum heating load= 18.4 W/m2 Li, H., Zhang, S., Yu, Z., Wu, J., Li, B., 2021. Cooling operation analysis of multienergy systems in a nearly zero energy building. Energy and Buildings 234, 110683.	1- Editorial - changed in the text 2-These are useful suggestions of additional literature, however, this table is a selection of a handfull of examples and it is beyond the scope of the table and the chapter to include all exisiting examples	Xinyan Yang	China Academy of Building Research	China
63075	33	5	33	5	There are only two Asian demonstration buildings, Indiaand Taiwan,China in Table 9.2. During the 13th Five-Year Plan period, China's near zero energy consumption buildings developed rapidly. A demonstration building in China, described by Li et al., 2021 and obviously different from other buildings should be added in Table 9.2.	These are useful suggestions of additional literature, however, this table is a selection of a handfull of examples and it is beyond the scope of the table and the chapter to include all exisiting examples	Changke WANG	National Climate Center, China Meteorological Administration	China
56443	33	5	34	1	NREL RSF doesn't use underfloor air distribution.	Noted - removed	Government of United States of America	U.S. Department of State	United States of America
77317	33	5	34	1	Column 'Measured energy performance' in table 9.2 may be presented in a common unit e.g. kWhr/m2.yr, currently different units appear with each study making it difficult for the reader to compare	Noted - all performance measures are now in KWh/m2	Gajanana Hegde	UNFCCC (Climate Change Secretariat)	Germany
11937	33	9	33	9	Depicts passive house database largely for Europe, japan, Australia, NZ, parts of coastal of US while India, middle eastern nations African are largely not documented thus cannot be overlooked for lacking passive house systems as there are many examples both in traditional and vernacular.	These are useful suggestions of additional literature, however, this table is a selection of a handfull of examples and it is beyond the scope of the table and the chapter to include all exisiting examples	Anjali Sharma	Research, Projects and Collaborative initiatives, Delhi.	India
14701	34	2	36	16	It would be relevant to cover new emerging business models for renovation, such as summarised in this report for Europe: Benchmarking of promising approaches to integrated renovation services in Europe. https://www.bpie.eu/wp-content/uploads/2019/09/TR_D1.1_BPIE_30_08_2019_FV.pdf	Rejected due to lack of space	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
56445	34	2	36	16	It is not clear why digitalization is shown as an emerging issue rather than a technology development. There is significant experience in the U.S. implementing smart, connected buildings. Recommend also mentioning terminology differences in different parts of the world so it is easier for readers to search the document.	Rejected: It is the electricity consumption due to digitalisation that is discussed in this section and not digitalisation per se.	Government of United States of America	U.S. Department of State	United States of America
61131	34	5			while the digitalization of construction practices deserves attention in the report, my concern is that it is given more attention than the much wider and complex issue of embodied impacts. This unbalanced discussion for the embodied and operational emissions can undermine the importance of the former	Noted - Changes were made in the chapter and this was considered. Embodied and operational issues were considered in a similar way	Marcella Saade	Graz University of Technology	Austria
76545	34	5			Provide energy use also in TJ, so that the reader has a reference value to compare to the changes in Table 9.	Rejected: All figures are provided in EJ to ease comparison	Edgar Hertwich	Norwegian University of Science and Technology	Norway
3281	34	5	34	5	Table 9.2: We were the architects and energy modelers of the NREL Research Support Facility. It was completed in 2010/11, and was indeed the largest commercial net zero energy building in the world. Change the comment in the 'measured energy performance' column to reflect this was achieved. The wording suggests it is still just a goal.	Noted - changes made to show the goal was achieved	Rachel Bannon-Godfrey	Stantec	United States of America
8417	34	5	35	4	In a number of office buildings in Hong Kong certified to platinum class under the HKBEAM; with employment of IOT, data collection and analytics, additional energy saving of 10% had been achieved.	Noted - These are useful suggestions of additional literature, however, this table is a selection of a handfull of examples and it is beyond the scope of the table and the chapter to include all exisiting examples	Otto Poon	President, Hong Kong Academy of Engineering Sciences.	China
56447	34	5	36	17	Another emerging issue is the growing sprawl of major cities, including the location of subsidized, low-income housing outside of urban cores. In many countries, this is pushing very low energy use families into high energy use situations, and disconnecting people from jobs (e.g., where they go from traditional housing with limited energy for cooling because of traditional passive technologies to multi-story buildings which must be artificially cooled and lighted, and where transportation energy requirements go up significantly).	Rejected: this is out of the scope of the building chapter and is discussed in the Urban chapter	Government of United States of America	U.S. Department of State	United States of America
20339	34	6	34	7	Suggest adding the elements under brackets to the following sentence: "European Union (2019) and Witthoeft and Kosta (2017) identified seven digital technologies already in use in the building sector [and that can improve the performance of the building and/or reduce energy consumption]"	Noted: text revised	Thibaud Voïta	IFRI	Germany
56449	34	9	34	9	Are authors referring to BIM or to BEM (Building Energy Modeling)? BIM is not an analysis. It is essentially a database for storing information about a building design. The database can be queried to produce subsets of information that can drive different analyses like energy (BEM), embodied carbon (LCA), etc.	Accepted: spelled out, authors refer to BIM	Government of United States of America	U.S. Department of State	United States of America
76541	34	11			Change caption to reflect what is really shown. Change in electricity consumption from appliances …	Noted: Legend clarifies appliances included	Edgar Hertwich	Norwegian University of Science and Technology	Norway
76543	34	13			Plug loads have the largest increase, but are not discussed in the text. We do not even get to know what they are.	Noted: Legend clarifies appliances included	Edgar Hertwich	Norwegian University of Science and Technology	Norway
56451	35	1	35	2	3D printing and robotics are not yet in any significant use in the buildings sector. At least not in the U.S.	Noted	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56453	35	14	35	14	Suggested new content for Section 9.4.6: Append after ""... peer-to-peer electricity trading (Morstyn et al. 2018).": ""Analogously, for commercial buildings, the market is now offering automated system optimization technologies that provide model-predictive control strategies to dynamically modify control actions based on forecasts of required service levels (system load), weather, occupancy, and other factors (Kramer et al., 2020). These emerging technologies will be key to ensuring and scaling grid responsive low carbon buildings."" Reference: Kramer, H., Lin, G., Curtin, C., Crowe, E., and Granderson, J. Proving the Business Case for Building Analytics. Lawrence Berkeley National Laboratory, October 2020. https://doi.org/10.20357/B7G022	Noted - text was revised	Government of United States of America	U.S. Department of State	United States of America
49669	35	15	35	25	The statement has highlighted on energy demand in global scenario ,relevant citation is missing.	Accepted:	Satyaprakas Das Das	Manipal Academy of Higher Education	India
9983	35	16		30	This statement and data are repeatedly uttered in some sections, and it does not really suitable with the topic in Box 9.5 Digitalization of the building sector. The “digitalization” mentioned in this box is about using integrated information and internet-based technology in a building, not about how building use small appliances that consuming energy. This statement and data are more relatable with the topic in Box 9.6 Electricity energy demand in the building sector.	Accepted: text clarified and box moved	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
49671	35	26	35	31	The statement has highlighted on use of connected digital appliances ownership in global scenario. The statement needs more explaination corelation with energy demand ,also relevant citation is missing.	Accepted	Satyaprakas Das Das	Manipal Academy of Higher Education	India
82029	35	37	35	40	This outcome is possible, but not guaranteed, so future energy consumption from appliances is perhaps the end-use with greatest uncertainty.The multifunctionality of newer electronic devices has potential to reduce both total number of appliances and energy consumption by product communities, but this effect is not yet evident for personal electronics (https://doi.org/10.1111/jiec.12130; https://doi.org/10.1021/es505121p). Some scenario analyses project large growth in energy use for appliances, see for instance the interpretation of SSP 5 by Levesque et al (https://doi.org/10.1016/j.energy.2018.01.139)	Noted	Berrill Peter	Yale University	United States of America
56455	35	41	35	42	What do data centers have to do with digitalization of buildings? For that matter, what do small appliances have to do with it? These were not among the seven things introduced at the top of this box.	Accepted: Text clarified.	Government of United States of America	U.S. Department of State	United States of America
8419	35	41	36	4	With exponential growth in data processing need and communication (5G), data centres are constructed at a rapid tempo (especially in cities). It is believed data storage, communication devices and network devices would soon take up more than 3% of global electricity consumption. Energy efficiency is of paramount importance.	Noted	Otto Poon	President, Hong Kong Academy of Engineering Sciences.	China
3283	35	43	35	43	data-centres' is used instead of datacentres which is used throughout the rest of the text	Accepted: corrected	Rachel Bannon-Godfrey	Stantec	United States of America
3285	35	43	35	43	Any data points on the increase in datacentre energy use from the increase of bitcoin transactions? I have seen a few reports that state this is a significant energy load, might be worth addressing.	Rejected: No data available at the time of drafting	Rachel Bannon-Godfrey	Stantec	United States of America
56457	35	43	35	43	Data centers seem like they would fit better under the case studies of specific building types. It is a major area for policy development with new codes and programs specifically dedicated to these buildings. The description of data center energy use is not very clear. Cooling for the high powered computers is a major part of the energy load. There are significant opportunities to improve energy efficiency through equipment design and building insulation, but growth in data centers has significantly outpaced improvements in their efficiency in the last few years.	Noted: This section discusses only the energy demand due to digitalisatioon and not the design nor teh technologeis used in datacentres	Government of United States of America	U.S. Department of State	United States of America
19931	35	45	35	45	highly packaging' should be 'densely packed' (?) or something more grammatically correct.	Accepted: Text revised	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
9957	36	11			(Figure a and b) The information and symbols provided in the figures are unclear. It should be re-lay outed.	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
10753	36	14	36	14	Figure 9.5 is another enlightening illustration of why it would be relevant to carry on projections up to 2100. In this case of small appliances, the SDS scenario performs worse than the 2 others; moreover the trend of energy demand is an increase which shows no tendency to softening.	Rejected: Scenarios available for buildings do not all carry on projections until 2100	Philippe Waldteufel	CNRS	France
64207	36	14	36	14	Please check again the name of the box and figure	Accepted - text revised	Ova Candra Dewi	Universitas Indonesia	Indonesia
22035	36		36		The legend of the last figure is missing in Box 9.5.	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Government of France	Ministère de la Transition écologique et solidaire	France
60207	37	1	37	1	The section 9.5 deals with Non-technological and behavioural mitigation options and strategies. Considering the previous section where embodied emissions from materials is included, it is not clear if this section focuses only on operation energy demand and related GHG emisions or if it actually include operation and embodied emissions. Most aspects deals with operation energy demand and the very small part dealing with materials is simplistic and lost in the middle. I suggest either to cut in two clear parts Non-technological determinants for operation energy demand (Part I) and for embodied carbon emissions (Part II).	Taken into account - The text has been updated in different parts of section 9.5 to make clear that embodied emissions are included, and how materials are dealt with.	Guillaume Habert	ETH Zurich	Switzerland
47501	37	2	37	4	There is no reference to the sufficiency approach in this final section. It should be included to make this perspective clear in all the document.	Accepted - text was revised	Gonzalo Sánchez	European Environmental Bureau	Belgium
16525	37	3			Section 9.5.2 -> Section 9.5.1	Editorial. Noted	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17031	37	3			Section 9.5.2 -> Section 9.5.1	Editorial. Noted	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
16527	37	4			Section 9.5.3 -> Section 9.5.2	Editorial. Noted	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17033	37	4			Section 9.5.3 -> Section 9.5.2	Editorial. Noted	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
82031	37	7	37	10	Peer influences can be an important part of stimulating energy efficient behaviour https://doi.org/10.1038/s41560-019-0541-9	Accepted - The reference has been included in section 9.5.1	Berrill Peter	Yale University	United States of America
76547	37	30	38	26	This section discusses the measurement of embodied energy and carbon rather than investigating how the choice of building material could reduce GHG emissions over the life cycle of the building. There is a growing literature on the issue of reducing embodied emissions, including some studies that consider the effect on operational energy use. See, for example, 10.1021/acs.est.5b01735, https://doi.org/10.21203/rs.3.rs-93217/v1 and for a review, https://doi.org/10.1088%2F1748-9326%2Fab0fe3, also 10.1016/j.jclepro.2019.06.233.	Accepted - text was revised	Edgar Hertwich	Norwegian University of Science and Technology	Norway

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
17933	37		47		Entire Section 9.5 needs heavy editing - difficult to read.	Editorial - The text has been revised for clarity and the entire report will be edited for coherence.	Robert Brecha	Climate Analytics	Germany
56459	38	1	38	47	NBI recently released a Building Electrification Technology Roadmap that describes scores of electrified products and their potential to reduce building energy demand, many of which are listed in this section. See the report at: https://newbuildings.org/resource/building-electrification-technology-roadmap/	Noted	Government of United States of America	U.S. Department of State	United States of America
70033	38	1	39	12	The word "cooling" is missing. For example, Page 38 line 3 should be cooking, water heating, space heating and cooling. At Page 39 line 10, doesn't cooling energy increase as well as water heating and cooling?	Accepted	Yoshiyuki Shimoda	Division of Sustainable Energy and Environmental Engineering, Osaka University	Japan
16529	38	1	39	20	Please move 'Box 9.6' to 36 page.	Accepted	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17035	38	1	39	20	Please move 'Box 9.6' to 36 page.	Accepted	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
20341	38	1	39	20	Important elements of the field of electricity energy demand in the building sector is missing in the box: electric vehicle power charging, but also all more general smart grid issues (smart metering and others), and their implications in terms of electricity savings	Rejected: EV is out of the scope of the building chapter	Thibaud Voïta	IFRI	Germany
56461	38	1	39	20	Why isn't cooling included more in this box? It's inconsistent with the rest of the document.	Accepted: Boxes moved and part of the text merged with 9.3	Government of United States of America	U.S. Department of State	United States of America
56463	38	1	39	20	Box 9.6 might organize services by importance. Cooling is not listed and is a major source of growth. There is a separate section on cooling, but not mentioning it here with electrification is missing a major source of growth. Cooking is not normally classified as a thermal service, and growth has not been in electric stoves per se. Recommend removing cooking from thermal services as it is confusing. Split into more standard building energy services.	Accepted: Boxes moved and part of the text merged with 9.3	Government of United States of America	U.S. Department of State	United States of America
52387	38	2	39	12	No pargaraph on cooling.	Accepted: Boxes moved and part of the text merged with 9.3	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
52385	38	14	38	15	No mention of cooling in the sentence regarding the use of electricity for thermal services.	Accepted: Boxes moved and part of the text merged with 9.3	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
9959	38	26		30	The information is unclear, it states that the highest demand for electricity demand for space heating during 2020-2018 period was South Asia and South East Asia. As we know, those regions are located in equatorial area, thus they don't need space heating as we found in Europe or 4 seasons countries. It doesn't provide how many percent the increase during the period of 2010-2018.	Rejected: The text is about the highest increase in the use of electricity for space heating	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
11219	38	26	38	41	Suggestion for reference : Runhau et al, 2020, for a paper on electrification of heating through heat pumps and wind power, since their seasonality are similar. https://www.sciencedirect.com/science/article/pii/S0140988320303078	Accepted	Bianka SHOAI-TEHRANI	RTE Réseau de Transport d'Electricité, CentraleSupelec Paris Saclay University	France
11221	38	26	38	41	Regarding heat pumps, bad settings could compromise the energy efficiency of the heat pumps by making its electricity consumption up to 50% higher than it should with the right settings. https://docs.lib.purdue.edu/ihpbc/110/ I put the comment should on Box 9.6 on electricity demand but it could be relevant for section 9.9 "Barriers, Feasability"	Accepted - considered in Section 9.4	Bianka SHOAI-TEHRANI	RTE Réseau de Transport d'Electricité, CentraleSupelec Paris Saclay University	France
44087	38	26	38	41	Within Box 9.6 "Electricity energy demand in the building sector" appropriately warns that heat pumps are more efficient if the passive performance of building envelopes are improved. Also, you have stated correctly that wholesale electrification of space heating would demand substantial capital investments by building owners as well as electricity networks. You should add mention of the risk of increasing use of electricity in summer if policy makers lock-in reverse-cycle air-conditioners [5], and the also please note that outdoor air-source evaporators demand defrosting [6], which particularly is a problem in oceanic climates of Northern Europe and East Asia. 5.Raynaud, M., et al., Evidence of an indirect rebound effect with reversible heat pumps: having air conditioning but not using it? Energy efficiency, 2016. 9(4): p. 847-860. 6.Zhu, J., et al., Developing a new frosting map to guide defrosting control for air-source heat pump units. Applied thermal engineering, 2015. 90: p. 782-791.	Noted - the text was completely rewritten	Eric Peterson	University of Leeds	United Kingdom (of Great Britain and Northern Ireland)
62103	38	26	38	41	Electric heating induces peak demand in winter, during which electricity is generally produced with higher emissions. Using annual average GHG emissions may not be precise (Roux et al., 2016). Roux C., Schalbart P. and Peuportier B., Accounting for temporal variation of electricity production and consumption in the LCA of an energy-efficient house, Journal of Cleaner Production 113 (2016) 532-540	Noted - the text was completely rewritten	Bruno Peuportier	MINES ParisTech	France
5459	38	36	38	36	replace Renewables" by "low carbon sources"	Rejected	Michel SIMON	Retraité/ Pdt d'association	France
56465	38	36	38	38	Passing mention is made of the impact on peak electricity demand due to decarbonization efforts associate with electrification of buildings. This is a critical issue that deserves more than a passing mention. This is incredibly important with regard to the renovation of existing buildings.	Noted - due to lack of space, the text could not be expanded	Government of United States of America	U.S. Department of State	United States of America
63755	38	37	38	38	Add words in italics to existing sentence: "...electrification of the heat supply in the buildings sector will lead to additional electricity demand, particularly when coupled with increased electric vehicle uptake, and consequently additional investment in new power plants and distribution infrastruture will be necessary."	Noted: text revised	Government of Canada	Environment and Climate Change Canada	Canada
28693	38	39	38	40	The statement that heat pumps are most efficient when used in highly eficienct buildings is either incorrect or overstated. The heat pump system itself operates at an efficiency level independent of the building to which it is attached (informed only by the indoor and outdoor temperatures). Higher-performance building shells may allow use of smaller heat pump systems, or benefit more from variable speed HP systems that tend to be more efficient, and provide can increased comfort for a given level of energy input. This statement should be amended to discuss the efficiency of the heat pump wthin the larger system including the building shell and occupants, and that the overall system is mort efficient when the building shell is most highly performing.	Noted: text revised	Asa Hopkins	Synapse Energy Economics	United States of America
28695	38	40	38	41	When viewed in the context of the additional costs for gas heating systems (piping, connections to the gas system, etc., especialy in new construction), and particularly in climates/buildings where air conditioning is desired, heat pumps are not more expensive than fossil fuel based heating systems. This statement is too definitive, and shoudl reflect hte differences in economics in different circumstances.	Noted: due to lack of space, no more detais could be added	Asa Hopkins	Synapse Energy Economics	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
19933	38	42	38	42	The comma after 'experienced' should be moved to after 'regions'.	Accepted	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
82033	38	43	38	45	There is an opportunity to reduce electricity demand from clothes drying by increased use of line-drying in regions such as North America where ownership and use of clothes dryers is very high.	Noted: no references on this issue	Berrill Peter	Yale University	United States of America
74971	38		38		Consider Solar Water Heating (SWH) regulations in Kenya as a response mechanism toward reducing energy demand in buildings	Noted: see section 9.4 on technologies	Government of Kenya	Kenya Meteorological Service	Kenya
77123	39	6	39	6	The report is probably correct in predicting world electricity growth to double by 2050 – and that will require continued flexible gas-fired generation, to compensate for the variability and unreliability in supply from renewables.	Noted	Jim O'Brien	Expert Reviewer AR6 SOD WG1	Ireland
69747	39	10	39	12	Figure 1b of Box 9 suggests instead that the highest increases are to occur in electricity demand for cooling, followed by connected and small appliances - not water heating and cooking.	Noted: Figures revised	Cédric PHILIBERT	Institut Français des Relations Internationales	France
9961	39	15			The information and symbols provided in the figures are unclear. It should be re-lay outed. (Box 9.6 Figure 1.a)	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
60209	40	2	40	2	The section 9.5.1 deals with Non-technological determinants of energy demand and carbon emissions. Considering the previous section where embodied emissions from materials is included, it should include operation and embodied emissions. But most aspects deals with operation energy demand. Can it be included inside a specific section on operation energy? Or it is important to link Climate and physical environment to embodied emissions and state that usually embodied emissions are not correlated to climate differences or even energy performance of building. Embodied emissions are also not as first approximation related with building material type, they are related with quality of design. Many studies shows that we can have larger differences between two buildings built with same type of structure than between two buildings built with two different material type (Pomponi, Francesco & Moncaster, Alice, 2018. "Scrutinising embodied carbon in buildings: The next performance gap made manifest," Renewable and Sustainable Energy Reviews, Elsevier, vol. 81(P2), pages 2431-2442). It has also been shown that we have no correlation between energy performance of building and embodied emissions (Hoxha E., Habert G., Lasvaux S., Chevalier J., Le Roy R. 2017. Influence of construction material uncertainties on residential building LCA reliability. Journal of Cleaner Production, 144, 33-47)	Accepted - due to lack of space no new details could be added, but this comment was taken into consideration when rewritting Section 9.4 and 9.5	Guillaume Habert	ETH Zurich	Switzerland
28313	40	2	43	25	The roles of both good/optimised design and material efficiency seem wholly neglected in this section about non-technological determinants. Some useful references that would also help substantiate the discussion with quantified estimates of potential savings are: https://doi.org/10.1098/rsos.181265, https://doi.org/10.1038/s41563-018-0229-8, https://doi.org/10.1016/j.enbuild.2018.03.031, https://doi.org/10.1016/j.resconrec.2010.11.002, https://doi.org/10.1098/rsta.2012.0496	Noted - Material efficiency is included as a technological measure under 9.4.	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
17053	40	6	40	16	One of the key non-technological determinants used is also Heating Degree Days (HDD) or Colling Degree Days (CDD). It would be worth mentioning in this section.	Accepted - Text revised	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
49673	40	6	40	9	Concept of the Physical environment not clear. More clarity on the classification of parameters of Climate and Physical environment required. The parameters mentioned could be classified separately into Climatic and Physical parameters.	Taken into account -	Satyaprakas Das Das	Manipal Academy of Higher Education	India
10755	40	7	40	13	I considered checking Ayoub (2019) but was not up to paying $41 for obtaining access. Still, this attempt allowed me to note that in the reference list Ayoub et al (2014a) and Ayoub et al (2014b) are strictly identical. Then I attempted to check Oh and Kim 2019b but did not succeed: there is no (Oh and Kim) paper in the reference list.	Accepted - References updated.	Philippe Waldteufel	CNRS	France
10757	40	7	40	13	CONTINUED Actually, I was wondering about i) wind, ii) humidity, because I expected they would also be significant determinants ot energy demand. Reporting on this aspect would be welcome; alternatively, this would appear as a knowledge gap. In any case, please check the consistency of the reference list in this report.	Accepted - Text revised	Philippe Waldteufel	CNRS	France
78217	40	7	40	13	Urban microclimate may also be brought into the discourse.	Accepted - Text revised	SUCHANDRA BARDHAN	Jadavpur University	India
56467	40	7	40	8	Insert: ""Yearly variation of weather conditions can significantly influence building energy use especially peak demand (Hong et al., 2013; Cui et al., 2017)."" References: T. Hong, W.K. Chang, and H.W. Lin. A Fresh Look at Weather Impact on Peak Electricity Demand and Energy Use of Buildings Using 30-Year Actual Weather Data, Applied Energy, 2013. Y. Cui, D. Yan, T. Hong, C, Xiao, X. Luo, Q. Zhang. Comparison of typical and multiyear building simulations using a 55-year actual weather data set from China. Applied Energy, 2017.	Accepted - Text revised in the next paragraph in which variability is addressed, references included.	Government of United States of America	U.S. Department of State	United States of America
49675	40	9	40	10	The statement requires more clarity with suitable reference. The assumption made about single-family houses and rural areas as less compact than apartment buildings and urban areas could be simplified by comparing single-family houses to the apartment and urban to rural areas.	Accepted - the sentence has hovewer been removed in the revision.	Satyaprakas Das Das	Manipal Academy of Higher Education	India
22037	40	10	40	13	Energy consumption depends on urban morphology (Arantes and al., 2016). Rural houses not adjoined consume more than urban collective dwellings. But the finding is not clear. Density can lead to large differences in consumption between neighborhoods in a city (O'Brien and al., 2010). Urban production is also involved and can cause differences between national contexts: the dense zoning of European cities consume less than new Chinese cities, composed of isolated towers (Salat and Nowacki, 2010). There is also an "urban energy paradox" (Bonhomme, 2013) because cities that are too dense can generate heat islands (Masson and al., 2020) in the summer by increasing use of air conditioning, which consumes a lot of energy. Arantes L., Marry S., Baverel O. and Quenard D., Efficacité énergétique et formes urbaines : élaboration d'un outil d'optimisation morpho-énergétique, Cybergeo : European Journal of Geography [Online], Regional and Urban Planning, document 777, Online since 07 April 2016. URL : http://journals.openedition.org/cybergeo/27584 ; DOI : https://doi.org/10.4000/cybergeo.27584 Bonhomme M., 2013, Contribution à la génération de bases de données multiscalaires et évolutives pour une approche pluridisciplinaire de l'énergétique urbaine, LMDC et LRA, Université de Toulouse. Masson V., Heldens W., Bocher E., Bonhomme M., (…) Zeidler J., 2020, City-descriptive input data for urban climate models: Model requirements, data sources and challenges, Urban Climate, 31, 100536. O'Brien L.W., Kennedy C.A., Athienitis A.K., Kesik T.J., 2010, The relationship between net energy use and the urban density of solar buildings, Environment and Planning B: Planning and Design, 37, 6, 1002-1021. DOI : 10.1068/b36030 Salat S., Nowacki C., 2010, De l'importance de la morphologie dans l'efficience énergétique des villes dans Énergie et territoires ou comment construire les territoires de demain face à la nouvelle donne climatique et énergétique, Liaison énergie-francophonie, 86, 141-146	Accepted - the sentence has hovewer been removed in the revision.	Government of France	Ministère de la Transition écologique et solidaire	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
19935	40	17	40	27	Although I note the careful use of the word 'correlation' I think this section should recognise that, beyond total floor area, there is a significant variation in the influence of these variables (at least in the UK). My own PhD study, which was the first of its kind in the UK, found no clear relationship with building typology / form, and although it found a very strong relationship with the number of bedrooms our subsequent work, using essentially the same methodology, found this not (necessarily) to be the case. I think it would be more accurate to state specifically that total floor area is the only one of these variables which consistently exhibits a direct and causal correlation with energy consumption where other variables are controlled for. References: Baker, K.J., & Rylatt, M., 2008. Improving the prediction of UK domestic energy demand using annual consumption data. Applied Energy, Volume 85, Issue 6, June 2008, pages 475-482. Baker, K.J., Mould, R., & Restrick, S., 2016. Proiseact Spéird – The Spéird Project: Understanding influences on fuel poverty in rural and island Scotland. Final report for the Eaga Charitable Trust, November 2016. Available at: https://drive.google.com/file/d/19RhP3SqEVOo-ZdYHK7zhS83bUJ2KcQno/view?usp=sharing Mould, R., & Baker, K.J., 2017. Uncovering hidden geographies and socio-economic influences on fuel poverty using household fuel spend data: A meso-scale study in Scotland. Indoor and Built Environment, Vol. 20, (7), 1-23, DOI: 10.1177/1420326X17707326.	Taken into account - Text revised for clarity. The 2008 reference was published during period covered by AR5. Fuel poverty is addresed in section 9.8.	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
56469	40	17	40	27	The authors first state in lines 18-20 that the "building construction year" is one of the factors positively correlated to energy demand. On lines 23-24, the authors state that "building vintage" has a negative correlation (to residential consumption) as recently built buildings must comply with increasingly strict standards. So, are authors stating that energy demand is positively correlated to construction year (aka "vintage") (i.e., recently built buildings have higher demand) and also that construction year (aka "vintage") is negatively correlated to energy consumption (i.e., recently built buildings have lower energy consumption due to stricter standards)? This paragraph is confusing, and the relationship between construction year or vintage and energy demand and consumption needs to be clarified.	Accepted - Text revised	Government of United States of America	U.S. Department of State	United States of America
61133	40	17	40	27	the absence of the importance on material's embodied carbon emissions from this section also stands out – it would fit well into this "non-technological determinants" section	Accepted - Reference cited	Marcella Saade	Graz University of Technology	Austria
82035	40	18	40	20	In addition to the studies cited, errill et al., who show the particular importance of building type, construction year, and floor area https://doi.org/10.1021/acs.est.0c05696	Accepted - Text revised	Berrill Peter	Yale University	United States of America
82037	40	21	40	22	Apart from for domestic hot water uses, the influence of number of occupants is actually quite weak on energy end-use demand in an individual household. (Berrill et al. 2021, https://doi.org/10.1021/acs.est.0c05696). Increasing household size (while keeping population constant) can therefore substantially reduce residential energy demand, i.e. a large potential for energy reduction from household sharing (https://doi.org/10.3390/en13081909)	Noted - Decreases in houshold size are discussed in Section 9.5.2.2.	Berrill Peter	Yale University	United States of America
18453	40	23	40	23	'Vintage has a negative correlation' – what does 'vintage' refer to, age/archetype of the building? This is the only time the word is used in the chapter.	Accepted - Text revised.	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
22039	40	25	40	27	But the energy consumption of the building must be put into perspective with its life cycle, from design to rehabilitation and destruction. As Pannier & al. (2018) write : "To limit the environmental impacts of the building sector, it is necessary to apply an eco-design approach to buildings, whether they are new or are being renovated. This approach must make it possible to take into account all the potential impacts occurring during the life cycle of the buildings, in order to avoid shifting the emissions of pollutants from one environmental problem to another, from one place to another or even from one stage of the life cycle to another. Life cycle assessment (LCA) is particularly well suited for doing this. In addition to evaluating the environmental performance of a product, LCA offers the possibility of comparing the environmental impacts of products with the same function over their entire life cycle"	Accepted - Text revised.	Government of France	Ministère de la Transition écologique et solidaire	France
56471	40	25	40	27	This sentence is unclear: "As buildings are being renovated, the renovation year is instead a key indicator of the building status (Mangold et al., 2016; Osterbring et al., 2016)." What is meant by "building status"? Status in what way? This sentence needs to be clarified.	Accepted - Text revised.	Government of United States of America	U.S. Department of State	United States of America
56473	40	28	40	40	A reference to consider adding regarding the link between floorspace and energy: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0134135	Accepted - Text revised.	Government of United States of America	U.S. Department of State	United States of America
56475	40	28	40	40	Recommend citing: Yu. S. (2017). Transition pathways of China and implications for climate change mitigation: evolution of the buildings sector. Doctoral dissertation, University of Maryland. https://doi.org/10.13016/M2M03XX71. This includes a chapter with detailed global analysis of the correlation between building energy use and income.	Accepted - Reference added.	Government of United States of America	U.S. Department of State	United States of America
22041	40	32	40	32	Please consider these additional references: - Vaage, K. (2000). "Heating technology and energy use: a discrete/continuous choice approach to Norwegian household energy demand." Energy Economics 22(6): 649–666. - Meier, H. Rehdanz K. (2010), "Determinants of space heating expenditures in Great Breatain, Energy Economics. - Risch, A. and C. Salmon (2017). "What matters in residential energy consumption? Evidence from France." International Journal of Global Energy Issues 40(1/2): 79–116 - Santin, O. G., Itard, L., Visscher, H. (2009) The effect of occupancy and building characteristics on energy use for space and water heating in Dutch residential stock, Energy and Buildings -Sardianou E. (2008) Estimating space heating determinants: An analysis of Greek households, Energy and Buildings 40.	Taken into account - Risch, A. and C. Salmon (2017) is added. The other references were published before AR5.	Government of France	Ministère de la Transition écologique et solidaire	France
22043	40	36	40	37	The following reference show that households belonging to the last income quintiles no longer increase their energy consumption. The authors underline a phenomenon of saturation: Cayla, Jean-Michel, Maizi, Nadia, and Marchand, Christophe (2011), The role of income in energy consumption behaviour: Evidence from French households data, Energy Policy, 39 (12), 7874-83. This reference should be added to complete this paragraph.	Accepted - Reference added.	Government of France	Ministère de la Transition écologique et solidaire	France
4283	40	37	40	37	Add the following text: "Conversely, low-income households tend to refrain from spending on energy services and use that money to purchase food. This is an aspect of energy poverty known as the "heat or eat" effect and might be misleading because this low energy consumption does not stem from an energy conscious perspective but from the inability to keep their homes at a comfortable temperature, which, in turn, may lead to a higher recurrence of different kinds of illnesses" REASON: The paragraph gives a good insight on the wealthy households, but it would be also informative to include some information about financially deprived families. (Reference: Fixing fuel poverty. Challenges and solutions. Boardman, 2010).	Taken into account - Text revised to refer to lower income households and refer to section 9.8, in which fuel poverty is discussed.	Pulido Arcas Jesús Alberto	The University of Tokyo	Japan

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
22045	40	40	40	40	Please consider adding: Finally, the energy consumer profiles are linked to the characteristics of the dwelling, their location and the type of energy used. Lévy and Belaïd (2018) mobilised the National Housing Surveys by INSEE (French National Institute Of Statistics, 2002 and 2006). They performed factor analyses and hierarchical classifications in order to construct ten types of energy consumers, associating the energy intensity used (high [+]/low [-]/no consumption [0]); the mode : electricity (E), gas (G), fuel oil (F), propane (P), wood (W), district heating and charcoal (DH/C); household characteristics (family status, age, size, socioprofessional category and income); characteristics of the type of dwelling occupied (occupation status, type of dwelling, number of rooms, area, date of construction of the building) and the residential context (urban, suburban, rural). These types show that domestic energy modes are markers of dwelling characteristics and occupants' lifestyle profiles. Table 9.3: Dominant profiles of households and dwellings in the 10 types of French consumers in 2002. Table 9.3 also highlights the fact that in France in 2002, there were three predominant types of consumer in the population, accounting for 3/5 of households (types 3, 5 and 7). The combinations of the energy modes used, and the dominant profiles of households, buildings and dwellings, give us a glimpse of the leeway and constraints on energy use in the households belonging to these three types. For instance, type 3 represents consumers who combine high electricity use with the use of propane and wood (26.3%), typically characterised by average income families aged over 40 and under 60, who are homeowners in a rural or suburban area, and can therefore reduce their electricity consumption by means of an open fire (very common in houses, especially in rural and periurban areas) for heating and by the use of propane for cooking.	Taken into account - Reference added.	Government of France	Ministère de la Transition écologique et solidaire	France
29489	40	41	47	31	It seems that the advantage connected to retrofitting existing buildings compared constructions of new buildings are poorly covered in this text. We recommend to include findings related to issue. Furthermore we recommend that you include results and a reference to a SINTEF report is included here and also other places in this report and SPM. The study shows that it takes in average 30 years before the GHG emissions related to new constructions balances the emissions of retrofitting existing buildings. The potential for reducing GHG emissions by retrofitting and reuse of existing buildings compared to new constructions is documented in a quantitative analysis of 23 international case studies (SINTEF fag: 68. Bevaring med klimagevinst - Riksantikvaren). We recommend a reference to this report is made in Chapter 9 Buildings; 9.5.2 or 9.5.3 and SPM C.4.1 or C7.1. The SINTEF report is currently being translated to English and may be provided.	Taken into account - Text revised and references cited.	Government of Norway	Norwegian Environment Agency	Norway
56477	40	42	40	42	The current description of occupant behavior is limited. Suggest to add the following to the very beginning of Section 9.5.2: ""Technologies alone do not necessarily guarantee low energy use in buildings if the human dimensions are ignored or oversimplified (D'Oca et al., 2018). Occupant behavior has significant influences on building performance (Hong et al., 2017; Yan et al., 2017; O'Brien et al., 2020). Occupant behavior refers to (1) occupant presence in spaces and movement between spaces, (2) occupant interactions with building systems, and (3) occupant adaptations (e.g., changing clothing, having hot/cold drinks). Occupants' expectations of satisfaction with the indoor environment drive their interactions with devices, equipment and energy systems in buildings, such as adjusting thermostat settings, opening/closing windows, turning on/off lights, operating window blinds, consuming domestic hot water, and moving around, to satisfy their physical and nonphysical needs. These actions affect the built environment and energy use. A clear understanding and accurate modeling of occupant behavior in buildings is crucial in reducing the gap between design and actual building energy performance (Gunay et al., 2013; Hoes et al., 2009; Turner and Frankel, 2008; Yan et al., 2015), especially for low-energy buildings relying more on passive design features, occupancy-controlled technologies, and occupant engagement."" References: D'Oca, S., T. Hong, and J. Lanevin. 2018. The human dimensions of energy use in buildings: A review. Renewable and Sustainable Energy Reviews. T. Hong, D. Yan, S. D'Oca, C. Chen. Ten questions concerning occupant behavior in buildings: The big picture. Building and Environment, 2017. D. Yan, T. Hong, B. Dong, et al. IEA EBC Annex 66: Definition and Simulation of occupant behavior in buildings, Energy and Buildings, 2017. D. Yan, L. O'Brien, T. Hong, X. Feng, B. Gunay, F. Tahamasebi, A. Mahdavi. Occupant behavior modeling for building performance simulation: current state and future challenges. Energy and Buildings, 2015. W. O'Brien, A. Wagner, M. Schweiker, A. Mahdavi, J. Day, M.B. Korgaard, S. Carlucci, B. Dong, F. Tahmasebi, D. Yan, T. Hong, B. Gunay, Z. Nagy, C. Miller, C. Berger. Introducing IEA EBC Annex 79: Key challenges and opportunities in the field of occupant-centric building design and operation. Building and Environment, 2020. Gunay, H.B., W. O'Brien, and I. Beausoleil-Morrison. 2013. A critical review of observation studies, modeling, and simulation of adaptive occupant behaviors in offices. Building and Environment 70:31-47. Hoes, P., J. Hensen, M.G.L.C. Loomans, B. de Vries, and D. Bourgeois. 2009. User behavior in whole building simulation. Building and Environment 41:209-302. Turner, C., and M. Frankel. 2008. Energy performance of LEED for new construction buildings: Final report. U.S. Green Building Council, Washington, D.C. www.usgbc.org/Docs/Archive/General/Docs3930.pdf.	Taken into account - Text revised and references cited.	Government of United States of America	U.S. Department of State	United States of America
49677	40	42	40	44	Statement not clear, and related parameters could be classified.	Accepted - Text revised.	Satyaprakas Das Das	Manipal Academy of Higher Education	India
52389	40	42	40	44	Do not use "correlates". Occupant behaviour can have a major influence on energy use.	Accepted - Text revised.	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
9985	40			13	This paragraph could add more microclimate variables that have not been mentioned yet such as wind speed, moisture, etc.	Accepted - Text revised.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
9987	40			21	We agree that affluence is a prominent factor in energy consumption yet it can also be counter measured with better understanding on environmentally sound behaviour in energy use.	Taken into account - Text revised.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
47503	41	3	41	3	Point out not to put more pressure on occupant's behaviour in the less efficient buildings. These occupants do not have the opportunity to reduce their impact because of the efficiency performance of their houses.	Taken into account - Text revised.	Gonzalo Sánchez	European Environmental Bureau	Belgium
17055	41	3	41	4	This statement is not clear as it contradicts the fact that occupant behaviour has a high impact on the energy consumption, perhaps, some more detail would be useful here.	Accepted - Text revised	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
56479	41	5	41	17	This is the only place that shading is mentioned. In most developing countries and countries with hot climates, shading, if it is available, is typically built in, thus it is a passive technology, not an active one. The definition of passive in this section does not correspond with the typical use of passive in the context of building energy use. It is not about behavior, but actually the opposite: It is about technologies that can work without active intervention or mechanical devices.	Taken into account - Text revised for clarity.	Government of United States of America	U.S. Department of State	United States of America
56481	41	5	41	17	Shading features that require active occupant action typically have low efficacy (particularly if they are inside of fenestration, where the thermal impact is lessened). Recommend that shading gets it own paragraph under building technologies or elsewhere earlier in the report.	Taken into account - Text revised for clarity.	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
3637	41	6	41	30	From the perspective of a building scientist, this section discusses techniques that are almost inconsequential to overall building energy consumption.	Taken into accout - Evidence (Fig 9.14) shows that these behavioral solutions do influence building energy consumption. Text revised for clarity.	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
4285	41	8	41	8	Add the following text: “Other important passive management strategy builds upon the theory of adaptive thermal comfort, which states that occupants in buildings can adapt to thermal variations to some extent, given that outdoor conditions are not excessively cold or hot, by some strategies, such as naturally ventilating the building. There are two standards, namely, ASHRAE 55-2017, and EN 16798, which are internationally recognized in this field. Recent studies have shown that if setpoint temperatures for heating and cooling inside buildings are dynamically adapted following these standards, comfort can be achieved without compromising the energy consumption, specially in warm countries that are transforming into developed economies and considering the effects of climate change in 2050 (Bienvenido-Huertas at el. 2020).” REASON: This section offers a good insight on the potential of passive operation to reduce the energy consumption of buildings, and it would be also informative to include information about the two main standards that are used at a global scale (namely, ASRAE 55-2017 and EN 16798). The mentioned study contains information about the applicability of those standards to contain this consumption, not only in the present scenario, but also considering the future climate change scenario of 2050, with a special focus on the population affected by those changes in developed and underdeveloped countries. (Reference: D. Bienvenido-Huertas, C. Rubio-Bellido, A. Pérez-Fargallo, J.A. Pulido-Arcas, Energy saving potential in current and future world built environments based on the adaptive comfort approach, J. Clean. Prod. 249 (2020). https://doi:10.1016/j.jclepro.2019.119306).	Taken into account - Text revised to include the suggested references.	Pulido Arcas Jesús Alberto	The University of Tokyo	Japan
56483	41	8	41	8	"Green schedule" is not a generally recognized term. Recommend rephrasing to be more universal.	Accepted - Text revised.	Government of United States of America	U.S. Department of State	United States of America
56485	41	11	41	12	Suggest to add the following to the beginning of line 12: ""Social and demographics factors, personal characteristics, as well as local and contextual factors also influence occupant behavior and their interactions with buildings and energy systems thus energy use and GHG emissions (Hong et al., 2020; D'Oca et al., 2018)."" References: T. Hong, C. Chen, Z. Wang, X. Xu. Linking Human-Building Interactions in Shared Offices with Personality Traits, Building and Environment, 2020. S. D'OCa, A.L. Pisello, M. Simone, V.M. Barthelmes, T. Hong, S.P. Corgnati. Human-building interaction at work: Findings from an interdisciplinary cross-country survey in Italy. Building and Environment, 2018.	Taken into account - Text revised and references cited.	Government of United States of America	U.S. Department of State	United States of America
49679	41	18	41	19	The relation of Fig. 9.14 referred at 9.5.2 - Line 42 is not clear. Parameters of the figure and data referred to seem to be different and more explanation required.	Accepted - Text revised.	Satyaprakas Das Das	Manipal Academy of Higher Education	India
2317	41	20	41	20	The x-axis labels of the box plots are not in consistent order when compared between energy savings potential and GHG mitigation figures	Accepted - Text revised.	Siddarth Durga	PNNL	United States of America
22047	41	20	41	20	Legend : what do R and NR mean?	Accepted - Text revised.	Government of France	Ministère de la Transition écologique et solidaire	France
56487	41	25	41	26	Daylight savings time (summer setting) increases lighting energy use? One would assume standard time (winter setting) increases lighting energy use.	Taken into accout - Yes, that is correct, this paper shows that the effect of the measure is opposed to what can be expected.	Government of United States of America	U.S. Department of State	United States of America
72075	41	28	41	28	The author probably refers to hot water but the word "water" is missing.	Accepted - Text revised.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
82039	42	1	42	2	I am sympathetic to what I think the authors intentions are, but I suspect that "behavioural control" will be a term not so popular in some circles. Could rephrase somewhat to say that variations in behaviour are hard to predict, and that behaviour is difficult to influence. Improving understanding of appliance energy use can aid energy reductions. Householders tend to undersestimate the energy consumption of more energy intensive appliances, https://doi.org/10.1073/pnas.100150910. Improving householder knowledge of which devices consumed most energy has the potential to target energy use misperceptions and shape behavioural responses, Marghetis et al 2019 http://dx.doi.org/10.1038/s41560-019-0467-2	Taken into account - Text revised.	Berrill Peter	Yale University	United States of America
47673	42	5	42	23	For a some quantitative results on how behavioural change can limit the demand of energy services (as well as a broader disucssion on driversof residential energy demand), the recent publication by van den Berg et al. (2021) is very useful. In it a decomposition of energy demand and emissions for the residential and transport sectors is done, breaking down the drivers to (i) Activity, (ii) Structure, (iii) Intensity and (iv) fuel mix. They apply this decomposition to different residential energy services and across developed and developing countries in order to explore the potential energy and emission savings of different options. https://iopscience.iop.org/article/10.1088/2515-7620/abdd99	Accepted - Reference cited.	Vassilis Daioglou	Utrecht University	Netherlands
56489	42	16	42	16	There are triple negatives here.	Accepted - Text revised.	Government of United States of America	U.S. Department of State	United States of America
70035	42	16	42	21	"Adjust set-point temperature by 1°C" are appeared in both positive and negative examples.	Accepted - Text revised.	Yoshiyuki Shimoda	Division of Sustainable Energy and Environmental Engineering, Osaka University	Japan
22049	42	17	42	17	The meaning of HVAC should be added in parenthesis. We know later (p.9-90) that HVAC means « Heating, ventilation and air conditioning »	Noted - Text revised to introduce the abbreviation in section 9.4	Government of France	Ministère de la Transition écologique et solidaire	France
56491	42	23	42	23	Is this correlated with electricity price at all? The text does not correlate energy use with price.	Taken into account - Text revised.	Government of United States of America	U.S. Department of State	United States of America
47505	42	24	42	38	The “flexible” behaviour is an interesting point. However, the social impact has to be taken into account as the low-income households could be put under high pressure as the level of flexibility they have might be lower.	Taken into account - Text revised.	Gonzalo Sánchez	European Environmental Bureau	Belgium
56493	42	25	42	30	Load flexibility in buildings must be harnessed as a time-based service to the grid, in order to minimize fossil fuel utilization and leverage renewable generation. Electric vehicle charging is a growing end use that will be borne by buildings, especially for light duty vehicles, and campus fleets. Buildings, PV, batteries, and EVs must be considered as a well-coordinated system to provide demand flexibility and peak load shaving, which will also improve the integration of microgrids for resiliency. Campus/community scale digital platforms can become a critical technology to enable data acquisition from multiple supply and demand streams, in conjunction with locational and demographic data, for decarbonized planning and operations of energy systems in the built environment. See: Singh, Reshma, Prakash, Anand, Piette, Mary Ann, Agarwal, Shreya, and Chen, Grant. A Community Energy Operations and Planning System: Concept, Use cases, Metrics, and Benefits. United States: N. p., 2020. Web.	Taken into account - Text revised to include the suggested reference.	Government of United States of America	U.S. Department of State	United States of America
72077	42	34	42	34	ToU (time of use, I guess) is not defined. Indeed, after complementary research, it is difficiult to find information on consumers responses to ToU.	Taken into account - Abbreviation presented in the text.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
22051	42	37	42	38	40% of the building energy use could be influenced theorically ? Or is it an expected potential ? 40% seems very high for a potential.	Accepted - Text revised.	Government of France	Ministère de la Transition écologique et solidaire	France

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22053	42	38	42	38	Plase consider adding the following information: Another cause of the demand flexibility is the role of life cycle in energy consumption. It has been highlighted by numerous longitudinal studies carried out during the 1970s and 1980s (Morrison and Gladhart, 1977; Fritzsche, 1981; Frey and LaBay, 1983). Since, studies on household energy practices have abandoned the life-cycle approach, and the most recent studies on energy consumption ascribe great importance to the demographic characteristics of households (O'Neill and Chen, 2002; Brounen & al., 2012a; Valenzuela & al., 2014). Studies stand at the interface between pioneering work focusing on life-cycle sequences and more recent work focusing more on demographic characteristics alone (Lévy and Belaïd, 2018) shows that domestic energy consumption is highly dependent on adaptations of household size to dwelling size, and therefore, on household residential mobility. Insofar as household composition and size change throughout the household life cycle, these results illustrate the existence of flexibility over time in the processes of domestic energy consumption, with variations depending on whether these adaptations are made or not. Indeed, by neutralising the factors of dwelling type, location and energy modes, it becomes possible to fully explore the concept of efficiency and to evaluate the households most likely to regulate their consumption on the basis of their social and demographic characteristics (Valenzuela & al., 2014). These findings argue for the construction of complex consumption models that incorporate consumption per m2 (highly dependent on dwelling size) and per person (highly dependent on family structures) in a dynamic approach that includes the changing patterns of household behaviour over the life cycle depending on residential stability or mobility. While incentive policies for reducing domestic energy consumption are generally based only on consumption per m².	Taken into account - Text revised.	Government of France	Ministère de la Transition écologique et solidaire	France
60211	42	39	42	39	Section 9.5.2.4 deals with embodied emisions. But it's extremely short and actually focuses on resources. There is a large difference between circularity and carbon neutrality. Both are needed but do not necessarily involves the same processes. Here it seems the insight to reduce embodied emissions is circular economy. Aölthough, it is not wrong, it's a very limited way of addressing the problem. Steel and aluminium are recycled at close to 100%.. fully circular but not carbon neutral.	Taken into account - Text revised.	Guillaume Habert	ETH Zurich	Switzerland
43667	42	39	43	2	It does not make sense to deal with the topic of circular economy in isolation. It is recommended to discuss it in connection with topics of embodied energy/carbon at the level of construction products and buildings.	Taken into account - Text revised to make clear the structure of the section.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
72079	42	39	43	2	Circular economy is well defined but it could be good to illustrate quantitatively its possible mitigation impact on energy and carbon demand for construction materials. A recent european paper, Circular Economy - Principles for Building Design (2020) may be used for that purpose : https://ec.europa.eu/docsroom/documents/39984	Taken into account - Text revised. No quantfied potentials are found in the report though.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
72081	42	39	47	31	the European Environmental Agency (EEA), together with a consortium of European experts, has developed a new methodology. It combines the benefits of various approaches to quantifying the potential impacts of circular economy actions while requiring only limited investment in modelling. To demonstrate the utility and value of the new methodology, and to shed further light on a key policy area, the approach was applied to the buildings sector. Together, key actions can deliver emission reductions of up to 61 % across buildings' life cycles. Document available at: https://www.eea.europa.eu/themes/climate/cutting-greenhouse-gas-emissions-through/cutting-greenhouse-gas-emissions-through	Taken into account - Text revised	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
19937	42	40	42	40	world' should be 'world's'	Accepted - Text revised	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
2817	43	1	43	2	product durability, reusability, and reparability has to be improved, and their energy and resource efficiency increased.	Taken into account - Text revised.	Leonardo Barreto	Head of center "EU&International"	Austria
2815	43	4	43	9	Regulatory frameworks that promote a fair and effective sharing economy and reduce social and other risks must be implemented, for example to protect consumer interests, adapt existing tax frameworks to ensure a fair share of value added is captured by the state and shaping labor laws to ensure companies adhere to legitimate rules (see e.g. a-connected, 2020: Regulatory implications of the sharing economy. https://www.a-connect.com/knowledge/regulatory-implications-of-the-sharing-economy/)	Taken into account - Text revised in section 9.5.3	Leonardo Barreto	Head of center "EU&International"	Austria
56495	43	10	43	10	"value chain innovations" is not a good title for this section. A better one may be "soft costs" or "workforce innovations"?	Taken into account - Text revised.	Government of United States of America	U.S. Department of State	United States of America
60213	43	10	43	25	Section on value chain innovation deals only with operation energy, although it's also key for embodied emission reduction. This is not clear. Recent papers show that close collaboration of all actors along the value chain can cut CO2 emission from concrete use by more than 50% (Habert G., Miller S.A., John V., Provis J., Favier A., Horvath A., Scrivener K. 2020. Environmental impacts and decarbonization strategies in the cement and concrete industries. Nature Reviews Earth & Environment. DOI: 10.1038/s43017-020-0093-3). Other studies shows how transformation of project organisation in particular the use of Integrated Project delivery contract allows better coordination of actors on a construction project and save costs and environmental impact (Hall D., Bonanomi MM. 2021. Governing Collaborative Project Delivery as a Common-Pool Resource Scenario Project Management Journal, 8756972820982442)	Accepted - Text revised and reference included.	Guillaume Habert	ETH Zurich	Switzerland
79429	43	10	43	25	This section currently focuses only on operational energy. However, the value chain (supply chain) perspective is also crucial for reduction of embodied GHG emissions. Recent studies - e.g. Habert et al 2020 - investigated the potential to reduce emissions from cement and concrete production if all stakeholders across the value chain cut emissions according to their short/long-term capabilities. Their study found a potential reduction of concrete's embodied emissions by more than 50%! This implications/potentials of value chain innovation should be added here - See ref: Habert G., Miller S.A., John V., Provis J., Favier A., Horvath A., Scrivener K. 2020. Environmental impacts and decarbonization strategies in the cement and concrete industries. Nature Reviews Earth & Environment. DOI: 10.1038/s43017-020-0093-3).	Accepted - Text revised and reference included.	Martin Röck	KU Leuven	Austria
20343	43	11	43	25	You may want to mention here the local energy communities that provide advices to their neighbourgs in order to support their energy savings or RE-usage - as it is mentioned on p. 82	Accepted - Text revised.	Thibaud Voïta	IFRI	Germany
56497	43	14	43	18	What does this sentence mean? "Buildings owned by non-profit groups are less energy efficient compared to private buildings, or management changes for and establishing operational best practises (Azar and Menassa, 2014; Peterman et al., 2012)." What is meant by "management changes for and establishing operational best practices"? The sentence should be re-written to clarify meaning.	Taken into account - Text revised.	Government of United States of America	U.S. Department of State	United States of America
79505	43	17	43	17	Commissioning may be used for a new building. It can be used for a renovation, and called retro-commissioning. It may be applied during the building operation. In this case, it can be called On-goin commissionning. On-going commissioning supports the achievement of the performance over time.	Taken into account - Text revised.	Idriss KATHRADA	Novasirhe	France
22055	43	19	43	25	Please note that this sentence is long, and making it more concise would be helpful to make it more understandable.	Taken into account - Text revised.	Government of France	Ministère de la Transition écologique et solidaire	France
63757	43	26	47	45	District energy was included as a case study on page 32 but should also be included as a sub-section within this section on reasons and willingness for adoption of climate mitigation solutions in buildings. The build-out of district energy infrastructure, fueled with low carbon fuels such as waste heat and biomass, has played a key role in the decarbonization of many northern European countries (e.g. Sweden, Denmark, Germany) and there is potential for it to play a much larger role in most northern countries. It also a bit unique in that adoption is at the munipal/territoral/national level as opposed to at the level of the homeowner or builder, as is the case with most buildings solutions, taking the onus off of individuals.	Noted - We have however not found sufficient literature on the adoption of district heating from a building perspective. Additionally, district heating is more an energy system issue, therefore beyond the boundaries of this chapter.	Government of Canada	Environment and Climate Change Canada	Canada

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
76549	43	36	43	52	An econometric study based on newer evidence from the US Residential Energy Consumption Survey supports the statements in this section. Please note that older vintage buildings tend to have higher heating/cooling loads but newer vintage buildings often have higher appliance loads, especially those built in the 2000s. https://doi.org/10.1021/acs.est.0c05696	Taken into account - reference added in section 9.5.1.	Edgar Hertwich	Norwegian University of Science and Technology	Norway
8421	44	1	44	17	"OTTV" which is overall thermal transfer value could be effectively used to grade the envelope of buildings. There is a trend to use certain walls for office buildings (even some residential buildings). This practice should not be encouraged.	Rejected - due to lack of space	Otto Poon	President, Hong Kong Academy of Engineering Sciences.	China
49681	44	1	44	3	Parameters could be defined based on climatic zones rather than geographical classification based on continents since they may have sub climatic regions.	Taken into account - Text revised.	Satyaprakas Das Das	Manipal Academy of Higher Education	India
4981	44	5	44	5	The meaning of the following sentence is not clear :"In other world regions the literature is limited.". I would suggest to reword it	Taken into account - Text revised.	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
19939	44	12	44	12	envelope' should be 'envelopes'	Accepted - Text revised.	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
72083	44	12	44	13	Cooperative ownership can indeed be a barrier for building envelope renovation but besides normative criteria, it is also due to cooperative ownership decision process (decision needs to be agreed by the majority for external insultation for instance).	Taken into account - Text revised.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
56499	44	20	44	21	Envelope interventions beyond adding blown-in insulation are often quite disruptive and may make the home or building unusable for a lengthy period of time. That is also a major factor.	Taken into account - Text revised.	Government of United States of America	U.S. Department of State	United States of America
19941	44	23	44	23	are' should be 'as'	Accepted - Text revised.	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
64209	44	26	44	28	please shorten the title of Table 9.3	Noted	Ova Candra Dewi	Universitas Indonesia	Indonesia
22057	45	1	45	1	"heritage and easthetic values": It is not clear why there is a distinction between "Heritage or aesthetic values" and "Heritage and aesthetic values". Why not "Heritage" and "aesthetic values" ?	Taken into account - Text revised.	Government of France	Ministère de la Transition écologique et solidaire	France
45531	45	2	45	3	Legend is missing for this figure. What do the different shades of red and green mean? Is the willingness to invest in A-rated appliances indeed that low, or do I misinterpret the colour scheme?	The figure has been erased in the revision	Kornelis Blok	Delft University of Technology	Netherlands
70037	45	2	45	6	There is no explanation for color depth in Figure 9.15	The figure has been erased in the revision	Yoshiyuki Shimoda	Division of Sustainable Energy and Environmental Engineering, Osaka University	Japan
2319	45	4	45	4	The legend for the different shades of green/red is missing (figure 9.15)	The figure has been erased in the revision	Siddarth Durga	PNNL	United States of America
22059	45	4	45	4	To clarify the figure, a legend explaining the meaning of the shade of colors should be added	The figure has been erased in the revision	Government of France	Ministère de la Transition écologique et solidaire	France
3287	46	10	46	10	This section seems focused on residential buildings. Should also address the installation of RES in commercial buildings, driven by the increase in corporate sustainabiltiy goals. Obstacles include limited roof area in urban / downtown contexts, and the prevalence of purchasing offsets instead of additionality.	Noted - The key reference behind Table 9.3 includes both residential and non residential buildings, and the table covers the issues mentioned.	Rachel Bannon-Godfrey	Stantec	United States of America
56501	46	14	46	15	Other impacts on residential PV adoption are relative age of roof, roof orientation, and nearby shading.	Taken into account - Text revised.	Government of United States of America	U.S. Department of State	United States of America
82041	46	21	46	21	In addition, neighborhood peer effects can encourage adoption of residential PV, where households are more likely to install PV if their neighbors have already installer PV (https://doi.org/10.1093/jeg/lbu036 ; https://doi.org/10.1287/mksc.1120.0727)	Taken into account - Text revised to include references	Berrill Peter	Yale University	United States of America
17057	46	23	46	23	Upper case reference	Noted - Editorial	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
19943	46	23	46	23	Edit authors names that are in caps	Noted - Editorial	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
60589	46	23	46	23	reformat citation	Noted - Editorial	Evyatar Erell	Ben-Gurion University of the Negev	Israel
43669	46	24	46	35	An indication of a not yet fully developed structure in Chapter 9 is the isolated consideration of low carbon materials. Why is there no joint consideration with embodied energy/carbon? There is no consideration of low carbon buildings.	Taken into account - The chapter is revised for clarity. As for "low carbon buildings", we consider that all measures are necessary.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
19947	46	24	46	37	The focus on wood here is too restricted and not necessarily representative. Other materials to include would be hempcrete and straw bale, and possibly more. See: www.neesonline.org for examples from Northern Europe.	Accepted - Text revised.	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
61135	46	24	46	37	the importance of life cycle assessments to properly address the environmental performance of these materials would be very welcome. Expecting GHG emissions reduction solely due to certain material attributes might be misleading.	Noted - considered when rewriting the chapter	Marcella Saade	Graz University of Technology	Austria
82049	46	24	46	37	Regarding the potential for prefabrication, some national level policy targets are relevant. The following is a quote from UNEP/IRP 2020 (10.5281/zenodo.3542680): "In China, the State Council issued a policy circular (The 13th Five-year Plan for Economic and Social Development of the People's Republic of China) requiring that prefabricated buildings account for at least 30 per cent of total new construction for 10 years in the period starting in 2016 (http://english.www.gov.cn/policies/latest_releases/2016/09/30/content_281475455281032.htm).	Taken into account - Text revised to include the suggested reference.	Berrill Peter	Yale University	United States of America
9989	46	25		33	We doubt that wood-based building offer climate mitigation solutions due to several reasons: Wood is low carbon materials, however, an increase in wood-based buildings means more timber needed and more trees cut down; Even if the timber itself is supplied by industrial forestry, it may still considered as non-climate friendly, and not all countries (especially developing ones) have suitable public policy tools to manage a good industrial forestry. Maybe this paragraph could use another low-carbon material as an example. Additional comment regarding this matter can also be seen in our previous comment on Chapter 8 page 8-36.	Rejected - the chapter is based on literature based evidence	Government of Indonesia	Ministry of Environment and Forestry	Indonesia

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
19945	46	25	46	25	material' should be 'materials'	Accepted - Text revised.	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
47821	46	25	46	28	"Studies investigating the adoption of low-carbon material focus on the adoption of wood-based building system and prefabricated housing construction, mostly in high-income countries, as the majority of the resource (as in sustainable managed forestry) and technology (as in factories for prefabricated housing) availability are concentrated in such regions and countries (Mata el al, 2021c)." There are many more low carbon materials that are used in high-income countries as well as low income one. In Cuba, the adoption of low carbon cement was motivated by the possibility of supplying the raising demand with low initial investment costs. Cancio Díaz Y., Sánchez Berriel S., Heierli U., Favier A.R., Sánchez Machado I.R., Scrivener K., Martirena Hernández J.F., Habert G. 2017. Limestone calcined clay cement as a low-carbon solution to meet expanding cement demand in emerging economies. Development Engineering, 2, 82-91	Accepted - Text revised to include the suggested reference.	Guillaume Habert	ETH Zurich	Switzerland
47823	46	25	46	28	In Philippines, adoption of bamboo based social houses is motivated by the possibility of local job creation in the small decentralized workshops and the fact that these hourses are Typhoon resistant. Zea E., Habert G., Wohlmuth E. 2016. When CO2 counts: Sustainability assessment of industrialized bamboo as an alternative for social housing programs in the Philippines. Buildings and Environment. 103, 44-53Furthermore, promotion of wood as the only low carbon materials raises a serious risk of overconsumption of such resource. F Pomponi, J Hart, JH Arehart, B D'Amico Buildings as a Global Carbon Sink? A Reality Check on Feasibility Limits. One Earth 3 (2), 157-161	Accepted - Text revised to include the suggested references.	Guillaume Habert	ETH Zurich	Switzerland
82043	46	28	46	28	In addition to material substitution to low-carbon/carbon sequestering wood-based building, other opportunities for reducing GHG emissions from material production exist, such as building light-weighting (leaner design), and more efficient material production (higher yield, less onsite material waste). (UNEP/IRP 2020, (https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change, 10.5281/zenodo.3542680)	Taken into account - Text revised to include the suggeste reference.	Berrill Peter	Yale University	United States of America
43671	46	35	46	37	A discussion of the advantages of prefabrication does not fit here.	Taken into account - Text revised for clarity.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
56503	46	38	46	38	This section is really only about demand response, not the other two aspects.	Taken into account - Text revised for clarity.	Government of United States of America	U.S. Department of State	United States of America
56505	46	38	47	14	DOE published a study recently that lighting energy savings in the future would come in the commercial sector from connected lighting. It would be good to reference this in the lighting and digitalization section. This also relates to Table 9.3, which only mentions digitalization in the context of smart homes.	Accepted - considered in Section 9.4	Government of United States of America	U.S. Department of State	United States of America
56507	46	38	47	14	This section would more easily be understood if the terms grid integrated buildings or connected buildings were also included.	Accepted - considered when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56509	46	40	46	40	The regulatory framework in the U.S. does in most cases allow for demand response and time-of-use pricing, although there is some variability across states. Prices for peak demand resources can be very incentivizing. Maybe this section would benefit from a description of how demand response works in those markets where it is functioning, as well as other examples of the economic value of peak shaving? For example, in the U.S., there are efforts to include time-of-use rates in conducting cost-benefit analyses of policies such as building energy codes, which will make these codes more stringent in many locations. Likewise, page 47, lines 7-14, would benefit from concrete examples from where this is occurring rather than a theoretical discussion. Recommend expanding this discussion to highlight the practical experience in this area.	Accepted - considered in Section 9.9	Government of United States of America	U.S. Department of State	United States of America
74973	46		46		Consider Solar Photo Voltaic PV options and opportunities example of Strathmore University, wind power projects etc	Accepted - considered in Section 9.4	Government of Kenya	Kenya Meteorological Service	Kenya
56511	47	2			Define "sufficiency approach" or provide a supporting reference for the reader.	Accepted - in the overall chapter	Government of United States of America	U.S. Department of State	United States of America
22061	47	4	47	6	suggestion : mechanism to be better explained ? globaly it means balancing difficulties ?	Noted - section rewriten	Government of France	Ministère de la Transition écologique et solidaire	France
17935	47	7	47	14	Comments on interconnected homes as part of a smart grid - are there examples in this realm that could serve as a specific case study. Furthermore, this type of example may be particularly important for the decarbonization of isolated systems, in particular, for SIDS.	Rejected - due to lack of space	Robert Brecha	Climate Analytics	Germany
31335	47	15			Position on Circular economy/sharing-economy and it's potential seems at odds to some degree with caveats given in Chapter 5 (e.g. that the evidence for a positive climate impact is limited and in some cases can increase if primary market for materials is not reduced.) How to align?	Taken into account - Text revised in section 9.5.2 to mention rebounds.	Jacob HALCOMB	UNEP Affiliate	France
8423	47	15	47	20	To minimize construction wastes, there is a trend for modular construction. Recent practices are :- DfMA = Design for Manufacture and Assembly. MiMEP = MultiTrade Integrated Mechanical, Electrical & Plumbing. These designs can embody low energy materials, minimize construction waste and reduce construction time.	Rejected - due to lack of space	Otto Poon	President, Hong Kong Academy of Engineering Sciences.	China
28315	47	15	47	31	This section could do with citing two highly-cited papers [https://doi.org/10.1016/j.jclepro.2016.12.055, https://doi.org/10.1016/j.procir.2018.12.015] in this space and perhaps offer some more reasoning around key barriers and drivers linked to a wider uptake of the circular economy in the built environment.	Accepted - Text revised to include the suggested references.	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
56513	47	15	47	31	This should mention green building policies, which are mandatory in several jurisdictions (e.g., Washington, DC) and include requirements to use sustainable materials.	Noted - Text revised for clarity	Government of United States of America	U.S. Department of State	United States of America
82047	47	15	47	31	Design for disassembly can increase the likelihood of material re-use at building end of life. Recent work tries to measure the environmental benefits of circular economy strategies and design for disassembly, https://doi.org/10.1016/j.resconrec.2020.105120	Accepted - Text revised	Berrill Peter	Yale University	United States of America
4983	47	16	47	16	There is a typos. "recylces" should be substituted with "recycled"	Accepted - Text revised	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
56515	47	16	47	16	Seems odd to single out one country in starting a new section. Do authors have a data point for other countries? As phrased, it implies that the U.S. has a low level of recycling, but 20-30% is probably high compared to other countries, while still not representing the full potential.	Accepted - Text revised	Government of United States of America	U.S. Department of State	United States of America
56517	47	16	47	18	The data presented on recycling in the U.S. is over 10 years old. New data are available at https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/advancing-sustainable-materials-management This source shows recycling rates peaked in 2014-2017. There is no discussion on the global drop in recycling that has occurred in the last few years and the impact that has on the conclusion of this section.	Accepted - Text revised	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
82045	47	18	47	18	A recent study by Townsed et al shows the material flows of construction waste in the US (https://doi.org/10.1016/j.wasman.2018.11.048) Currently the main re-use is for road-bases, or waste to energy (Fig. 2)	Accepted - Text revised	Berrill Peter	Yale University	United States of America
78219	47	21			Both construction and deconstruction. This would be a ropewalk as circular economy is the need of the hour; but at the same time, market led forces may unnecessarily bring down old structures to feed the circular economy organisations. That will become a threat to the unprotected historic buildings, esp. where land value is high. Socio-economic tensions play a role here.	Accepted - Text revised	SUCHANDRA BARDHAN	Jadavpur University	India
56519	47	21	47	21	It seems odd to say that governments should promote decreased construction rates. By what mechanism, and what will this mean in terms of equity and affordable housing?	Accepted - Text revised	Government of United States of America	U.S. Department of State	United States of America
10759	47	29	47	31	This statement about "culture of waste" is disturbing; yet it reports accurately what is said by Ajayi et al. This gave me the opportunity to discover that Ajayi et al, 2015a and Ajayi et al, 2015b correspond to the same and identical paper. Check your references please. Perhaps you have a bug in the software organizing references.	Taken into account - The sentence has been rephrased. The duplicate reference has been erased.	Philippe Waldteufel	CNRS	France
14703	48	4	48	28	It seems that this chapter does not take into account the comprehensive scenario and roadmap work done by the Global Alliance for Buildings and Construction, e.g. for Asia, Africa and Latin America, which is available here: http://globalabc.org/resources/publications	Rejected: The work of the global alliance is based on IEA scenarios which are considered in the chapter	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
9991	48	5			There's some "Error! Reference source not found". Please check the destination formulas. Letter "q" in word quantifies is separated.	Editorial - text revised	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
56521	48	5	48	15	Check the claims made in this paragraph for completeness. The assessment of building controls strategies is not mentioned here, for example, though several studies since AR5 have investigated such operational strategies; moreover, not all of the studies referenced exclude the impacts of grid decarbonization (e.g., Langevin et al., 2019, as an example in the U.S.).	Taken into account. Thank you for your comment. We included the assessment of active and passive demand side management , which includes i.a. controls. We made a revision to make sure, we exclude studies with the impact of grid electricity (these measures and respective potentials are assessed in Ch on Energy supply). Among there, we had to exclude Langevin e al 2019.	Government of United States of America	U.S. Department of State	United States of America
2237	48	5	48	5	Shows "Error! Reference source not found."	Editorial - text revised	Stephen Wilkinson	University of Wollongong in Dubai	United Arab Emirates
17059	48	5	48	5	Error in reference!	Editorial - text revised	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
19949	48	5	48	5	Referencing error	Editorial - text revised	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
27787	48	5	48	5	Reference to be correctly presented.	Editorial - text revised	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
52391	48	5	48	5	Missing reference.	Editorial - text revised	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
60591	48	5	48	5	Error - reference not found.	Editorial - text revised	Evyatar Erell	Ben-Gurion University of the Negev	Israel
64211	48	5	48	5	Error! Reference (link is not working)	Editorial - text revised	Ova Candra Dewi	Universitas Indonesia	Indonesia
72085	48	5	48	5	A reference is missing.	Editorial - text revised	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
76551	48	6	49	34	I am really confused why sufficiency is discussed separately here from the behavioral aspects covered in 9.5.3 and the non-technical determinants discussed in 9.5.2. I cannot see that there are any new insights provided by this section. I think issues of plateauing demand for both building space and related services can be discussed as a part of historical or scenario analysis or in connection with policies. This section is potentially controversial and does not add anything of value.	Accepted: See box 9.1	Edgar Hertwich	Norwegian University of Science and Technology	Norway
14705	48	18	48	22	Please include scenario for EU presented in BPIE (2020): Contributions from the buildings sector to a strengthened 2030 climate target. https://www.bpie.eu/wp-content/uploads/2020/12/On-the-way-to-a-climate-neutral-Europe-_Final.pdf	Rejected: EU is merged with Eurasia	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
60593	48	18	48	22	This sentence misreprepresents the findings of the studies. Even assuming that all of the necessary investments are made (a heroic assumption in itself) and a very large increase in the rate of building retrofit, Germany, for example, will still have a requirement in 2050 of ~60 kWh/m2 per annum for space and water heating only. This will be a remarkable achievement (if in fact it can be achieved!) - but it is still not carbon neutral, and does not account for all other uses of energy.	Noted. Thank you for your comment. This feasibility constrain is now discussed in section 9.6.4 Determinants of the potentials and costs, as well as in the feasiblity annex (Supplementary tables to Chapter 9)	Evyatar Erell	Ben-Gurion University of the Negev	Israel
82051	48	18	48	22	Additional studies relevant to the statements here, for Switzerland (https://doi.org/10.5334/ bc.61), USA (www.pnas.org/cgi/doi/10.1073/pnas.1922205117), Norway (https://doi.org/10.1016/j.enpol.2020.112114)	Accepted. Thank you for your comment. The results of these three studies are now included into the review of potentials and the aggregation of the potential for Europe and USA.	Berrill Peter	Yale University	United States of America
72087	48	18	48	26	The figure of 90% emission reduction by 2050 in Europe and North America compared to the baseline 2010/2020 is a bit surprising. It is not clear if it corresponds only to buildings emissions. Usually, Europe tends to use the 1990 baseline. Eventually, if this figure relies on best-case scenarios, this could be reminded. About Asia and Developing Pacific, it would be good to know what is the baseline.	Taken into account. Thank you for your comment. We included even more Iterature quantifying the potential and the range for Europe and North America is now wider; we also indicated for each study (all regions including Asia) whether the potential refers to the basleine emssions or emissions in the base year (Figure 9.14). We also inclded the sentense that the studies were selected to rely on a comprehensive set or measures i.e. they are best case scenarious.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
56523	48	30			Figure 9.16 superficially reveals that there is high variability and uncertainty across the literature estimates of national GHG emissions reductions, even within one world region. Consider the following improvements: - Show box plots rather than individual points for each study. This will help to identify the central estimates for each region, improving comparison across regions. - Anchor each of these percentages to a common starting/reference emissions point (e.g., emissions in 2005, or 2020), rather than showing relative to the study's 2030/2050 baselines, which introduces additional variability into the results. - Further disaggregate North America, to separate the U.S. from other countries given the significantly different buildings sectors and emissions profiles. - There are many studies lumped together in the figure sources, with no way of tying specific estimates to a particular study. Consider at least attributing the studies to the countries in the caption.	Taken into account. Thank you for your comment. - Unfortunately, the central estimate would not provide a perfect indicator of the potential because not each study covered the whole sector emissions (sometimes only one segment was taken into account i.e. residential or non -residential, or only appliances, or only electricity-relaeted measures). This is why when judging about the emission reducion level, this additional information on study coverage was taken into account. - Anchoring the percentage to a common reference point in the past does not work because for some developing countries emissions will grow more than 100% as compared to their level at that time point and refering to them is confusing - We did not dissaggregate the US from North America because a similar degree of variabity was also observed withi other regions , i.e. Europe and Eurasia - We attributed the studies to countries by region in the reference	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
17937	48				Fig. 9 should be better explained. Is each data point one study? Is there only one study in total for LAC?	Noted. Thank you for your comment, we did our best to improve the text and provide more details, but could not describe in detail each individual region due to space limit. Yes, there are only afew studies for developing countries, even though we spent enomous time on conacting experts across the world and searching for literature. This is acknowledge in research gaps.	Robert Brecha	Climate Analytics	Germany
17061	49	5	49	5	Error in references!	Accepted. Thank you for your comment, errors in references are fixed.	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
56525	49	24	49	25	The statement that "the potential for energy efficiency must be realised prior to that of renewable energy" requires further support. As deployment of efficiency is limited by stock turnover rates and consumer adoption dynamics, a more feasible path to net-zero would be to allow efficiency improvements to progress alongside decarbonization of the energy supply, rather than requiring demand-side improvements be achieved before supply-side improvements (or vice versa).	Rejected. Thank you for your comment. The sequence of measures follows the conclusion of the IPCC Global warming of 1.5°C Report (Rogelj et al. 2018) that lower energy demand allows more choice of low-carbon energy supply options leading to higher energy security and afordability.	Government of United States of America	U.S. Department of State	United States of America
5461	49	25	49	29	OK. This confirm a previous remark: In urbal dense areas, the guarantee of supply come from mass production units (Hydro or nuclear) which are not located on-site. Renewable (heat or electricity) can only be a complement, not the base supply.	Rejected. The sentence does not confirm and/or refer to the security of energy supply from hydro or nuclear in urban areas.	Michel SIMON	Retraité/ Pdt d'association	France
56527	49	28	49	29	The text suggests Figure 9.17 is not yet complete; if top-down estimates are ultimately excluded, the reasoning for excluding them should be expanded beyond "not sufficiently clear" -- e.g., what specifically precludes their use in the figure, particularly given that the opening sentence of this subsection highlights the importance of using top-down and bottom-up approaches to improve the accuracy of potential assessments.	Noted. Thank you for your comment. The top down (IAM) estimates were not ready by the time of SOD; they are now discusssed in section 9.3.	Government of United States of America	U.S. Department of State	United States of America
56529	49	31	49	44	It would be helpful to explain in greater detail how the potentials were estimated in terms of cost. Are they deemed to be cost-effective and over what time period (like the buildings' life?), or how else does cost factor into the potentials? It would also be helpful to have information on the range of technical potentials available from the literature.	Noted. Thank you for your comment. The discussion of costs was expended in 9.6.3 Assessment of the potential costs, with literature references added. Additionally, supplementary materials provides the assessment of costs, as a feasiblity criteria, also with support of literature.	Government of United States of America	U.S. Department of State	United States of America
56531	49	33	49	34	For completeness, the authors should report which subset of studies from the previous figure were included in generating Figure 9.17, perhaps as a note in the caption.	Accepted. Thank you for your comment. We included the number of studies which were the basis of the potential aggregtion (67 BU technological studies + 10 BU sufficiency studies)	Government of United States of America	U.S. Department of State	United States of America
76553	49	36	50		This is a discussion of ideas. There is plenty of research out there investigating the potential contribution of reuse and recycling of buildings, components, and materials to GHG mitigation. Given that the materials with the highest potential energy savings are mostly recycled already, the emissions reductions from additional recycling are limited and there is a risk of counterproductive recycling. The issue of lifetime extension depends very much on context and country, but especially in Asia where buildings tend to have shorter lifetimes there is a significant potential benefit, especially when buildings are adequately renovated. The building component reuse is the least explored part and may not have very large benefits. doi 10.1088/1748-9326/ab0fe3 https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change but also IEA work on refurbishment. The modeling work in https://doi.org/10.21203/rs.3.rs-93217/v1 may be relevant.	Noted. Thank you for your comment. The potential of recycling/reuse is considered under the circular economy approach , which is introduced in detail in section 9.5.3.6 and which potential is plotted in Figure 9.13 Energy saving and GHG mitigation potentials for categories of non-technological interventions.	Edgar Hertwich	Norwegian University of Science and Technology	Norway
4985	50	1	50	1	Figure 9.17 is confusing or somehow wrong as the bar charts show, for instance, two shades of green but, in caption, just one shade of green is described. Altogether, tfigure 9.17 is unclear an confusing	Noted. Thank you for your comment. We had a central guideline on figure colors and shades, but indeed the results for these figures were not successful in the draft. We made a revision for the final draft.	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
22063	50	1	50	1	The coulour legend is not clear for the figure 9.17 : 2 meanings for one brown coulor and one green coulour without meaning. The difference between the two green/yellow and red columns does not appeared	Noted. Thank you for your comment. We had a central guideline on figure colors and shades, but indeed the results for these figures were not successful in the draft. We made a revision for the final draft.	Government of France	Ministère de la Transition écologique et solidaire	France
45533	50	1	50	1	The two bars for mitigation potential are difficult to distinguish. Maybe use a colour scheme with better distinction. Note that also the caption gives the wrong impression: it seems that up and bottom should be: left en right.	Noted. Thank you for your comment. We had a central guideline on figure colors and shades, but indeed the results for these figures were not successful in the draft. We made a revision for the final draft. The caption was also revised.	Kornelis Blok	Delft University of Technology	Netherlands
47507	50	1	50	1	There are no references to the impact that sufficiency measure could have on these figures. I suggest including the sufficiency approach.	Partially rejected. We identified ten pieces of research, which attest sufficiency potentials at national, regional or global levels. We referred to the results of this liretature in Table 9.4 Potential GHG emission reduction in the building sector offered by the introduction of sufficiency, as reported by bottom-up (or hybrid) literature	Gonzalo Sánchez	European Environmental Bureau	Belgium
70039	50	1	50	1	The relationship between the legend and the color of the graph is difficult to understand.	Noted. Thank you for your comment. We had a central guideline on figure colors, but indeed the results for these figures were not successful in SOD. We made a revision for the final draft.	Yoshiyuki Shimoda	Division of Sustainable Energy and Environmental Engineering, Osaka University	Japan
72089	50	1	50	4	The legend of the figure is difficult to understand. The differences between up and bottom emissions are not clear.	Noted. Thank you for your comment. We had a central guideline on figure colors, but indeed the results for these figures were not successful in SOD. We made a revision for the final draft.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
56533	50	2			Figure 9.17 is difficult to interpret and should be revised for clarity, in particular: - The fill patterns (solid, hatched) are almost impossible to discern. - The caption suggests there is an ""up"" and ""bottom"" but it is not apparent what is different between the top and bottom portions of the figure. - The meaning of the two sets of stacked bars with a green line between them, each marked 2050, is not readily apparent. - In all cases, the mitigation potential sums to 100% of the 2050 baseline. This result is suspect, given that large portions of baseline energy use will be difficult to impact via efficiency (e.g., miscellaneous electrical/unknown building loads) and on-site renewables can only offset so much given constraints the authors noted about siting these distributed renewable sources. Moreover, it is not apparent from this figure what the potential for emissions reduction through fuel switching to a more highly decarbonized central electricity supply is.	Noted. Thank you for your comment. We had a central guideline on figure colors, but indeed the results for these figures were not successful in SOD. We made a revision for the final draft.	Government of United States of America	U.S. Department of State	United States of America
10761	50	2	50	4	I am unable to use the colour code. Which colour corresponds to the green part of the mitigation potential? Also I assume that the left part of mitigation potential chart corresponds to 2020 rather than 2050?	Noted. Thank you for your comment. -We had a central guideline on figure colors, but indeed the results for these figures were not successful in SOD. We made a revision for the final draft. - the caption was revised - revised - the potential adds up to 100% with remaining baseline emissions which were not mitigated, i.e. there is no potential of 100% in neither of world regions. the figure is revised to improve clarify	Philippe Waldteufel	CNRS	France
56535	50	5	50	7	Consider clarifying this statement. In particular, the meaning of "incremental improvements" is not apparent; often such improvements are taken to signify individual technological options, yet the authors position these as two different concepts.	Accepted. Thank you for your comment. We rephrased the sentence to improve its clarity.	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56537	50	10	50	11	The concept of "sufficiency" should be further explained or referenced.	Accepted. Thank you for your comment. Sufficiency is now introduced in Box 9.1 in 9.1 (Introduction) and the final text of 9.6 refers to it.	Government of United States of America	U.S. Department of State	United States of America
56539	50	10	50	11	What does this sentence even mean? Please consider rewording to more clearly convey intent.	Accepted. Thank you for your comment. We rephrased the sentence to improve its clarity.	Government of United States of America	U.S. Department of State	United States of America
3673	50	12	50	23	This sector introduces three bottom up method to analysis the impact of non-technical method on decarbonization in building sector. In fact, there are more similar methods, e.g. Zhang et al. (2020) and Yang et al. (2019) uses bottom up method to study the impact of policy packages on mid-to-long term buidling energy consumption in China and APEC region. It is suggest to change the sentence "…there are three very detailed models relying on bottom-up approaches"to"…there are many detailed models relying on bottom-up approaches (Yang et al., 2019; Zhang et al., 2020)" Yang, X., Zhang, S., Xu, W., 2019. Impact of zero energy buildings on medium-to-long term building energy consumption in China. Energy Policy 129, 574-586. Zhang, S., Xu, W., Wang, K., Feng, W., Athienitis, A., Hua, G., Okumiya, M., Yoon, G., Cho, D.W., Iyer-Raniga, U., Mazria, E., Lyu, Y., 2020. Scenarios of energy reduction potential of zero energy building promotion in the Asia-Pacific region to year 2050. Energy (Oxf) 213, 118792.	Accepted. Thank you for your comment and additional references. We included the information from them to the extent we could.	Xinyan Yang	China Academy of Building Research	China
63077	50	12	50	23	Please change "…there are three very detailed models relying on bottom-up approaches"" into "…there are many detailed models relying on bottom-up approaches(Yang et al., 2019; Zhang et al., 2020)"	Accepted. Thank you for your comment. The sentence does not feature in the final chapter version, but we included the literature.	Changke WANG	National Climate Center, China Meteorological Administration	China
27791	50	13	50	13	It is not countries, but regions.	Noted. Thank you for your comment. The sentence does not feature in the final chapter version.	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
72091	50	18	50	21	The potential for the decent living energy scenario is missing but seems to be expected as for january 2021.	Noted. Thank you for your comment. This is right; we added all missing sufficiency potential estimates in new Table 9.4 Potential GHG emission reduction in the building sector offered by the introduction of sufficiency, as reported by bottom-up (or hybrid) literature	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
16531	50	20			Correct xx%.	Accepted. Thank you for your comment. The study results were not yet ready by the time of submitting SOD. We included the latest results of the respective piece of research into the final version of the chapter.	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17037	50	20			xx% is error. Check please.	Accepted. Thank you for your comment. The study results were not yet ready by the time of submitting SOD. We included the latest results of the respective piece of research into the final version of the chapter.	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
27789	50	20	50	20	Present the estimated persentage changes.	Accepted. Thank you for your comment. The study results were not yet ready by the time of submitting SOD. We included the latest results of the respective piece of research into the final version of the chapter.	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
56541	50	20	50	20	Missing value "xx%".	Accepted. Thank you for your comment. The study results were not yet ready by the time of submitting SOD. We included the latest results of the respective piece of research into the final version of the chapter.	Government of United States of America	U.S. Department of State	United States of America
60595	50	21	50	21	scarifying???	Accepted. Thank you for your comment. This was a mistype; the sentence does not appear in the final chapter.	Evyatar Erell	Ben-Gurion University of the Negev	Israel
56543	50	24	50	24	In Table 9.4, Europe row, Envelope improvement (new) is reported twice perhaps instead of Envelope improvement (renovation).	Accepted. Thank you for your comment. This was a mistype; the Table does not appear in the final chapter, it is replace by a Figure illustrating the potential by measure and cost .	Government of United States of America	U.S. Department of State	United States of America
56545	50	25			Table 9.4 appears to entirely ignore the importance of building controls, which are capable of drastically lowering the need for energy services, in line with the concept of "sufficiency" mentioned throughout these sections. The authors are encouraged to highlight controls measures as part of this table (see Langevin et al., 2019, for a demonstration of these measures' potential in the U.S. context, https://www.sciencedirect.com/science/article/pii/S2542435119303575). It is also not apparent why fuel switching measures show up only for Europe (and only with reference to onsite renewables), when fuel switching of building heating, water heating, and cooking alongside grid decarbonization is emerging as one of the most important ways that buildings can contribute to overall net-zero pathways (for example, see https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020AV000284). Finally, the authors are encouraged to double-check this table, as it appears there are important errors (e.g., the row for Europe shows new envelope measures as the highest priority, when one would expect existing envelope to be more important, and indeed new envelope shows twice in this row).	Taken into account. Thank you for your comment. Controls were among the options; but they are integrated into DSM aggregated in turn under HVAC label. In the table replacing the figure, we added DSM to reflect better this measure. Fuel switching is a very important and recorded across all measures: for space heating - in the exchange or installation of HVAC, for cooking, water heating, and lighting - in the category of replacing appliances, equipment, and lighting. The ranking of options is also revised.	Government of United States of America	U.S. Department of State	United States of America
56547	50	25	51	1	Table 9.4 has two columns labeled "Priority 4". The last column should be labeled "Priority 5".	Accepted. Thank you for your comment. This was a mistype; the Table does not appear in the final chapter, it is replace by a Figure illustrating the potential by measure and cost .	Government of United States of America	U.S. Department of State	United States of America
56549	50	25	51	1	Envelope retrofits are extremely costly and disruptive. How are they seen as high priority in so many regions? What is the justification for this?	Noted. Thank you for your comment. The ranking in Table 9.4 were provided in terms of the potential size, not in terms of costs.	Government of United States of America	U.S. Department of State	United States of America
56551	50	25	51	13	Need sources for Table 9.4 and Figure 9.18.	Noted. Thank you for your comment. Table 9.4 and Figure 9.18 relied to on the same sources as Figure 9.16 and 9.17. were provided in terms of the potential size, not in terms of costs. We revised the text, clarifying this. Table 9.4 was replace by a figure in the final version.	Government of United States of America	U.S. Department of State	United States of America
25037	50				The label of the last column should be Priority 5 not 4; the last two columns have the same label.	Accepted. Thank you for your comment. This was a mistype; the Table does not appear in the final chapter, it is replace by a Figure illustrating the potential by measure and cost .	Bassam AbuHijleh	The British University in Dubai	United Arab Emirates
72093	51	1	51	1	In the table 9.4, the measure about envelope improvement for new buildings appears twice for Europe. Probably, there's one about renovation. The figure is misleading. The text refers to emission reduction then but in the previous lines, it refers to energy demand. As HVAC measures appear to be a high prioritisation measure, the table seems to refer to emission reduction.	Accepted. Thank you for your comment. This was a mistype; the Table does not appear in the final chapter, it is replace by a Figure illustrating the potential by measure and cost . The results were revised.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
76555	51	1	51	10	The policy chapter in https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change has a very good discussion about the sharing economy and how it does not always and necessarily reduce emissions, also for AirBNB. Check for the references provided therein.	Accepted. Thank you for your comment. We added a review of sufficency studies which is an emerging trend in literature and thus which were just recently published (Table 9.4). We added the suggested reference and its results to the table.	Edgar Hertwich	Norwegian University of Science and Technology	Norway

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
45535	51	2	51	4	Not clear what in Figure 9.18 is derived from the 9.17 results and what is from Grubler. And what are non-technological approaches?	Accepted. Thank you for your comment. We added Box 9.1 to Section 9.1 (introduction) to introduce and define sufficiency i.e. non-techno approaches referred here. In the final version, regional and global potentials are plotted on one figure and they both rely on the same methodology, deriving the estimates from 67 techno studies and 10 sufficiency studies, one of which is Gruber. We added a sentence specifically clarifying this/	Kornelis Blok	Delft University of Technology	Netherlands
5463	51	3	51	3	replace Renewables" by "low carbon sources"	Noted. Thank you for your comment. We replaced renewables with onsite renewable energy technologies. The figure does not plot other energy carriers than renewable energy therefore we did not replace with low carbon sources.	Michel SIMON	Retraité/ Pdt d'association	France
16533	51	6	51	9	Please Correct the numbrers as figure 9.18.	Accepted. Thank you for your comment. The numbers of the global potentials were finalized and included into the final version of the chapter.	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17039	51	6	51	9	Please Correct the numbrers as figure 9.18.	Accepted. Thank you for your comment. The numbers of the global potentials were finalized and included into the final version of the chapter.	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
56553	51	7	51	8	The concept of "non-technological approaches such as the change in energy service and its amount delivered" requires further explanation. In particular, it is not apparent whether "change in energy service" refers to decarbonization of the energy supply or something else, and how "amount delivered" is distinct from reductions in demand due to energy efficiency measures (another segment on this plot). Presumably, the latter is referring to the concept of "energy sufficiency" -- e.g., reduced demand for services from improved envelopes, behavior changes, and better controls, as opposed to equipment efficiency improvements. The text should confirm or further explain this.	Taken into account. Thank you for your comment. Sufficiency (change in energy services) is now introduced in Box 9.1 in 9.1 (Introduction) and the final text of 9.6 refers to it.	Government of United States of America	U.S. Department of State	United States of America
16535	51	10			Revise the sentenses.	Accepted. Thank you for your comment. We finalized the aggregation of the potential and the sentences respectively were revised	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17041	51	10			Revise the sentenses.	Accepted. Thank you for your comment. We finalized the aggregation of the potential and the sentences respectively were revised	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
82053	51	10	51	10	Regarding attempts to integrate sufficiency in Figure 9.18 in the next round, One resource which can demonstrate national/regional/global emission reductions from sufficiency (reduced m2/cap) is the UNEP/IRP 2020 report on Resource Efficiency and Climate Change (https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change, 10.5281/zenodo.3542680). See Fig. 10 of the report for global totals. National/regional data are also available if you contact the authors, some data associated with this preprint may be useful https://doi.org/10.21203/rs.3.rs-93217/v1	Accepted. Thank you for your comment. We added a review of sufficency studies which is an emerging trend in literature and thus which were just recently published (Table 9.4). We added the suggested reference and its results to the table.	Berrill Peter	Yale University	United States of America
47509	51	12	51	13	There are no references to the impact that sufficiency measure could have on these figures. I suggest including the sufficiency approach.	Noted. Thank you for your comment, the calculation of the sufficiency impacts is now added in "Table 9.4 Potential GHG emission reduction in the building sector offered by the introduction of sufficiency, as reported by bottom-up (or hybrid) literature " as well as "Figure 9.6 Drivers of GHG emissions" in Section 9.3.2	Gonzalo Sánchez	European Environmental Bureau	Belgium
10763	51	13	51	13	I can try to imagine what this figure means but the legend does not help me much. You should definitely define what the middle column stands for. Probably it represents the emission in the baseline situation (no emission reduction); but what is the scenario for 2050?	Noted. Thank you for your comment. We revised the legend of the figure.	Philippe Waldteufel	CNRS	France
4987	51	20	51	20	xx% should be substutuded with a figure	Accepted. Thank you for your comment. The resuts of this study were not availabe for SOD, and its final results are now reflected in "Table 9.4 Potential GHG emission reduction in the building sector offered by the introduction of sufficiency, as reported by bottom-up (or hybrid) literature ".	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
22065	51		51		Enveloppe improvement is mentioned twice whereas Enveloppe improvement in renovation is not, should'nt it be mentioned in priority 1 ?	Accepted. Thank you for your comment. This was a mistype; the Table does not appear in the final chapter, it is replace by a Figure illustrating the potential by measure and cost .	Government of France	Ministère de la Transition écologique et solidaire	France
56555	52	7			The crucial determinant of consumer adoption preferences is missing and is worth expanding upon in this section. For example, if fuel switching to a decarbonized energy supply is needed to achieve a net-zero buildings sector, but electric alternatives to gas heating/water heating/cooking are not attractive to consumers, potential emissions reductions from fuel switching will be significantly limited. Barriers to electrification have been examined at least qualitatively in a few studies, for example, in the U.S.: https://eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf https://www.nrel.gov/docs/fy18osti/71500.pdf	Noted. These determinants are discussed in feasibility assessment provided in supplementary materials to the chapter. The reference is checked. It is important to note that the process of electrification is happening globally at much higher rates than the models predicted some 15-20 years ago, as reflected in baselines used in AR4 for 2020 as compared to the status quo today.	Government of United States of America	U.S. Department of State	United States of America
56557	52	16	52	19	This contains a policy recommendation, and it is not clear how to have a policy to limit space per capita anyway. Delete it.	Noted. Thank you for your comment. The sentence is rephrased to avoid its understanding as a policy recommendation. We added the specification of measures implementing the reduction of floor space per capita and the supporting literature.	Government of United States of America	U.S. Department of State	United States of America
76557	52	18			I would call these user behavior. See the famous 'Behavioral wedge' article in PNAS.	Noted. Thank you for your comment. It is indeed a non-technological measure, recently referred to many publications as sufficiency. A growing amount of literature recognizes the importance of reducting activity (m2, cars, etc), and given that floor area is the key determinant in buildings, we added Box 9.1 in section 9.1 (Introduction) to define it separatly from other non-technological measures and respectively assess it, as it is reflected in literature.	Edgar Hertwich	Norwegian University of Science and Technology	Norway
10765	52	19	52	21	This text implies that sharing a household with an additional member is an alternative service rather than a lower service. From the viewpoint of the preexisting inhabitants, this does not make sense. Please clarify.	Noted. Thank you for your comment. It could be both, we expanded the explanation of more efficiency use of space, and provided the identification of measures, as provided by literature. This particiular sentence is gone, but we revised the text to address the comment. We also added Box 9.1 to Section 9.1 (Introduction) which explains the sufficinecy concept.	Philippe Waldteufel	CNRS	France
19951	52	24	52	25	I'm not convinced this statement is entirely accurate. As a general rule, yes, the bulk of emissions (particularly of whole life emissions) are locked in, but a key failure of building procurement policies is the lack of post occupancy evaluation. Although more work is needed to evaluate emissions savings, the 'soft landings' approach offers significant potential for reducing emissions post-occupancy, and although aimed at non-domestic buildings it could be adapted for domestic buildings. See: https://www.bsria.com/uk/consultancy/project-improvement/soft-landings/	Noted. Thank you for your comment. The reference is checked.	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
48401	52	24	52	33	Recently studies quantified stranded assets in the buildings sector due to rapid energy system changes as well as energy supply. For example, Oshiro et al. (2020) indicated that energy investment in energy demand sectors can be stranded in Japan, while the risk of stranded investment can be reduced by sectoral policies such as subsidy for electrified equipment. * Oshiro, K., Fujimori, S. (2020). Stranded investment associated with rapid energy system changes under the mid-century strategy in Japan. Sustainability Science, in press. doi:10.1007/s11625-020-00862-2	Noted. Thank you for your comment. The reference is checked. The issue is addressed in Section Financial incentives for buildings and systems are 9.9 Sectoral policies	Ken Oshiro	Kyoto University	Japan

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
82055	52	26	52	27	Can a reference be given to support this claim, e.g. examples of models with assume high renovation rates to decarbonize the building stock	Noted. Thank you for your comment. The references are the same as those of Figure 9.16 of SOD; we added a phrase to clarify this.	Berrill Peter	Yale University	United States of America
82057	52	27	52	30	A similar, relatively low, renovation rate is expected in the US, 1.1-1.7% (https://doi.org/10.1073/pnas.1922205117)	Noted. Thank you for your comment and the reference, we checked it. These are assumed BAU rates of retrofits, whereas the sentence meant to provide simulated rates based on solid evidence in the past, hence we did not revise the text.	Berrill Peter	Yale University	United States of America
56559	53	2	53	5	This section starts by discussing the large amount of literature supporting Integrated Design but no mention of this literature is made on page 25, lines 45-46, where the authors write about the issue with linear design. Some coordination is needed between these two thoughts. See related U.S. comment on page 25, line 45.	Noted. Thank you for your comment. The text here was amended and a cross reference to respective lines in 9.4.1 is made.	Government of United States of America	U.S. Department of State	United States of America
56561	53	8	53	9	While the authors' claim here is understood, they are encouraged to soften the language about "all studies reviewed" considering only commercially available or near-available technologies, as this is not accurate. For example, at least one of the U.S. studies referenced (Langevin et al., 2019) models technologies that are at least 10 years away from market introduction, with often aggressive improvements in performance and reductions in the need for energy services (https://www.sciencedirect.com/science/article/pii/S2542435119303575). At least some of the other reviewed studies have similar representation of such emerging technologies in their most optimistic scenarios. Suggest using "most reviewed studies" or similar.	Accepted. Thank you for your comment."all studies" are replaced with "most studies"	Government of United States of America	U.S. Department of State	United States of America
79135	53	9	53	10	The reference to (Lovins 2018) wholly mistates its content. That paper is not about technology but about design—how technologies are chosen, combined, timed, and sequenced. This is a separate source of improvement, and a dramatic one largely overlooked in this chapter: the "integrative design" required can make the whole energy-efficiency resource severalfold larger than conventionally assumed, yet cheaper, often with increasing returns. While this is best-recognized in buildings (vs mobility and industry), it is far from widely understood and applied by building analysts. Other papers show that integrative design and indeed energy efficiency generally are largely neglected in IAMs (doi:10.1088/1748-9326/ab55ab), causing most to gravely understate the quantity and overstate the cost of end-use efficiency, but that energy efficiency may help to accelerate the already dramatic flight of financial capital from fossil fuels to renewables and efficiency (10.1088/1748-9326/abc3f2) because its transmissibility by memes, phrases, and images at potentially the speed of social media could greatly accelerate its spread, perhaps even rivaling that of solar scaleup—relevant to this chapter's discussion of impediments to wide adoption.	Accepted. Thank you for your comment. Indeed the reference Lovine (2018) was wrongly placed. The role of integrative design is recognized in 9.6 aand the placement of the reference is corrected.	Amory B. Lovins	Rocky Mountain Institute; also Adjunct Professor of Environmental & Civil Engineering, Stanford University	United States of America
79133	53	19	53	19	This reference to (Lovins 2018) should also cite (Lovins and Bond 2021), doi:10.1088/1748-9326/abc3f2, which elaborates novel ways to operationalize the spread of such integrative design.	Noted. Thank you for your comment. The reference was checked.	Amory B. Lovins	Rocky Mountain Institute; also Adjunct Professor of Environmental & Civil Engineering, Stanford University	United States of America
16537	53	20	53	24	Delete this section because it is a duplicate of 9.4.2 section(26 page).	Accepted. Thank you for your comment. Ths piece of text is now revised to reflect the global estimates of embodied mitigation potential in buildings. Section 9.4.2 does not contain this information and therefore there is no dublication now.	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17043	53	20	53	24	Delete this section because it is a duplicate of 9.4.2 section(26 page).	Accepted. Thank you for your comment. Ths piece of text is now revised to reflect the global estimates of embodied mitigation potential in buildings. Section 9.4.2 does not contain this information and therefore there is no dublication now.	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
19953	53	20	53	24	I would add a caveat here that, whilst the reduction of embodied emissions is an important objective, policies (such as the UK's Building Regulations / Standards) need to be careful not to leverage reductions in embodied emissions if they serve to disincentivise the construction of naturally heated, ventilated, lit and cooled buildings that deliver lower energy consumption at some cost to embodied energy. A further consideration is in regard to the materials used for such buildings, in that materials used for high thermal mass (and other benefits) may have lower environmental impacts through being less 'manufactured' and / or being more easily recyclable / biodegradable. Yet another consideration is the relative life-spans and the energy embodied in maintaining light-build, 'climate responsive', buildings using MHVR versus naturally 'passive' buildings (and the use of the term 'passive' or 'passiv' in this discussion is confusing for non-specialists so some clarification of the use of these terms in this report is probably advisable).	Rejected. This section has been removed	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
28319	53	20	53	24	The underemphasis on embodied emissions seem to continue in this part of the chapter too with only few lines given to potential reduction of embodied emissions. Material efficiency and the role of building forms in design could be given visibility here too to emphasise the great potential that these offer (sometimes up to 40% reduction). In general, I feel the chapter fails to communicate a key point to the reader: for any given building in 2021 embodied emissions occur now and are locked in for decades compared to operational emissions (which can be mitigated in time but always at the expense of increasing the embodied ones - e.g. extra insulation in retrofit: decreases operational over the years and increases embodied instantly). This is a thorny point in the sustainability discourse and one in which the IPCC should offer at least clarity and a balanced perspective.	Rejected. This short section of text has been removed, but the treatment of embodied emissions in 9.6 as a whole has expanded.	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
43673	53	20	53	24	It is not approapriate to dedicate only 4 lines of text to the importance of the embodied emissions, see https://www.sciencedirect.com/science/article/pii/S0306261919317945?via%3Dihub; There is diverse literature on the subject of embodied emissions. It turns out to be a major problem in the structure of the chapter that the topic of embodied emissions is not dealt with systematically, is divided into several sub-topics and dealt with using varying terms.	Rejected. This short section of text has been removed, but the treatment of embodied emissions in 9.6 as a whole has expanded.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
56563	53	21	53	24	Consider merging with discussion on page 26, line 13 through page 27, line 25.	Rejected. Thank you for your comment. That piece of text (9.4.2 Embodied energy and embodied carbon in building materials) identifies the measures, whereas this section 9.6 discusses the associated global potential, as a part of the overall discussion of the global potentials.	Government of United States of America	U.S. Department of State	United States of America
62105	53	21	53	24	Reducing embodied GHG emissions should not lead to increasing energy use. Therefore lifecycle emissions embodied in buildings at national level should be assessed together with operational emissions.	Rejected. This short section of text has been removed, but the treatment of embodied emissions in 9.6 as a whole has expanded.	Bruno Peuportier	MINES ParisTech	France
60215	53	22	53	24	I'm not sure this is an emerging literature as this topic has been around over the last 20 years, but if you need a recent review of the contribution of embodied emission in life cycle of buildings then you can cite: Röck M., Mendes Saade M.R., Balouktsi M., Nygaard Rasmussen F., Birgisdottird H., Frischknecht R., Habert G., Lützkendorf T., Passer A. 2020. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy. 258, 114107. DOI: 10.1016/j.apenergy.2019.114107	Rejected. This short section of text has been removed, but the treatment of embodied emissions in 9.6 as a whole has expanded.	Guillaume Habert	ETH Zurich	Switzerland
79431	53	22	53	24	It is unfortunate to only see such a short section on embodied emissions here. Other than what is stated, the literature on this topic is not just "emerging" but has been around for more than a decade. Recent efforts have, e.g., systematically reviewed and analysed hundreds of life cycle assessment case studies to investigate the growing relevance of embodied GHG emissions in buildings and ways to improve them, e.g. through related legislation and inclusion in building codes in order to incentivise the use of low-emissions construction materials. For the meta-study on GHG emisisons across the life cycle of buildings, which found embodied emissions to be the "hidden challenge for effective climate change mitigation", you can cite: Röck M., Mendes Saade M.R., Balouktsi M., Nygaard Rasmussen F., Birgisdottird H., Frischknecht R., Habert G., Lützkendorf T., Passer A. 2020. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy. 258, 114107. DOI: https://doi.org/10.1016/j.apenergy.2019.114107	Rejected. This short section of text has been removed, but the treatment of embodied emissions in 9.6 as a whole has expanded.	Martin Röck	KU Leuven	Austria

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
79691	53	22	53	24	Buildings are major sources of greenhouse gas (GHG) emissions and contributors to the climate crisis. To meet climate-change mitigation needs, one must go beyond operational energy consumption and related GHG emissions of buildings and address their full life cycle. This study investigates the global trends of GHG emissions arising across the life cycle of buildings by systematically compiling and analysing more than 650 life cycle assessment (LCA) case studies. The results, presented for different energy performance classes based on a final sample of 238 cases, show a clear reduction trend in life cycle GHG emissions due to improved operational energy performance. However, the analysis reveals an increase in relative and absolute contributions of so-called 'embodied' GHG emissions, i.e., emissions arising from manufacturing and processing of building materials. Ref: Röck M., Mendes Saade M.R., Balouktsi M., Nygaard Rasmussen F., Birgisdottird H., Frischknecht R., Habert G., Lützkendorf T., Passer A. 2020. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy. 258, 114107. DOI: 10.1016/j.apenergy.2019.114107	Rejected. This short section of text has been removed, but the treatment of embodied emissions in 9.6 as a whole has expanded.	Alexander Passer	Graz University of Technology	Austria
53741	53	31	53	32	The sentence of "nearly 40% of new buildings in China had green certification in 2018" is not accurate. It should be nearly 40% of new buildings in the urban areas of China. The original text in the reference is "... more than 40% of the new residential and commercial buildings in the urban areas are green building".	Noted. Thank you for your comment. This sentence was however cut during the chapter revision and it is no more relevant.	ZHENG XINZHU	China University of Petroleum (Beijing)	China
63079	53	31	53	32	It is suggested to add "in the urban areas" before "in China". Shen and Faure 2020: By the end of 2018, 10, 139 projects with a total GFA of 2.5 billion m2 in China obtained GBEL certification, and more than 40% of the new residential and commercial buildings in the urban areas are green building.	Noted. Thank you for your comment. This sentence was however cut during the chapter revision and it is no more relevant.	Changke WANG	National Climate Center, China Meteorological Administration	China
56565	54	4	54	9	The point that higher humidity can hasten/accelerate deterioration of wood, etc., thus causing negative impacts on indoor air quality, is important. And could be expanded to include other water events that can damage a building and adversely impact indoor air quality and public health such as rain, snow, flood, etc.	This is an important point and we included it. But more discussion is not possible due to page limitations.	Government of United States of America	U.S. Department of State	United States of America
56567	54	11	54	11	What does "cost learning" refer to here? The fact that technologies get cheaper over time because of refinements in process and increases in volume? That is called the "technology cost curve".	Accepted. Thank you for your comment. The wording is corrected to the technology cost curve.	Government of United States of America	U.S. Department of State	United States of America
86653	54	12		13	11 9.6.4.2 Cost learning on retrofit projects. There is a well established literature on technology learning or experience curves. Here waht is being talked about is a better understanding of integrating design and build. But it does lead to very raoid and substantioal cost savings, and COULD be usefully related to the litertaure on technology learning.	Noted. Thank you for your comment. We added a source reviewing compehensive body of literature on experience curves of nZEBs	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
45537	54	19	54	20	These 111,000 have by far not been realized: only 10,000 were realized in 2020. Happy to dig up more information.	Accepted. Thank you for your comment. We have revised the sentence accordingly.	Kornelis Blok	Delft University of Technology	Netherlands
22067	54	22	54	26	It is important to notice that the cost effectiveness is calculated including all the available public subsidies and grant.	Accepted. Thank you for your comment. We revised the sentence including this information.	Government of France	Ministère de la Transition écologique et solidaire	France
11223	54	23	54	26	There seems to be something wrong with the sentence ("a cap was set"... odd repetition)	Accepted. Thank you for your comment. We revised the sentence to imporve its clarify.	Bianka SHOAI-TEHRANI	RTE Réseau de Transport d'Electricité, CentraleSupelec Paris Saclay University	France
47511	54	28	57	41	There are no explicit references to the impact of sufficiency measures and the SER approach in this chapter.	In this section we explore SER measures, both in terms of impacts and interactions mitigation-adaptation. However, the literature herein use does not use such categorization.	Gonzalo Sánchez	European Environmental Bureau	Belgium
10767	54	29	54	30	What is meant by "decades in the futures"? When considering good quality buildings, we should consider a time span covering many decades. How many? A couple of centuries? more? This issue is very relevant when discussing renovation, retrofitting, etc. against demolition. Hopefully some literature is available on this point.	This opening statement aims to simply convey the message that buildings will likely face future climate conditions given their long life span. A discussion about how long it is falls outside the scope of the section. For purpose of avoiding this confusion and reducing the number of words in the section we deleted "for decades into the future", without jeopardizing the key message.	Philippe Waldteufel	CNRS	France
56569	54	37	54	44	LBNL published a very nice study on the connection between energy efficiency and resilience using a nursing home as a case study last year. It would be a good reference to include. See: Sun, Kaiyu, Michael Specian, and Tianzhen Hong. "Nexus of thermal resilience and energy efficiency in buildings: A case study of a nursing home." Building and Environment 177 (2020) 106842.	We thank the reviewers for the suggested references, some of which have been incorporated.	Government of United States of America	U.S. Department of State	United States of America
56571	54	37	56	20	Climate is also expected to increase the frequency of wildfires, which presents challenges to the built environment through the direct impact of the fire and via smoke intrusion. Is there an angle that should be addressed under adaptation to address fire-risks, better filtration of indoor PM associated with wildfire smoke, and rebuilding?	Thank you, we now mention wildfires	Government of United States of America	U.S. Department of State	United States of America
56573	54	38	54	39	There is significant literature that focuses on impacts other than heating and cooling needs. Address the need to adapt buildings to more frequent high winds, water events including flooding, rain, snow, pest intrusion, and wildfire smoke -- in order to protect public health. Important literature on climate change, indoor environments (interior of buildings) and health is available and could be cited. See suggested references below for examples. Buildings can and should be places of refuge from the extremes of climate, not just temperature changes, but increases in wind, water, snow, pollen, wildfire smoke, pests, etc. Sample References: Exploring the consequences of climate change for indoor air quality. William W Nazaroff, Environ. Res. Lett. 8 (2013) 015022 (20pp) doi:10.1088/1748-9326/8/1/015022 Climate change, indoor environments, and health. Spengler, J. Indoor Air 2012; 22: 89-95 https://doi.org/10.1111/j.1600-0668.2012.00768.x Review of some effects of climate change on indoor environmental quality and health and associated no-regrets mitigation measures. William J. Fisk. Building and Environment 86 (2015) 70e80 http://dx.doi.org/10.1016/j.buildenv.2014.12.024 Health benefits and costs of filtration interventions that reduce indoor exposure to PM2.5 during wildfires. Fisk and Chan. Indoor Air 2017; 27: 191--204 ¬© 2016 John Wiley. 2017. & Sons A/S. Published by John Wiley & Sons Ltd wileyonlinelibrary.com/journal/ina https://doi.org/10.1111/ina.12285 https://iaqscience.lbl.gov/topic/downloadable-papers Fann, N., T. Brennan, P. Dolwick, J.L. Gamble, V. Ilacqua, L. Kolb, C.G. Nolte, T.L. Spero, and L. Ziska, 2016: Ch. 3: Air Quality Impacts. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. U.S. Global Change Research Program, Washington, DC, 69--98. http://dx.doi.org/10.7930/J0GQ6VP6	We agree with the reviewer that there are many other impacts and we have included those later in the text. This paragraph, however, focuses on heating and cooling. So we changed the opening sentence to clarify that this is only a share of the literature. We thank the reviewers for the suggested references, some of which have been incorporated.	Government of United States of America	U.S. Department of State	United States of America
56575	54	38	56	20	There is no discussion about the concept of passive survivability in the design of buildings. This is a novel concept that is being widely studied in the United States and is worth mention in Section 9.7, Links to Adaptation.	Thank you, but we are strugling with the number of pages and are not able to include this.	Government of United States of America	U.S. Department of State	United States of America
4287	54	41	54	41	Add the following text "However, the adoption of dynamic cooling setpoint temperatures, which may very depending on the external conditions, may help to contain this increase, specially in densely populated areas of South-East Asia". REASON: The mentioned study contains maps that may be informative for the readers on a global perspective. (Reference: D. Bienvenido-Huertas, C. Rubio-Bellido, A. Pérez-Fargallo, J.A. Pulido-Arcas, Energy saving potential in current and future world built environments based on the adaptive comfort approach, J. Clean. Prod. 249 (2020). https://doi:10.1016/j.jclepro.2019.119306).	Thank you for the suggestion. Here we are simply stating the impacts. The suggested text is valid, but falls better in the discussion of Section 9.7.2 -links between mitigation and adaptation, where we added text about it.	Pulido Arcas Jesús Alberto	The University of Tokyo	Japan

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56577	54	41	54	41	Consider adding two directly related references: B. Tarrja, F. Chiang, A. AghaKouchak, S. Samuelsen, S.V. Raghavan, M. Wei, K. Sun, T. Hong. Translating Climate Change and Heating System Electrification Impacts on Building Energy Use to Future Greenhouse Gas Emissions and Electric Grid Capacity Requirements in California, Applied Energy, 2018. T. Hong, W.K. Chang, and H.W. Lin. A Fresh Look at Weather Impact on Peak Electricity Demand and Energy Use of Buildings Using 30-Year Actual Weather Data, Applied Energy, 2013.	We thank the reviewers for the suggested references, some of which have been incorporated.	Government of United States of America	U.S. Department of State	United States of America
72095	55	1	55	22	Besides all possible impacts due to climate change, the link between urban heat island and buildings is not mentioned. Besides contributing to less thermal comfort and higher cooling demand, extended use of cooling systems contributes to urban heat islands because of hot air rejection. (Palme et al, 2017) https://www.sciencedirect.com/science/article/abs/pii/S0378778817311027 eventually provide more information. Nevertheless, it is mentioned in the next part about the link with the sustainable development	The heat island effect, although very relevant, is not directly related to climate change.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
60599	55	5	55	6	The definition of CDD provided in the footnote is imprecise. Accordng to ASHRAE: A degree-day is the difference in temperature between the outdoor mean temperature over a 24-hour period and a given base temperature, used in estimating heating and cooling energy use. For cooling, ASHRAE uses a reference temperature of 10 deg C. I tis NOT the set point temperature, but rather a temperature that will provide the best estimate of air conditioning needs, which must also account for latent heat.	Thank you, we have corrected the definition and added a reference. We could not cite ASHRAE because it is considered grey literature in the IPCC.	Evyatar Erell	Ben-Gurion University of the Negev	Israel
56579	55	20	55	22	There have been large power outages as a result of wildland fires. In addition to driving indoor temperatures, they also reduce indoor air quality as a result of non-working HVAC systems.	Agreed. However, this paragraph discusses cooling demand systemic repercussions. We have included wildfires later in the text.	Government of United States of America	U.S. Department of State	United States of America
2525	55	23	55	25	Heating demand decreases in cold climate regions such as Sweden. In Sweden/Stockholm district heating is the primary energy source for space heating. Currently an increase in cooling demands will require electricity and not district cooling, which can put further contraints to the shortage of electricity given the incresed demand in the region. And have an impact on the primary energy use.	Indeed. We believe we have already addressed this causal chain. Also, we discuss district heating at the end of the paragraph.	Johanna Wikander	Company	Sweden
9993	55	30		34	While it is difficult to predict how much rise of global temperature or how much extreme cold may result in the future, climate adaptation technology may be made as adaptive as possible, i.e. portable or removable	Agreed. This is discussed in section 9.7.2, below.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
56581	55	30	55	30	Is the problem over-insulation or under-ventilation which traps warm air indoors?	The referred authors mention insulation	Government of United States of America	U.S. Department of State	United States of America
56583	55	30	55	34	Ventilation is an important part of a building's heating and cooling system because it helps reduce indoor pollutants. Weatherizing without maintaining proper ventilation can negatively affect indoor air quality.	Agreed. However, here we discuss the issue of overheating as a consequence of higher future temperatures. Indoor air quality is dealt with in section 9.6 on SDGs.	Government of United States of America	U.S. Department of State	United States of America
22069	55	32	55	33	This question is often mentioned but seams unsufficiently explained, leading to potential misperception. It may be partly conflictuous, but there is also a share of convergence : for exemple rooftop insulation is positive for warm as for cold. The reflex of treatment against cold has to develop, to take into acount the effect on warm season. It may be uneasy for buildings exposed to unfavoured environement (noise, unsecurity), forced to remain closed. cf p 57 line 5	Indeed. We deal with this later when we argue “However, while overheating may occur as a result of poor insulation design, better insulation may actually reduce overheating when properly projected, meaning that the apparent trade-off between mitigation through building insulation and higher overheating risk can be overcome by clever designs”	Government of France	Ministère de la Transition écologique et solidaire	France
56585	55	34	55	34	Consider adding the following to end of the paragraph: ""Energy efficiency measures and low-energy building designs should be evaluated considering yearly weather variations (Hong et al., 2013), future climate changes (Tarrja et al., 2018), and intersection with thermal resilience as co-benefits (Sun et al., 2020) and robustness of building performance (Picard et al., 2020)."" References: T. Hong, W.K. Chang, and H.W. Lin. A Fresh Look at Weather Impact on Peak Electricity Demand and Energy Use of Buildings Using 30-Year Actual Weather Data, Applied Energy, 2013. T. Picard, T. Hong, N. Luo, S.H. Lee, K. Sun. Robustness of Energy Performance of Zero-Net-Energy (ZNE) Homes. Energy and Buildings, 2020. K. Sun, M. Specian, T. Hong. Nexus of Thermal Resilience and Energy Efficiency in Buildings: A case study of a nursing home. Building and Environment, 2020. B. Tarrja, F. Chiang, A. AghaKouchak, S. Samuelsen, S.V. Raghavan, M. Wei, K. Sun, T. Hong. Translating Climate Change and Heating System Electrification Impacts on Building Energy Use to Future Greenhouse Gas Emissions and Electric Grid Capacity Requirements in California, Applied Energy, 2018.	We thank you for the suggestion. However, this is not the right place for this discussion. So we moved to section 9.7.2	Government of United States of America	U.S. Department of State	United States of America
60597	55	37	55	39	The temperature coefficient of PV panels is a standard performance characteristic provided by all manufacturers. Why use general terms such as 'relatively small' when real data can be provided. For most panels it is about 0.4-0.45% decrease per 1 degree increase in panel temperature above 25 deg C.	The overall effect depend on a larger number of variables, including the overall PV potential, the degree of climate change driven temperature increase, changes in cloud formation and irradiation, etc. So it is difficult to provide a precise figure here,.	Evyatar Erell	Ben-Gurion University of the Negev	Israel
72097	55	39	55	41	In case of hot temperatures, the effect on the performance of PV may be not significant but there were also studies highlighting the fact that electric material from PV may be affected by high temperatures and also by hot spots, causing more issue. (Bahaidarah et al, 2013) https://www.sciencedirect.com/science/article/abs/pii/S0360544213006567 suggest to use water cooling to limit overtemperature.	We added text and reference accordingly	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
43271	56	1	56	15	Is it only evaluated the constructions or is it also evaluated how to build a city to mitigate climate change?	Here we focus on buildings construction only. City level mitigation options should be addressed in chapter 8.	Government of Chile	Ministry of Environment	Chile
56587	56	5	56	5	"hastens" not "fastens"	Fixed	Government of United States of America	U.S. Department of State	United States of America
60601	56	5	56	5	change 'fastens' to 'hastens'	Fixed	Evyatar Erell	Ben-Gurion University of the Negev	Israel
10167	56	10	56	15	This is incorrect. It is true that chloride penetration from sea or deicing salt or CO2 from ambient air can cause damage if you do not use the right concrete. And also the humidity and temperature affect. But it is not a problem, there is an enormous amount of knowledge about this and that is why we build with the support of the regulations with exposure classes - then our concrete structures will stand for hundreds of years. If the concentration of CO2 or seawater levels or changed humidity conditions would increase so dramatically that it would accelerate the attack on concrete (the reinforcement) to some significant degree, then we are talking about major changes, and completely different conditions for all types of constructions, not least wood.	Fixed. Also, buildings’ standards and codes are not homogeneously applied and reinforced across countries/regions. Also, the average old age of buildings mean that many buildings predate building condes.	Ebba Örwall Lovén	Betongindustri AB	Sweden
9995	56	15			These two paragraphs indicate the need of regular assessment and maintenance of buildings, essential and public buildings at the foremost important.	Yes. However, this is dealt with in the next section (9.7.2)	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
22071	56	16	56	20	Please consider developing this part further. Sea-level rise issues are one of the central climate change issues that can impact coastal buildings. A lot of researches and data exist about these questions and the OECD have integrated this issue as the cornerstone of ODD9, 11, 13, 14. E.g.: Building design to face sea-level rise (Barnett and Hill) (Moosa et al., 2020)	Thank you for the suggestion. However, given our page limit, we are not able to further develop this issue. More information can be found in the report of WGII.	Government of France	Ministère de la Transition écologique et solidaire	France
56589	56	16	56	20	Flood-related damage is expected in non-coastal areas as well. Across these scenarios (floods, hurricanes, and storms), there will be more impacts than just direct infrastructure damage. Specifically, increased indoor dampness and humidity can lead to increases in mold, dust mites, bacteria, and other biological contaminants indoors. Additionally, extreme weather events and wildfires can increase conditions for the growth and spread of pests, infectious agents, and disease vectors that can make their way indoors.	We added some discussion in a new subsequent paragraph.	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
2527	56	27	56	32	Previous comment relates to this conclusion. But, the increased electricity demand can lead to higher emissions even though the electricity is produced with a high degree of renewables. It depends on the mix of fuels in the district heating, which can vary between seasons.	Agreed. There are two effects, both mentioned here: increased emissions (depending on the share of renewables in the grid) and pressures on the operation of power systems.	Johanna Wikander	Company	Sweden
49683	56	32	56	35	The statement can be supported with an example to make it more understandable and relatable.	Agreed, but we have a limited space for the section. For examples, the reader can refer to the references.	Satyaprakas Das Das	Manipal Academy of Higher Education	India
5465	56	36	56	38	This is wrong. It has been demonstrated again in 2020 in California: The period of the day where consumers need more cooling is late afternoon, when the sun is down. Please, correct the sentence.	Studies show evidence for other situations where this happened. So we changed the text to “there can be a timely correlation” so as to be not so affirmative.	Michel SIMON	Retraité/ Pdt d'association	France
69749	56	36	56	38	There is an excellent seasonal match between solar PV availability and air conditioning loads; however, there is slight mismatch for homes on a daily basis due to the thermal inertia of buildings, as well as to the times of occupancy of homes. Cooling needs continue for several hours after sunset, and in some countries all night round..	Studies show evidence for load matching. Nevertheless, we changed the text to “there can be a timely correlation” so as to be not so affirmative.	Cédric PHILIBERT	Institut Français des Relations Internationales	France
3289	56	42	56	42	Re "Climate change may reduce their effectiveness" - there is not enough attention paid to the fact that passive strategies such as natural ventilation via operable windows is not viable in the face of increasing wildfires and unhealthy air quality.	Yes. Here we assume situations where passive strategies can be applied.	Rachel Bannon-Godfrey	Stantec	United States of America
49685	56	43	56	45	The statement can be supported with an example to make it more understandable and relatable.	Agreed, but we have a limited space for the section. For examples, the reader can refer to the references.	Satyaprakas Das Das	Manipal Academy of Higher Education	India
66745	56	43	56	45	However, it requires further analysis to idenfitfy potential onflicts and synergies between environmental policy goals. See e.g., van der Voorn, T., Svenfelt, Å., Björnberg, K.E. et al. Envisioning carbon-free land use futures for Sweden: a scenario study on conflicts and synergies between environmental policy goals. Reg Environ Change 20, 35 (2020). https://doi.org/10.1007/s10113-020-01618-5	Agreed. This is discussed at the end of the section. The reference suggested focuses on land use, not buildings.	Tom van der Voorn	Institute of Environmental Systems Research	Netherlands
3291	57	1	57	1	"high energy performance buildings" should be hyphenated to indicate you are talking about 'high-performance' relating to energy, versus how it reads right now as 'high energy' buildings (as in, buildings that are high energy consumers). In AE industry, we typically use the term high-performance with a hyphen.	Fixed	Rachel Bannon-Godfrey	Stantec	United States of America
56591	57	1	57	3	Increased airtightness, if not accompanied by attention to ventilation, may increase risk for other public health outcomes as well. The discussion focuses on insulation design to overcome overheating, but ventilation should be addressed as well. Also consider referring to Section 9.8.5.1.	Climate change driven health issues are now addressed at the end of the previous section	Government of United States of America	U.S. Department of State	United States of America
56593	57	1	57	8	Increasing insulation and airtightness without adequate ventilation can result in moisture problems and the growth of mold indoors, leading to poor indoor air quality and adverse health outcomes from exposure to mold, other biological contaminants, and off-gassing from damp building materials and furnishings. There will also be damage to the building and furnishings and the costs of needed repairs. IOM (Institute of Medicine). 2011. Climate Change, the Indoor Environment, and Health. Washington, DC: The National Academies Press. https://www.nap.edu/catalog/13115/climate-change-the-indoor-environment-and-health	Climate change driven health issues are now addressed at the end of the previous section. The reference suggested is grey literature, cannot be cited in IPCC.	Government of United States of America	U.S. Department of State	United States of America
22073	57	9	57	10	The risks for the structure itself occurs essentially with clay expansion caused by draughts, with torrential floods, and with and with stronger hurricanes, if that is (or not), it could be mentionned for better understanding. Enhancing foundations in advance is'nt common.	Given our page limit, there is no room for this discussion, unfortunately. We tried to clarify, nonetheless.	Government of France	Ministère de la Transition écologique et solidaire	France
56595	57	15	57	16	The sentence too quickly dismisses both the potential for building retrofits and the applicability of building codes to renovations and retrofits. There is a literature on building energy-focused retrofits and public health that may be of interest. See, e.g., Shrestha, P.M., Humphrey, J.L., Barton, K.E., Carlton, E.J., Adgate, J.L., Root, E.D., and Miller, S.L. (2019). Impact of low-income home energy-efficiency retrofits on building air tightness and healthy home indicators. Sustainability, 11(9), 2667.	The sentence has been rewritten to show that both options have costs.	Government of United States of America	U.S. Department of State	United States of America
56597	57	15	57	16	Suggest text be revised to: ""While adaptation on the existing building stock may be more expensive and require building retrofit, climate change must be considered in the design of new buildings, so that they can operate in both current and future climates to ensure performance robustness (Picard et al., 2020). Reference: T. Picard, T. Hong, N. Luo, S.H. Lee, K. Sun. Robustness of Energy Performance of Zero-Net-Energy (ZNE) Homes. Energy and Buildings, 2020.	We added “performance robustness”, but also kept the implications to cots, as pointed out by the other references.	Government of United States of America	U.S. Department of State	United States of America
56599	57	18	57	20	Most building energy codes around the world are based on cost-effectiveness or cost-optimal principles. Incorporating future climate would require updating these rules	Information added.	Government of United States of America	U.S. Department of State	United States of America
4289	57	25	57	25	Add this reference at the end of the paragraph (Rubio-Bellido et al, 2017). REASON: This study specifically tackles the effect of climate change in the thermal comfort of social dwelling in a developing country, it would be informative to have a reference for this statement (Reference: Rubio-Bellido, C., Pérez-Fargallo, A., Pulido-Arcas, J. A., & Trebilcock, M. (2017). Application of adaptive comfort behaviors in Chilean social housing standards under the influence of climate change. Building Simulation, 10(6). https://doi.org/10.1007/s12273-017-0385-9)	Reference added	Pulido Arcas Jesús Alberto	The University of Tokyo	Japan
56601	57	32	57	33	This is an important point deserving greater emphasis. Stating explicitly what the potential for conflict is could increase the impact of the rest of the paragraph.	We agree that this is a crucial issue, but we are unable to explore it within the page limit allocated to this section, unfortunately.	Government of United States of America	U.S. Department of State	United States of America
43675	57	35	57	37	Here, too, the issue of embodied emissions is dealt with in a completely isolated manner. It is proposed to integrate this passage into a new subchapter on embodied emissions in buildings and constructed assets.	We agree with the need to better explore embodied emissions, but the page limit does not allow us to have a specific section on the subject.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
79433	57	36	57	37	The citation of Röck et al 2020 here is a good choice, but the citation is not yet listed in the references section (page 93ff, Röck 2020 should be on page 137/138). Add full citation to reference list: Röck M, Saade MRM, Balouktsi M, Rasmussen FN, Birgisdottir H, Frischknecht R, et al. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Appl Energy 2020;258:114107. DOI: https://doi.org/10.1016/j.apenergy.2019.114107.	Fixed.	Martin Röck	KU Leuven	Austria
47513	58	1	70	16	There are no clear references to the impact of sufficiency measures and the SER approach in this chapter. Sufficiency and the SER approach should play an essential role in the development of the SDGs.	Noted - considered when rewriting the chapter	Gonzalo Sánchez	European Environmental Bureau	Belgium
52393	58	3	58	24	It is true that many mitigation actions can provide social and economic co-benefits, and it is important to discuss these. But it is also important to think about the potential adverse side-effects, such as the adverse side-effects associated with sufficiency policies. For example, higher incomes are likely to be associated with larger living spaces, leading to an increase in floor area per capita, the sufficiency factor in the decomposition. Sufficiency policies could work against this increase in the standard of living. Also, energy sufficiency tries to determine an equitable level of energy services for people, but doing so is difficult and there could be adverse effects if the sufficiency bar is set too low.	Noted - considered when rewriting the chapter	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
20031	58	11			On fuel poverty and its measurement, see: Charlier, D., Legendre, B., 2019. A Multidimensional Approach to Measuring Fuel Poverty. Energy Journal 40, 27–53. https://doi.org/10.5547/01956574.40.2.bleg	Accepted - We found most appropriate to cite this reference in Section 9.8.4.1, which focuses on fuel poverty and its measurement, rather than in the beginning of Section 9.8.1, in which review studies on the multiple impacts of mitigation actions in buildings are discussed.	Louis-Gaëtan Giraudet	CIRED, Ecole des Ponts ParisTech	France
4989	58	12	58	12	"mitigation actions in buildings can eliminate urban heat island". Actually, urban heat island formation is mainly due to urbanization, which includes also, for instance, building energy use and that contributes to urban heat island exacerbation. However, since UHI is related to urbanization, mitigation actions cannot eliminate it	Accepted - Text revised noting that mitigation actions may contribute to reduce the heat island effect (e.g. through green roofs and green walls or sufficiency interventions).	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
60603	58	12	58	12	Urban heat islands cannot be eliminated. At best, their intensity can be somewhat mitigated.	Accepted - Text revised.	Evyatar Erell	Ben-Gurion University of the Negev	Israel
72099	58	16	58	16	I am wondering if "energy poverty" would be more apropriate than "fuel poverty" in this particular sentence?	Noted - Both issues (i.e., fuel poverty and energy poverty) are covered here. Improved access to energy sources is related to energy poverty alleviation.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
28321	58	25	58	26	Figure is rather blurred, also it's asthma, not ashma.	Accepted	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
19169	58	26	56	26	DALY is mentioned in the figure but not explained in text (DALY is spelled out in page 63, which 5 pages later)	Accepted - Explanation added.	Paraskevi Dorizas	BPIE	Belgium
3293	58	26	58	26	"Up to 28% of premium price for decarbonized builings..." the wording is confusing, what is this data point saying about premium price? Is it saying real estate in decarbonized buildings can charge a 28% premium? Or it is 72% cheaper to develop decarbonized buildings? Is a word missing in this statement? Per pg 68 it sounds like this is just for residential buildngs, and the range is 1.5 - 28%, with a median of 7.8%. So is 28% an over statement?	Accepted - Text revised to clarify this point.	Rachel Bannon-Godfrey	Stantec	United States of America
64213	58	27	58	27	sources are needed	Accepted - References added.	Ova Candra Dewi	Universitas Indonesia	Indonesia
63759	58		60		Use of biomass to decarbonize space heating in buildings is a relatively low cost mitigation options that has been widely adopted in Europe and is increasingly being adopted in North America and developing countries, and is not recognized in this report. Specific to the section on SDGs, there are many ways that bioenergy for space heat (or heat and power) contribute to SDGs that is unique relative to other renewables (e.g. job creation along supply chains, improved resource management and resource use efficiency and rural economic development. Some of the bioheat-specific contributions to SDGs should be included in this section, see: Blair, M. J.; Gagnon, Bruno; Klain, Andrew; Kulišić, Biljana. 2021. "Contribution of Biomass Supply Chains for Bioenergy to Sustainable Development Goals" Land 10, no. 2: 181. https://doi.org/10.3390/land10020181	Taken into account - The use of biomass through modern systems/technologies is considered as a mitigation option in the buildings sector. Usually is included under the broaden category "improved access and fuel switch to lower carbon and renewable energy". I agree that biomass contributes to SDGs, and this is already reflected in text. The proposed reference is very useful and included in the revised text.	Government of Canada	Environment and Climate Change Canada	Canada
72101	59	17	60	38	The table 9.5, despite appearing a bit dense, gives a clear and measured assessment of the link between sustainable development and building optimisation.	Noted	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
72103	59	17	60	53	The table includes the wording "building sufficiency" ; is that synonimous to "energy sufficiency"?	Accepted - Text revised.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
3295	59	18	59	18	The table is really hard to read, hard to track the scores in each column to the right row. Would be much more impactful in a colour coded table or graphic.	Accepted - The format of the table changed.	Rachel Bannon-Godfrey	Stantec	United States of America
2819	59	21	59	25	Already before COVID-19, progress to achieve universal access to affordable, reliable and clean energy carriers had been insufficient but the new coronavirus has exacerbated the need for rapid solutions to energy access, which is an essential component of equitable and sustainable development. Dedicated efforts on energy access for both rural communities and urban slums and informal settlements are urgently needed. Thereby, special attention has to be given to energy for healthcare and other pressing needs of the poorest and most vulnerable populations.	Noted - This section analyses the interlinkages of mitigation actions in the sector of buildings and the SDGs, among which is SDG7 'affordable and clean energy'. However, it is out of the scope of this section a broaden discussion on universal access to affordable, reliable and clean energy carriers, and the necessary support policies. Such a discussion takes place in other parts of the report, and particularly in chapters 5 and 6.	Leonardo Barreto	Head of center "EU&International"	Austria
63761	60	32	60	32	Include SDG 14 in terms of marine pollution (i.e construction material/run-off)	Rejected - We did not found references to include SDG14 in this analysis.	Government of Canada	Environment and Climate Change Canada	Canada
56603	60	54	61	9	Important discussion on how economic analysis focuses solely on energy savings yet there is no specific mention of including the "Social Cost of Carbon" in economic analysis to change this paradigm.	Noted - This section attempts to quantify and if possible monetize some of the multiple impacts associated with mitigation actions in buidings with a view to facilitate their incorporation in decision making processes. The SCC is a measure of damages to all countries caused by GHG emissions. Depending on the scope of the analysis it could be also incorporated in the evaluation of the policies and measures aiming to reduce GHG emissions as an additional dimension. However, the discussion on SCC, including its estimates and uncertainties, is more broaden, affects all sectors and has been done in Chapter 3 of this report and in WGII.	Government of United States of America	U.S. Department of State	United States of America
20345	61	10	65	45	This part should at least mention the impact of good ventilation/efficiency measures on the spreading of virus such as COVID-19	Noted - This issue is mentioned briefly in Introduction of this Chapter. No data available for a more detailed analysis here.	Thibaud Voïta	IFRI	Germany
56605	61	11	64	45	This section on indoor environmental quality made no reference to indoor sources of particulate matter (PM) other than fuel sources primarily used in developing countries. 1.https://doi.org/10.1016/j.envint.2018.12.052 2.https://doi.org/10.1016/j.envint.2019.104968 3.https://doi.org/10.1016/j.chemosphere.2020.126932 4.https://doi.org/10.1111/ina.12268 5.https://doi.org/10.1111/ina.12268	Noted - This section aims at analysing to what extent mitigation actions in buildings contribute also to better indoor environmental quality and the resulting health benefits. A discussion on the potential sources of the indoor air pollution is out of the scope of this analysis. The issue of cook-stoves in developing countries is highlighted as cooking is an important energy service taking part in buidling, which is associated with significant GHG and other air pollutant emissions.	Government of United States of America	U.S. Department of State	United States of America
69743	61	11	67	27	The sharp cost reduction of renewables, in particular PV, allows for more rapid electrification of households by a combination of solar home systems, mini-grids, and relatively distributed solar PV plants bypassing the need for full-fledged grid electrification, at least for some time.	Noted - Please see section 9.8.5.4 for a brief discussion of these issues.	Cédric PHILIBERT	Institut Français des Relations Internationales	France
69745	61	11	67	27	While ~1 bn people lack access to electricity, over ~2 bn lack access to clean cooking. On top of the cost reduction of solar PV, the emergence of very efficient electric cooking devices bring about new solutions to get rid of dirty fuels, in-house air pollution, time and money spent in collecting or acquiring biomass (incl. charcoal) and fossil fuels. In particular electric pressure cookers are proving capable of delivering the cooking service for only a fraction of the energy required by stoves, even the most efficient electric induction stoves. This is due to the combination of pressure, which shortens the cooking times, insulation, which reduces heat losses, and full integration of induction device. See e.g. Batchelor, S. et al. 2019, Two Birds, One Stone - Reframing Cooking Energy Policies in Africa and Asia, Energies 12, 1591; Couture T. and D. Jacobs, 2019, Beyond Fire, World Future Council - Hivos; Esmap, MECS and World Bank Group, 2020, Cooking with Electricity, A Cost Perspective, The World Bank. On recent improvement and prospects for distributed solar PV on-grid linked to electric cookstoves see Khan, R and I Alam, 2020, A Solar PV-Based Inverter-Less Grid-Integrated Cooking Solution for Low-Cost Clean Cooking, Energies, 13, 5507.	Taking account - This comment is about technologies which are covered in another part of the Chapter. Electric pressure cookers are mentioned in Section 9.8.5.1. The proposed references are very useful and included elsewhere in the Section.	Cédric PHILIBERT	Institut Français des Relations Internationales	France
27793	61	12	61	17	More recent data are available, as presented also in other Chapters.	Accepted - Data updated.	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
77125	61	12	61	26	The report rightly mentions the plight of 3bn people in primitive dwellings exposed to cooking fumes and still without electricity, a WGIII priority area to address.	Accepted	Jim O'Brien	Expert Reviewer AR6 SOD WG1	Ireland
9997	61	16			It may be better to explain the definition of “clean energy” in the first place.	Accepted - Text has been modified.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
56607	61	28	61	32	It is odd to see LPG, ethanol, biogas, and electricity listed as cleaner fuels than biomass, without any mention of one of the more widely used cooking fuels of natural gas. If LPG is a "clean fuel", then natural gas should be mentioned as well. It is true that natural gas typically requires some sort of fixed delivery network such as gas lines, which LPG, ethanol, and biogas do not, but electricity (in the form of grid electricity, even microgrids) also requires some sort of "delivery network".	Accepted - a mention to natural gas added.	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
69741	61	31	61	33	It is unclear why climate change mitigation politicies may increase the costs of clean fuels; lpg is clearly a cleaner fuel than kerosene, but its GHG emissions are far from negligible.	Accepted - Explanations added. Many governments in developing countries support the use of non-solid fuels for cooking. Carbon pricing may increase the cost of these fuels hindering their further penetration.	Cédric PHILIBERT	Institut Français des Relations Internationales	France
43677	62	1	62	34	Box 9.8 deals with the use of biomass. Embodied emissions are mentioned. The values should be compared with the information in Section 9.4.2. The term "factor" should be checked. It is suggested to discuss the special features of the life cycle assessment of wood (0/0 versus -1/1) here.	Rejected. The section referring to embodied impacts of wood-based buildings has been rephrased to make the comparison at the building scale.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
1201	62	1	62	35	Chapter 7 includes a lot of material on substitution effect that should also be included here. See pages 104 to 106 of the draft of Chapter 7.	accepted, will consider	Reid Miner	Private Consultant	United States of America
25053	62	2	62	10	"Biomass is used, if the wood is available locally, either for constructing buildings or for providing end use services such as cooking and heating. According to (Stark et al. 2019), the use of biomass in the form of wood to construct buildings, in countries with high availability of timber and no competition for land with food production, contributes to reducing GHG emissions by storing carbon and displacing carbon intensive construction materials such as cement, bricks, and steel. Embodied emissions of wooden buildings are lower than those of concrete buildings given the low embodied impact factor of wood products, which ranges between 0.29 and 1.02 kg CO2-eq·kg-1 compared to the embodied impact factor of material for concrete, which ranges between 0.05 and 5.15 kg CO2-eq·kg-1 (Basbagill et al. 10 2013)." There are many estimations of material related embodied emissions out there and we believe all assessment should be represented here. To provide a better idea of the ranges we recommend adding the following reference figure 5 of the following report https://www.chathamhouse.org/sites/default/files/publications/research/2018-06-13-making-concrete-change-cement-lehne-preston.pdf. Source Source: Authors' analysis of data from Hammond and Jones (2011), Inventory of Carbon & Energy V2.0.	Rejected. The section referring to embodied impacts of wood-based buildings has been rephrased to make the comparison at the building scale.	|Claude Lorea	GCCA	Belgium
82059	62	3	62	3	Another relevant reference here is Churkina et al https://doi.org/10.1038/s41893-019-0462-4	accepted, will consider	Berrill Peter	Yale University	United States of America
28323	62	6	62	10	Some more recent sources for ranges for embodied coefficients: https://doi.org/10.1016/j.rser.2017.06.049; https://doi.org/10.5334/bc.59	Rejected. The section referring to embodied impacts of wood-based buildings has been rephrased to make the comparison at the building scale.	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
17939	62	6	62	9	Statement of lower embodied emissions doesn't correspond absolutely to the numbers given, for which the uncertainty ranges of wood vs. concrete embodied energy actually overlap. Probably a better measure is in embodied energy needs for a building of a given footprint or volume. As is, the numerical values are hard to interpret or don't support the qualitative statement.	Rejected. The section referring to embodied impacts of wood-based buildings has been rephrased to make the comparison at the building scale.	Robert Brecha	Climate Analytics	Germany
19955	62	18	62	18	pre mature' should be 'premature'	Editorial - text revised	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
22075	62	31	62	34	The reasons and involvements for the snapshot decrease in biomass use between 2020 an 2030 in the SDS should be brievely explained	Rejected - due to lack of space	Government of France	Ministère de la Transition écologique et solidaire	France
63763	62		63		In Box 9.8 a spotlight on biomass in the building sector is given but it focusses on traditional biomass/bioenergy. It is predicted that traditional biomass use will decrease, as detailed in the box, but the IEA Global Energy Outlook for 2020 predicts that modern bioenergy use (including modern bioamss boilers and biomass district heating for buildings) will increase and will be the most important form of renewable energy through 2030. Reduced detail on traditional biomass and increased focus on the use of modern bioenergy for decarbonization of building space and water heating, and cooking in developing countries, is recommended.	Accepted: Box moved and text merged with 9.3	Government of Canada	Environment and Climate Change Canada	Canada
19171	63	16	64	16	The sentence should be written more clearly explaining the link of damp housing to health effects and mortality	Accepted - Done.	Paraskevi Dorizas	BPIE	Belgium
9963	63				The information and symbols provided in the figures are unclear. It should be re-lay outed. (Box 9.8 Figure 1)	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
9965	63				The information and symbols provided in the figures are unclear. It should be re-lay outed. (Figure 9.20)	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
2341	63		65		This section provides a good reiew, however, there are other studies and reports that could add to the content. Note that these are advisory comments rather than mandatory changes, that better establish the link between energy efficiency and health in builsdings. See comments below	Taken into account - The proposed studies reviewed and to the extent possible included in the assessment.	Iain Walker	Lawrence Berkeley National Laboratory	United States of America
2343	63		65		(Maidment et al., 2014) performed a meta-analysis that pooled together the results from 36 past studies of the health effects of energy efficiency, for a total sample of over 33,736 participants. On average, interventions had a small, but significant, positive impact on residents' health (overall mean improvement of 8%). Maidment noted that larger health effects were observed in more recent studies, and that effects on some specific medical conditions (e.g., respiratory health) were greater than those observed for general health. Overall, Maidment's review agreed with past assessments reporting modest physical health improvements from housing interventions (Liddell and Morris, 2010), as well as more mixed though mainly positive outcomes in other past reviews (Thomson and Thomas 2015; Thomson et al., 2009).	Accepted - The main findings of the study are presented at the end of section 9.8.2.2.	Iain Walker	Lawrence Berkeley National Laboratory	United States of America
2345	63		65		(Denson and Hayes, 2018) authored an ACEEE review of: (1) exemplary programs in the US working on these issues; (2) trends across programs; and (3) sharing of best practices and recommendations. ACEEE sought nominations nationally for exemplary programs that combined energy efficiency and health, and they used a national panel of public health and efficiency experts to rank and assess the programs. Overall, the best programs with documented health and energy benefits targeted buildings/households where people suffer from chronic respiratory illnesses, and the interventions they provided were multi-faceted. They combined: (1) health/asthma management education using actual community health professionals; (2) helped directly address sources of asthma irritants (e.g., dust mite mattress covers, HEPA vacuums, etc.); and (3) also improved the energy efficiency and thermal performance of the dwelling with traditional weatherization type audits and work scopes, which can reduce heat/cold stress, lessen fuel poverty, etc. The best programs also offered referrals to related agencies serving specific needs that are not within the scope of the energy efficiency/health program. In these situations, meaningful and measurable improvements were possible for both energy use and health outcomes, such as asthma-related hospitalizations, sick days from work/school, etc.	Noted - Unfortunately there is no space for such a detailed presentation of the best programs.	Iain Walker	Lawrence Berkeley National Laboratory	United States of America
2347	63		65		(IEA, 2014) outlines the multiple benefits of energy efficiency, with a chapter dedicated to the health benefits of energy efficiency. The key findings were: improving energy efficiency in buildings creates conditions that support improved health and well-being for occupants. Positive health outcomes are consistently strongest among vulnerable groups, including children, the elderly and those with pre-existing illnesses, health improvements at the individual level generate indirect social impacts and relieve pressure on public health budgets (an estimated savings to the European public health budget of USD 99 billion per year in 2020), and health benefits represent up to 75% of overall energy efficiency program benefits	Accepted - The main findings of the study are presented at the end of section 9.8.2.2.	Iain Walker	Lawrence Berkeley National Laboratory	United States of America
2349	63		65		A more recent study examined evaluations of the influence of residential energy efficiency retrofits on indoor environmental quality conditions and self-reported thermal comfort and health (Fisk et al., 2020). A total of 36 studies were reviewed, with most studies focused on low-income homes in Europe or United States. Overall, these studies found that subjectively reported thermal comfort, thermal discomfort, non-asthma respiratory symptoms, general health, and mental health nearly always improved after retrofits.	Accepted - The study is mentioned the end of section 9.8.2.2.	Iain Walker	Lawrence Berkeley National Laboratory	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
2351	63		65		In 2016 the US DOE published a report (Wilson et al., 2016) that reviewed the available evidence on the relationship between health and home performance. This review was conducted primarily by representatives from the National Center for Healthy Housing (NCHH), along with other individual contributors. Forty studies were reviewed and are summarized in the white paper. The reviewed works were categorized by the type of intervention (e.g., basic weatherization, green renovation, ventilation intervention, etc.). They report that interventions at all levels improved occupant health and had positive impacts.	Noted - This study has been cited in several places of this section.	Iain Walker	Lawrence Berkeley National Laboratory	United States of America
2353	63		65		Other US studies: (WSUEP, 2019 Schueler, 2019) delivered integrated healthy home and weatherization services to 53 low-income households with 78 occupants that had pre-existing respiratory conditions, including asthma (71%) and COPD (29%). The results showed improved respiratory/asthma control, scores for COPD also improved, but without reaching statistical significance. 7 in 10 respondents reported improved quality of life, and there was a net-decrease in missed school/work days due to illness. Ortiz et al. (2019) found positive health outcomes from upgrding existing social housing to new stndards.	Taken into account - As there are many studies highlighting these messages we tried to cite peer reviewed references. The main findings of the study Ortiz et al. 2019 are now mentioned in the Section.	Iain Walker	Lawrence Berkeley National Laboratory	United States of America
2355	63		65		A recent European study found siginifcant positive outcomes from upgrading existing social housing (Ortiz 2019)	Accepted - Main findings of the study are presented in the Section.	Iain Walker	Lawrence Berkeley National Laboratory	United States of America
2357	63		65		References: Denson, Ronald, and Sara Hayes. 2018. "The Next Nexus: Exemplary Programs That Save Energy and Improve Health." Report H1802. Washington, DC (United States): American Council for an Energy Efficient Economy (ACEEE). Fisk, William J., Brett C. Singer, and Wanyu R. Chan. 2020. "Association of Residential Energy Efficiency Retrofits with Indoor Environmental Quality, Comfort, and Health: A Review of Empirical Data." Building and Environment 180 (August): 107067. https://doi.org/10.1016/j.buildenv.2020.107067. IEA. 2014. "Capturing the Multiple Benefits of Energy Efficiency." International Energy Agency. Liddell, Christine, and Chris Morris. 2010. "Fuel Poverty and Human Health: A Review of Recent Evidence." Energy Policy 38 (6): 2987–97. https://doi.org/10.1016/j.enpol.2010.01.037. Maidment, Christopher D., Christopher R. Jones, Thomas L. Webb, E. Abigail Hathway, and Jan M. Gilbertson. 2014. "The Impact of Household Energy Efficiency Measures on Health: A Meta-Analysis." Energy Policy 65 (February): 583–93. https://doi.org/10.1016/j.enpol.2013.10.054. Ortiz, J., N. Casquero-Modrego, and J. Salom. 2019. "Health and Related Economic Effects of Residential Energy Retrofitting in Spain." Energy Policy 130 (July): 375–88. https://doi.org/10.1016/j.enpol.2019.04.013.	Taken into account - We tried (given the space limitations we have) to include as many of the proposed studies as possible.	Iain Walker	Lawrence Berkeley National Laboratory	United States of America
2359	63		65		Schueler, Vince. 2018. "The Washington State Weatherization Plus Health Pilot: Implementation and Lessons Learned." WSUEEP18-002. Washington State University Energy Program. Thomson, Hilary, and Sian Thomas. 2015. "Developing Empirically Supported Theories of Change for Housing Investment and Health." Social Science & Medicine 124 (January): 205–14. https://doi.org/10.1016/j.socscimed.2014.11.043. Thomson, Hilary, Sian Thomas, Eva Sellstrom, and Mark Petticrew. 2009. "The Health Impacts of Housing Improvement: A Systematic Review of Intervention Studies From 1887 to 2007." American Journal of Public Health 99 (S3): S681–92. https://doi.org/10.2105/AJPH.2008.143909. Wilson, J., D. Jacobs, A. Reddy, E. Tohn, J. Cohen, and E. Jacobsohn. 2016. "Home Rx: The Health Benefits of Home Performance - A Review of the Current Evidence." DOE/EE-1505. National Center for Healthy Housing, US DOE. file:///G:/.shortcut-targets-by-id/1i8l99jaKx22OGMV5XGmoli4v9m80DlGa/DER_CostStacks/LiteratureReview/PAPERS/Wilson%202016%20-%20Home%20Rx%20The%20Health%20Benefits%20of%20Home%20Performance.pdf. WSUEP. 2019. "Washington State Weatherization Plus Health Pilot: Pierce County Healthy Homes Case Study." WSUEP19-003. Olympia, WA: Washington State University Energy Program.	Taken into account - We tried (given the space limitations we have) to include as many of the proposed studies as possible. We avoided to cite some old studies.	Iain Walker	Lawrence Berkeley National Laboratory	United States of America
19175	64	1	64	1	Health risks from exposure to cold and 'inadequate indoor environmental quality' or 'inadequate air quality' could be also added	Accepted - text revised.	Paraskevi Dorizas	BPIE	Belgium
19173	64	2	64	2	It could be mentioned that young children are a susceptible group of people due to their growing lungs	Noted - Unfortunately there are space limititations that do not allow to provide more details.	Paraskevi Dorizas	BPIE	Belgium
72105	64	3	64	10	Another interesting figure, which can be mentioned, is the fact that, based on a survey in Paris, that an increase of 0.5°C at night could double the mortality during heat waves. (Laaidi et al, 2012) https://www.researchgate.net/publication/51613559_The_Impact_of_Heat_Islands_on_Mortality_in_Paris_during_the_August_2003_Heat_Wave	Noted - Unfortunately there is no space available to provide more details. Also, the proposed reference is rather old.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
17063	64	4	64	6	Could be referred to as 'Summer overheating risk'	Accepted - Text revised (please see at the end of this paragraph).	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
2239	64	8	64	10	the sentence starting "Summer" and ending "vulnerable" does not make sense. Particularly "and other adults". Should "to be" be replaced by "being"? I can understand the poorest being the most vulnerable. But I can't work out what the "and other adults" is about.	Taken into account - It is "older adults" and no "other adults". Text revised to be more clear.	Stephen Wilkinson	University of Wollongong in Dubai	United Arab Emirates
22077	64	14	64	16	This result in also underlined in the following paper: Charlier D., Risch A., Salmon C., 2018, "Energy Burden Alleviation and Greenhouse Gas Emissions Reduction: Can We Reach Two Objectives with One Policy?" Ecological Economics, vol. 143, p. 294–313	Accepted - Reference added.	Government of France	Ministère de la Transition écologique et solidaire	France
56609	64	26	64	41	There are multiple pathways by which climate change is expected to affect indoor environments and thereby health of indoor occupants. This section could expand on some of the pathways not mentioned, such as wildfires, consequences of increased indoor humidity and moisture from temperature differentials, storms, flooding, and hurricanes which can lead to increases in biological contaminants indoors (this is mentioned briefly as mould, but there is limited evidence to suggest health issues associated with increased Legionella are likely), and consequences of power outages on degredation of indoor thermal comfort and air quality.	Noted - This paragraph aims at analysing how energy efficiency measures may affect indoor conditions (apart from thermal comfort) and the resulting implications on public health. It is out of the scope of this analysis to present a complete overview of the pathways by which climate change is expected to affect indoor enviroments. Instead, some indicative pathways are mentioned, focusing to their endpoints.	Government of United States of America	U.S. Department of State	United States of America
19177	64	28	64	28	Noise is not only due to traffic. It can be from commmercial, indistrial, construction activities etc. I would leave that as outdoor noise so that is more general	Accepted - Text modified appropriately.	Paraskevi Dorizas	BPIE	Belgium
19179	64	30	64	30	…mould and moisture problems 'due to' reduced air flow rates leading to indoor environments that are unhealthy…	Accepted - Text modified appropriately.	Paraskevi Dorizas	BPIE	Belgium
56611	64	33	64	33	Over-insulation cannot be a problem in any significant way other than opportunity cost and material use. The real problem is under-ventilation.	Accepted - Text modified appropriately.	Government of United States of America	U.S. Department of State	United States of America
56613	64	37	64	40	Fisk (2018) adds complementary findings but also the importance of source control together with ventilation: https://onlinelibrary.wiley.com/doi/full/10.1111/ina.12469	Accepted - The proposed refence included and the text modified appropriately.	Government of United States of America	U.S. Department of State	United States of America
56615	64	40	64	41	There could be mention of options available to low income households to improve both Indoor Air Quality (IAQ) and energy efficiency. Perhaps a reference to the Energy Savings Plus Health IAQ guidelines? 1.https://www.mdpi.com/2071-1050/11/9/2667/pdf 2. https://doi.org/10.1289/ehp.119-a76 3.https://doi.org/10.1016/j.socscimed.2015.02.005 4.https://doi.org/10.1177/003335491112605110 5.https://doi.org/10.1007/s00038-012-0441-2	Taken into account - Unfortunately no space available for a more extensive discussion. The proposed references are very useful and some of them were cited in various parts of the text.	Government of United States of America	U.S. Department of State	United States of America
72107	65	20	65	45	The environmental co-benefits are clear, but there is few reference on the development of gardens and green surfaces in the buildings, which is considered as a growing positive vector for biodiversity.	Accepted - A short mention is made in the beginning of Section 9.8.3. Unfortunately there is no space for a more extensive discussion.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
72955	65	21	65	45	Other environmental benefits include reduced overheating affecting both occupants and building services systems, especially into future weather scenarios, by use of thermal insulation that has high thermal mass as well as low thermal conductivity – increased 'decrement delay' or 'thermal lag' of buildings – eg incorporating wood fibre thermal insulation to walls and roofs of existing and new buildings	Taken into account - The benefits of reduced overheating are discussed in Sections 9.8.2.2 and 9.8.5.1	David Gale	Gale & Snowden Architedcts Ltd	United Kingdom (of Great Britain and Northern Ireland)
43679	65	39	65	41	The topic of embodied energy should be discussed centrally at another place; if necessary, reference can be made here again.	Noted - The issue of embodied energy is discussed in Section 9.4.2, and elsewhere in the chapter. Here a mention is made on the potential co-benefits associated with mitigation actions aiming to reduce the embodied energy of buildings through the use of local and sustainable materials.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
19957	65	39	65	42	Although biodiversity is mentioned above in this section it may be worth a repeat mention here with respect to green roofs and the creation of wildlife corridors in urban areas.	Taken into account - Unfortunately no space available for a more extensive discussion. However, more references added in the beginning of this section for highlighting the impact of green roofs and walls on biodiversity.	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
3297	65	44	65	45	Thank you for mentioning the impact of noise pollution in the context of health. However, this would be a more impactful statement if the text included how noise pollution impacts health - increased stress levels, sleep loss etc - so the reader understands why teh cost benefit is so high. The International WELL Building Standard wellographies may have some good sources to pull from, in suport of their acoustic control concepts.	Accepted - Text modified appropriately.	Rachel Bannon-Godfrey	Stantec	United States of America
49687	66	0	67	0	A general comment with respect to energy poverty and social well-being / heath, the concept of ESC (Energy service cascade) by Gerald Kalt et al, 2019 could be considered in this section.	Noted - The ESC provides a framework for understanding of how energy use contributes to human wellbeing. Such a discussion is provided in Chapter 5. This Section focuses, to the extent possible, on a quantitative analysis of the contribution of mitigation actions to social well being. Unfortunately there is no space for a more conceptual/theoretical disccussion. On the other hand, we consider that such a quantitative analysis could facilitate the implementation of the ESC framework.	Satyaprakas Das Das	Manipal Academy of Higher Education	India
2529	66	1	6	1	One aspect of the social agenda not mentioned is the potential cost implications for new requirements on energy and carbon efficiency in buildings codes. It may result in higher costs for contruction and renovation of buildings, which may have an impact on costs for landlords and therefore may impact the tenants. Especially tenants that are in need of affordable homes.	Noted - The issue of the cost of high performance buildings (new and renovated) is discussed in Section 9.6.4.1. The potential implications on selling and rental prices of the dwellings are shortly discussed in Section 9.8.5.2.	Johanna Wikander	Company	Sweden
20347	66	1	66	47	The EU Energy Poverty Observatory is an initiative worth mentioning here, especially as they have conducted important work on the definition, measuurement and other issues related to energy poverty	Accepted - Done on the 1st paragraph of this Section.	Thibaud Voïta	IFRI	Germany
77127	66	1	66	47	In developed regions, increased penetration of renewables inevitably leads to higher energy costs for consumers, leading to energy poverty for many.	Rejected - In several cases renewables are characterized by lower costs than fossil fuels. As clearly mentioned in Chapter 6 low-carbon electricity is now cheaper than fossil generation in many regions. Also, comparing the energy costs related to various technologies one should also take into account the associated externalities. The issue that some climate mitigation policies may increase the costs of clean energy sources, slowing down their penetration on the poor segment of the population, is discussed in section 9.8.2.1.	Jim O'Brien	Expert Reviewer AR6 SOD WG1	Ireland
27795	66	3	66	14	More recent data are available, as presented also in other Chapters.	Accepted - Data updated	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
49689	66	25	66	28	This sentence talks about benefits of the residents with respect to better inddor conditions in which the words social isolation and social cohesion seem appropriate whereas lower crime doesn't seem to fit in. However, since a reference has been cited, it can be looked into.	Taken into account - Text revised to be more clear.	Satyaprakas Das Das	Manipal Academy of Higher Education	India
49691	66	33	66	33	With respect to emphasis on " challenging" in terms of energy poverty, the argument of Thompson et al (2017) could be stated that it is also culturally sensitive and private condition, which is temporally and spatially dynamic as well., from a qualitaive perspective and these aspects can be associated with social well-being too.	Taken into account - Text slightly revised. Below in this paragraph fuel poverty is highlighted as a multidimensional social problem, citing the proposed reference. No space available for a more analytical discussion.	Satyaprakas Das Das	Manipal Academy of Higher Education	India
19959	66	39	66	41	I hesitate to plug my own work but the development of dynamic metrics for fuel / energy poverty is the subject of our article in Nature Energy: Baker, K.J., Mould, R., & Restrick, S., 2018. Rethink fuel poverty as a complex problem. Nature Energy, 2nd July 2018. DOI: https://doi.org/10.1038/s41560-018-0204-2 Available at: https://rdcu.be/2j8E	Accepted - Reference added.	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
81423	67	1	67	10	The section focuses on Africa only, but access to modern cooking fuels is according to IEA data also still a severe problem in large parts of rural and peri-urban Asia. Developing Asia is home to almost 65% of the global population without access, with 1.6 billion people lacking clean cooking facilities. In India alone around 680 Million people don't have access to modern cooking fuels (LPG). I feel this should also be mentioned here since otherwise it creates the impression this would be a pure "African Problem".	Taken into account - Africa is presented as an indicative example. Text revised to be more clear. Unfortunately we do not have space for a more analytical discussion.	Hans Poertner	Alfred-Wegener-Institute	Germany
2821	67	8	67	11	Other aspects of gender equality should be taken into account such as the involvement of women in the development and implementation of energy access policies and their involvgement in the energy access business as entrepreneurs and technical staff	Noted - This section does not address all issues related to energy access and gender equality; it focuses on how improving energy access contributes to time savings for women and children, a problem which affects millions of people worldwide.	Leonardo Barreto	Head of center "EU&International"	Austria
18455	67	17	67	18	'analysed a number of energy-saving interventions in Nepal, Kenya and Sudan and found that apart from the case of Sudan…' – if the finding only applies in two of the three countries studied can a general conclusion really be drawn?	Accepted - text deleted.	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
22079	67	23	67	25	One explanation is the quality of electricity, or the hours of daily supply, as explained in the paper: Chakravorty U., Pelli M., Ural Marchand B. (2014) Does the qality of electricity matter? Evidence from Rural India, Journal of economic behavior & organization, 107(A), pp.228-247. This reference can complete this paragraph	Accepted - text revised appropriately.	Government of France	Ministère de la Transition écologique et solidaire	France
3635	67	28	68	9	The chapter is missing mention of the unintended consequences of energy efficiency renovations and other mitigation activites. I know these are mentioned very briefly here in the context of potential impacts due to poor ventilation and elsewhere due to rising energy prices, but I'm talking about issues like the role of poor energy efficiency improvements in worsening air quality or mould growth leading to structural damage. I do like the inclusion of human factors, e.g., that people in "high performance" offices tend to be more satisfied/productive, or conversely that those living in efficient houses may consume more heating or cooling, but I think some discussion of the unintended harms is useful to acknowledge. I think this section can be refined to make it very clear that *holistic* retrofits leading to high performance buildings are desirable rather than narrow energy efficiency retrofits that may lead to worse human outcomes. Line 45-47 (pg. 67) are particularly misleading.	Taken into accout - As clearly stated in the beginnng, this sub-section focuses on the productivity gains of well-designed, operated and maintained high-performance buildings. Trade-offs of mitigation actions are also discussed in the corresponding sections. A coclusion that *holistic* retrofits leading to high performance buildings are desirable rather than narrow energy efficiency retrofits, is out of the scope of this section, as such an evaluation should also take into account costs and potentials, rebound effects, etc., that are discussed elsewhere. The feasibility assessment presented at the end of the chapter attempts to present integrated evaluations of the mitigation actions. In any case, the importance of deep energy retrofits is highlighted in this paragraph. The lines 45-47 have been re-drafted.	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
14709	67	29	68	17	For an overview of studies see BPIE (2018): Building 4 People: Quantifying the benefits of energy renovation investments in schools, offices and hospitals. https://www.bpie.eu/wp-content/uploads/2018/12/BPIE_methodology_031218.pdf	Accepted - Elements of the report added in the text.	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
76559	68	1			There is a lot of newer work on building retrofits, and on the issue of refurbishment. See, eg. https://www.pnas.org/content/117/32/19122, https://linkinghub.elsevier.com/retrieve/pii/S0921344919300588,	Noted - The references are useful but they do not fit in this section, which discusses the multiple impact of mitigation actions in buildings.	Edgar Hertwich	Norwegian University of Science and Technology	Norway
10769	68	1	68	1	On the whole, many subsections of section 9.8 demonstrate that mitigation actions around buildings generate co-benefits which can be monetised and turn out to be of comparable, if not larger, magnitude than gain/savings in terms of GHG emissions. This is good news. At the same time, one wonders then why the beneficiaries of these co-benefits do not carry out these actions for their own sake, in such a way that mitigation results would become co-benefits. It would be logical and interesting to assess the literature where for example healthcare specialists describe their proposed actions, and point out the co-benefits in terms of climate change mitigation.	Noted - The issue regarding why the beneficiaries do not carry out the mitigation actions for their own sake, as they are associated with significant co-benefits, is discussed on Section 9.9.1 entitled Barriers, feasibility and acceptance. Furthemore, Section 9.8 aims at quantifying and if possible, monetizing, these wider impacts of climate action in order to facilitate their inclusion in cost-benefit analysis, strengthen the adoption of ambitious emissions reduction targets, and improve coordination across policy areas reducing costs. The results presented particularly in section 9.8.5 have been derived by an extensive literature review, concening various types of buildings.	Philippe Waldteufel	CNRS	France
3299	68	4	68	6	Provide a definition for teritary buildings	Taken into account - The term non-resdential buildings is used instead of tertiary buildings.	Rachel Bannon-Godfrey	Stantec	United States of America
56617	68	6	68	6	What is a "tertiary building"?	Taken into account - The term non-resdential buildings is used instead of tertiary buildings.	Government of United States of America	U.S. Department of State	United States of America
56619	68	18	68	45	This is a valuable, data-rich discussion on enhanced asset value of energy-efficient buildings. However, could information be added to discuss an emerging area of research: how energy consumption impacts mortgage default risk in commercial real estate. According to studies being conducted by Lawrence Berkeley National Laboratory (LBNL) and the University of California's Haas School of Business (UCB), there is a statistically significant relationship between energy usage and mortgage defaults -- whereby higher energy use and electricity prices are linked to higher default rates. Additional pilot studies conducted by LBNL and UCB show that energy risks can vary between different properties and across different years within a given property, due to variations in energy usage. For more information, see: https://buildings.lbl.gov/cbs/energy-factors-commercial-mortgages	Accepted - Relevant text added.	Government of United States of America	U.S. Department of State	United States of America
56621	68	34	68	41	Consider adding the following text at line 41: ""Other studies have shown that energy efficiency and green certifications have been associated with lower default rates for commercial mortgages (An and Pivo, 2018; Wallace et al., 2018; Mathew et al., 2021). "" References: An, X., Pivo, G., 2017. Green buildings in commercial mortgage-backed securities: the effects of LEED and energy star certification on default risk and loan terms. R. Estate Econ. 48 (4) https://doi.org/10.1111/1540-6229.12228. Mathew, P., Issler, P., Wallace, N. 2021. Should commercial mortgage lenders care about energy efficiency? Lessons from a pilot study. Energy Policy. Vol. 150, March 2021. https://doi.org/10.1016/j.enpol.2021.112137 Wallace, N., Issler, P., Mathew, P., Sun, K., February 2018. Impact of Energy Factors on Default Risk in Commercial Mortgages. Technical Report. Lawrence Berkeley National Laboratory. LBNL-2001111	Accepted - The proposed text and the relevant references added.	Government of United States of America	U.S. Department of State	United States of America
14711	69	25	69	31	For an updated literature review on the job effects of energy renovation see: Building Renovation: A kick-starter for the EU Recovery. https://www.renovate-europe.eu/wp-content/uploads/2020/06/BPIE-Research-Layout_FINALPDF_08.06.pdf	Taken into account- The text updated based on IEA's estimates on employment implacts of energy efficiency inetrventions in buildings.	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
56623	70	1	70	3	Suggesting the peak demand impacts of electrification can be offset by deep energy retrofits and net-zero design is a bit mis-leading. This is certainly not possible in dense urban areas with tall buildings that have limited access to harness on-site renewables and/or a shift away from thermal to electric infrastructure would be impossible due to constraints of the electric grid.	Taken into account - This sentence discusses the implications of electrification on electricity demand rather than on peak loads. Modifications have been inserted to better reflect the literature reviewed.	Government of United States of America	U.S. Department of State	United States of America
17065	70	4			Typo: "This is. Due to Several barriers"	Editorial - text revised	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
17067	70	14	70	15	Unclear where section SM9.3 is	Noted - considered when chapter revised	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
17069	70	14	70	15	Is the EU viewed as a positive or negative example?	Rejected, not pertinent due to change in text	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
56625	70	17			Section 9.9 makes no mention of energy efficiency programs funded by utility customers -- often known as demand-side management programs. These are one of the primary delivery mechanisms for energy efficiency in U.S. buildings. They should be included somewhere. Two references include: Goldman, C., S.Murphy, I. Hoffman, N. Frick, G. Leventis, L. Schwartz. What does the future hold for utility efficiency programs? The Electricity Journal 33.4. (2020). Goldman, C., S.Murphy, I. Hoffman, N. Frick, G. Leventis, L. Schwartz. The Future of U.S. Electricity Efficiency Programs Funded by Utility Customers: Program Spending and Savings Projections to 2030. 2018.	Accepted, US utility programmes have bene added in the section on energy companies obligations, which nw has a new title. Suggested reference added.	Government of United States of America	U.S. Department of State	United States of America
17071	70	17	70	18	Table 9.6 should be moved to the previous section on the rebound effect	OK wil be moved to the rebound effect section	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
28687	70	17	71	4	This comment applies to the whole chapter, but is most relevant for the barriers discussion. The chapter is silent on the workforce training and transition needs to implement the technologies and policies presented, in actual buidlings. The chapter appears to take as given that if appropriate policies to motivate building owenrs and tenants to take appropriate actions were in place, that the actions would occur. However, in many locations the workforce is not present and skilled, and even hte reelvant firms may not exist, to immediately ramp up to provide these services. Given the need for rapid transition, the chapter should identify the lack of a trained and ready workforce as a barrier, and identify what the potential options are to address it (such as cross-training of fossil fuel heating system technicians to sell, design, and install heat pumps).	Accepted. Added a mention of lack of qualified workforce	Asa Hopkins	Synapse Energy Economics	United States of America
56627	70	18	71	4	Would be helpful to have a sentence or two comparing the barriers in developed and developing countries. Are they the same in nature or depth of impact, or different?	Partly accepted. From the literature analysed the barriers are similar, in the section literature from develping countries is cited.	Government of United States of America	U.S. Department of State	United States of America
60605	70	18	71	4	This entire section should be edited. It requires synthesis of findings in various studies, instead of giving a list with no interpretation. For example: what is the benefit of the sentence that "recently, barriers have been analysed by (Bagaini et al. 2020) and classified in three main categories" - without listing and explaining the categories?	Accepted. the section has been shortened and a synthesis provided; the sentence has been removed	Evyatar Erell	Ben-Gurion University of the Negev	Israel
72109	70	18	71	4	Legal, administrative obstacles can definitely occur. But what about the decision making process, especially for co-ownerships, as the retrofitting decisions need to be taken collectively and require a lot of discussion? (Buesseler et al, 2017) have studied this obstacle, which seems to remain a difficult issue despistes the availability of subisidies, at least in Europe. https://www.sciencedirect.com/science/article/abs/pii/S2214629617301159	Accepted. Text and reference added	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
43681	70	19	70	21	Buildings are not a "sector". The importance of cross-sectoral actions (e.g. decarbonisation of the cement industry while at the same time influencing the demand for concrete structures) should be pointed out.	Partly accepted. removed sector, but it is not here the place to discuss cross sectoral actions, which indeed are very important.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
82063	70	19	70	45	There is too much repitition of "more recently" in this paragraph, which would benefit from some rephrasing	Accepted, the text has been rephrased.	Berrill Peter	Yale University	United States of America
52395	70	19	71	4	No mention of the energy efficiency gap and its literature.	Partly accepted. The eenrgy efficiency gap is mentioned later on at pag.73	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
82061	70	21	70	23	Another paper on barriers to energy efficiency, in particular residential retrofits https://doi.org/10.1016/j.regsciurbeco.2013.09.001	Accepted. Reference added	Berrill Peter	Yale University	United States of America
63081	70	29	70	31	Improving building energy efficiency is one of the important measures for China's energy conservation and emission reduction. There are not legal and social barriers to improving building energy efficiency in China. Therefore, the research by Zhang and Wang did not accurately reflect the situation in China. Please delete '(Zhang and Wang 2013) has identified major barriers to promoting energy efficiency in buildings in China classified as: legal; administrative; financial; market; social.'	Accepted, reference removed	Changke WANG	National Climate Center, China Meteorological Administration	China
3675	70	31	70	32	This chapter analyzes the barriers and difficulties of improving building energy efficiency. However, it lacks analysis of technical difficulties. In addition to policy, financial, and market reasons, Yang et al. (2019) analyzed the technical obstacles of passive products, high-efficiency energy systems, and design and construction testing methods for promotion nearly zero energy buildings in China. The lack of related products affects the incremental cost and large-scale development of nearly zero energy buildings. It is suggested to add sentence "Yang et al. (2019) indicated that lack of high-performance products, and corresponding design, testing, and construction method, are the technical barriers to develop NZEB in China. Such barriers may further influence the reduction of increment cost and also the large-scale development"after the sentence "(Song et al. 2020) analysed the barriers of investment risks, monitoring capacity and policies intermittency in the building sector in China." Yang, X., Zhang, S., Xu, W., 2019. Impact of zero energy buildings on medium-to-long term building energy consumption in China. Energy Policy 129, 574-586.	Accepted, text added	Xinyan Yang	China Academy of Building Research	China
63083	70	31	70	32	Please add "Yang et al. (2019) indicated that lack of high-performance products, and corresponding design, testing, and construction method, are the technical barriers to develop NZEB in China. Such barriers may further influence the reduction of increment cost and also the large-scale development"after "(Song et al. 2020) analysed the barriers of investment risks, monitoring capacity and policiesintermittency in the building sector in China."	Accepted, text added	Changke WANG	National Climate Center, China Meteorological Administration	China
82065	70	40	70	41	Gillingham and Palmer (https://doi.org/10.1093/reep/ret021) review many of the policy relevant contributors to the 'energy efficiency gap' (https://doi.org/10.1093/reep/ret021), including information gaps, principal agent problems, measurement errors, and behavioral anomalies	Accepted, text added	Berrill Peter	Yale University	United States of America
56629	70	43	70	45	Statement about tenant/landlord barriers is repeated from page 5, line 30, without any mention that this barrier is bi-directional. Tenants are reluctant to make energy efficient upgrades that are more "permananent" because it benefits the landlord. More discussion on this important issue is warranted. See comment for page 5, line 30.	Accepted, text modified to indicate the bidirection barriers	Government of United States of America	U.S. Department of State	United States of America
72111	71	5	71	43	The rebound effect is clearly assessed and evaluated for the different world regions but there is no clear description or example about what is a rebound effect.	Noted - The definition of rebound effects is included in the glossary. No space available to provide here a more detailed discussion on what is the rebound effects.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
47515	71	5	73	13	There are not enough and clear references on the sufficiency approach and the renewables. This section focuses on energy efficiency. I suggest including the sufficiency and renewables references and impacts in this section.	Noted - In the beginning of this section the various types of reboud effects associated with suffiency and renewables interventions are menntinoed. No space for a more detailed discussion.	Gonzalo Sánchez	European Environmental Bureau	Belgium
56631	71	7	71	8	Any measures to reduce energy use can potentially have rebound effects by lowering the price of energy. Recommend deleting the clause on sufficiency.	Noted - The lower energy prices due to energy savings are related to secondary rebound effects. This is reflected in the text.	Government of United States of America	U.S. Department of State	United States of America
3301	71	11	71	11	Should 'prebound' be 'rebound'?	Rejected - It should be prebound. The term is explained in the same sentence.	Rachel Bannon-Godfrey	Stantec	United States of America
52397	71	23	71	28	Yes, this is an important point that can be emphasized with more literature. The rebound effect can be welfare-enhancing. It depends on the benefits that consumers gain from using more of an energy service, compared to the external costs associated with the increased energy use as a result of rebound. There are several papers on the welfare implications of the rebound effect that the authors can look at, such as: Chan and Gillingham 2015, Borenstein 2015, Alfawzan and Gasim, 2019.	Accepted - some of the proposed references added in the corresponding paragraph.	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
60607	71	29	71	31	Saying that rebound effects range from "9-91% in Europe… and 66-236% in China" is essentially meaningless, beyond the fact that the rebound effect exists. The range is so wide that any guess might be better.	Taken into account - Median estimates added in order the results presented to be more meaningful.	Evyatar Erell	Ben-Gurion University of the Negev	Israel
63085	71	31	71	31	"66-236%" is data of 1994 according to Lin, B. and H. Liu, 2015(A study on the energy rebound effect of China's residential building energy efficiency). This data is too old. So it is suggested to delete "66-236% in China."	Taken into account - The study published in 2015 and provides estimates of the rebound effects in urban and rural China for each year of the period 1994-2011.The text revised to incude the results from the most recent year (i.e., 2011).	Changke WANG	National Climate Center, China Meteorological Administration	China
60609	71	36	71	40	The sentence beginning with "It should be noted…" could be moved to the beginning of the paragraph.	Accepted	Evyatar Erell	Ben-Gurion University of the Negev	Israel
22081	71	43	71	43	Please consider adding the following information: This effect can hence be defined as a behavioural response caused by an improvement in the energy efficiency of housing and buildings (Binswanger, 2001). But the rebound effect may also come from a difficulty of statistical models in integrating household energy behavior in building energy consumption (Guerra-Santin et al., 2009). There is a gap between the forecast of energy consumption of buildings provided by the models and the results of the experimentations. Most experiments show that the current technical responses are inadequate, in particular because of the difficulty of quantifying different social behaviours. The technical models reduce energy practices to a few discrete indicators, which do not reflect the overall logic of social practices by incorporating them as an adjustment variable. On the other hand, although qualitative studies on household energy behaviours are able to describe the behavioural processes comprehensively in all technical, political, economic and social dimensions (Shove and al., 2012; Sovacool, 2014), they are difficult to model numerically. More broadly, combining inductive, deterministic and statistical approaches with mathematical, deductive and stochastic approaches, in other words combining social sciences and economics, urban ecology and urban engineering is no easy matter. Some researches are nevertheless trying to integrate social behavior into digital models of energy consumption in buildings or urban heat islands (Bourgeois and al., 2017; Schoetter and al., 2017).	Noted - No space for such analytical discussion. However, the consideration of the rebound effects from both social and technical perspectives is highlighted in the beginning of this section.	Government of France	Ministère de la Transition écologique et solidaire	France
43683	71	44	72	14	Legislation to decarbonise construction should not be limited to legislation on energy efficiency. It becomes a political instrument in its own right. Countries such as France, Finland and Denmark have long been working on corresponding laws to limit GHG emissions in the life cycle - see https://journal-buildingscities.org/articles/10.5334/bc.30/	Accepted, text added as suggested.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
12039	71	44	78	43	Currently, the Policy section does not include any discussion of policy (and governance) re embedding carbon/biomass in buildings as a form of removals. The Royal Society (2018) has suggested between 0.5 and 1 GtCO2 per annum could be sequestered by building with biomass in place of conventional materials, whilst Oliver (2014) indicates that the approach could save between 12% to 19% of global fossil fuel use. A positive benefit of using more timber and other plant materials in construction could be the decrease in demand for carbon-intensive steel and concrete. The required coupling of building with biomass with afforestation and reforestation CDR policy, creates important policy and governance questions not addressed in the text. The practice of embedding biomass could, for example, play an important role in longer term afforestation governance, providing an outlet for biomass harvested at the end of its carbon removal lifetime. If timber and plant material for building is imported, an international agreement about who can claim the credit for the removal, along with a mechanism to monitor the flow of materials, and the carbon storage may be needed (Royal Society, 2018). For effective international oversight, more comprehensive and consistent national accounting standards and reporting may be required. National and supra national building regulations may constrain the use of materials in some circumstances. However, there is evidence that these can and are changing in the light of the new potentialities of wooden structures. For example, wood building codes in Canada, China and the United States have all recently changed giving greater flexibility for the inclusion of wood in builds. See Ramage MH, Burridge H, Busse-Wicher M, Fereday G, Reynolds T, Shah DU, et al. The wood from the trees: The use of timber in construction. Renewable and Sustainable Energy Reviews. 2017 Feb;68:333–59. Available from: http://dx.doi. org/10.1016/j.rser.2016.09.107. OLIVER, C. N., N.: LIPPKE, B.: MCCARTER, J. 2014. Carbon, Fossil Fuel, and Biodiversity Mitigation With Wood and Forests. Journal of Sustainable Forestry, 33, 248-275. CECCO, L. 2019. Canadian cities take wooden skyscrapers to new heights The Guardian Newspaper, 22 July 2019. The Royal Society, Greenhouse Gas Removal. London: Royal Society and Royal Academy of Engineering https://royalsociety.org/topics-policy/projects/greenhouse-gas-removal/?gclid=EAIaIQobChMIg8292JCR7wIVjZntCh1MRgOVEAAYASAAEgIdHPD_BwE Gustavsson L, Sathre R. Variability in energy and carbon dioxide balances of wood and concrete building materials. Building and Environment. 2006 Jul;41(7):940–51. Available from: http://dx.doi.org/10.1016/j.buildenv.2005.04.008 . Gosselin A, Blanchet P, Lehoux N, Cimon Y. Main Motivations and Barriers for Using Wood in Multi-Story and NonResidential Construction Projects. BioResources. 2016 Nov 23;12(1). Available from: http://dx.doi.org/10.15376/ biores.12.1.546-570	Accepted, now policies for fostering the use of wood in builings are mentioned in the section on builing codes. Paper by Ramage cited.	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
60611	71	44	78	43	Section 9.9.3 needs extensive reorganization. This should begin with the recognition that for a policy to be proposed, the barriers it seeks to overcome must be first identfied. Policies can only be successful if they address the root causes of specific barriers. The entire section as it stands lacks focus.	Reject. Section 9.9.3 has been structured on the policy instruments classification presented in Chapter 13. Each policy instrument conttibute to eliminate or redice some the barriets identified. Some policy instruments remove/reduce more than one barriers, while for other barriers are necessary more than one indivudual policy instrument. For exmaple there are several polices that are adopted to remove split-incentives (e.g. information, reguclation, financing).	Evyatar Erell	Ben-Gurion University of the Negev	Israel
3677	72	1	72	15	This section shows that only through policies packages can it be possible to achieve low-carbon development in building sector. During the "13th Five-Year Plan" period, in order to achieve the goal of nearly zero energy buildings of 10 million m2 proposed by the Ministry of Housing and Urban-Rural Development, local governments have formulated corresponding policies and measures according to their own conditions. As a successful example of the policy package, it is recommended to added in the report. Related incentive policies can also be added to Supplementary Material. It is suggested to add "The Ministry of Housing and Urban-Rural Development of China proposed to develop goal of 10 million m2 NZEB during the 13th Five-Year Plan. To accomplish the goal, local government have successively formulated incentive policies. The incentive measures include subsidies, land use support, floor area ratio bonus and reduced city infrastructure supporting fees. (Yang et al., 2019)."after the sentence "… in the Supplementary Material (Section SM9.3).". Yang, X., Zhang, S., Xu, W., 2019. Impact of zero energy buildings on medium-to-long term building energy consumption in China. Energy Policy 129, 574-586.	Accepted mentioned in the report and added in the Supplementary material	Xinyan Yang	China Academy of Building Research	China
56633	72	3	72	4	"Not a single energy efficiency policy" implies that building energy efficiency policies do not decarbonize. The authors appear to mean that no single policy can address all aspects of decarbonization.	Accepted, text modified as suggested	Government of United States of America	U.S. Department of State	United States of America
2241	72	4	72	4	"This is. due to: the several barriers;" should be I think "This is due to several barriers:"	Accepted, text corrected	Stephen Wilkinson	University of Wollongong in Dubai	United Arab Emirates
4991	72	4	72	4	The authors write: "This is. due to: the several barriers;...". There is an unecessary fullstop within the sentence. It should be deleted	Accepted, text corrected	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
14713	72	8	72	15	Suggest to reference BPIE's updated (2020) comprehensive policy overview for the EU: A guidebook to European building policy. https://www.bpie.eu/publication/a-guidebook-to-european-building-policy-key-legislation-and-initiatives/	Accepted to be mentioned in the	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
43685	73	9	73	9	With SIA 2040 in Switzerland and a current draft law, there are already examples of requirements for GHG emissions in the life cycle of buildings.	accepted	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
5467	73	13	73	13	Add an additional sentence : "However, actual implemntation examples remain limited, du to additional costs tied to renewble energies.	Rejected, PV costs have dropped substantially.	Michel SIMON	Retraité/ Pdt d'association	France
20029	73	14			In Section 9.9.3.1, I find it suprising not to find anything about energy efficiency subsidy programmes, which are a pervasive public policy tool (e.g., tax credits) as well as an important part of energy efficiency obligations. For further references about these programmes, see Section 6.1 of Giraudet (2020) (already referenced)	Accepted, subsidies are discussed in details in 9.9.4. in 9.9.3 some policies such as tax credits and white certificates are discussed.	Louis-Gaëtan Giraudet	CIRED, Ecole des Ponts ParisTech	France
10771	73	14	73	38	Sufficiency seems indeed a major concept, which impacts the whole organisation of civilization. It is interesting that this concept is almost exclusively developed in the "buildings" chapter. No mention in the "transport" chapter, nothing in the AFOLU chapter either!	Good comment but not for Chapter 9, should be transferred to chapter 10	Philippe Waldteufel	CNRS	France
47517	73	14	74	13	The policies mentioned in this section focus on efficiency policies. There are no references to sufficiency policies. It makes the text less understandable and less linked to other chapters. I suggest including explicit references on sufficiency policies.	Accepted. Please note that at page 73, lines 33 ot 38 the text is fully dedicated to sufficiency policies. More policies and more details have been added in this section.	Gonzalo Sánchez	European Environmental Bureau	Belgium

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56635	73	14	74	13	The evidence base for sufficiency policies in the buildings sector is extremely limited. The citations provided are theoretical and not based on actual policy experience. As such, it does not appear appropriate to include them in a policy section. Moreover, this points to a more fundamental problem with this section: What is the practical experience and potential for sufficiency policy? It may be possible to have zoning that encourages growth near dense transit corridors, which likely would lead to smaller housing, but otherwise limiting housing space appears to undermine the idea of a just and equitable transition as affordable housing is already scarce in cities around the world. Moreover, it is not clear what the sufficiency concept would mean for commercial real estate. Does this mean that businesses should not grow if this requires additional floorspace?	Partly Accepted. Your comment is very relevant and add to the discussion. Even if there is limited experience with sufficiency policies, it is important to present the theoretical framework, because these policies will become more important in the decarbonization of buildings complementing technological development. Limiting floor space to what is associated with concept of wellbeing (for example by limiting the floor space per capita) could indeed have a more just and equitable transition as everybody will have a “sufficient” residential space, without large discrepancies across society. Example is facilitating exchange of properties between “older” citizens, which may have a large family house, but no more children living at home, with a young family with kids, needing a larger living space. This can contribute to more affordable housing. The section highlights clearly that “Sufficiency touches upon individual liberties:” and “that sufficiency should be "integrated in a more comprehensive normative framework related to welfare and social justice". Alcott highlights that in sufficiency there is a loss of utility or welfare”. Thus presenting in a fair manner the limitation or risks associated with sufficiency policies. In the non-residential sector sufficiency could be implemented through the sharing economy, for example flexible offices space with hot desking	Government of United States of America	U.S. Department of State	United States of America
45539	73	14	78	43	Many countries struggle with getting their existing building stock retrofitted. There is little help for them in this section. Energy labeling and carbon taxes only help a bit. The one regulatory example for the UK is only for the two most inefficient categories. Are there no great examples of effective policies? If not, then also good to say that.	Accepted. Information and financing are instrumental for building renovation, but also regulation as in the UK, carbon pricing and non-energy benefits play an important role. Sentence added at the end of the section 9.9.4 as financial instruments play a key role.	Kornelis Blok	Delft University of Technology	Netherlands
82067	73	15	73	38	Removing or altering policies which currently support supply of larger home typologies (e.g. tax/finance regulations more supportive of single-family home ownership https://doi.org/10.1021/acs.est.0c05696; or local land-use regulations restricting construction of small and multifamily housing http://www.nber.org/papers/w26573) can aid sufficiency targets, by attenuating or reversing the growth in floor area per person	Accepted, text included.	Berrill Peter	Yale University	United States of America
52399	73	18	73	20	As noted in a previous comment, determining what is a sufficient level of an energy service is difficult, and therefore sufficiency actions could have negative consequences on houshold welfare. There should be a detailed discussion, or even a text box, on this.	Accepted, there is a text box (Box 9.1) at page 9. The text indicating the loss of welfare has been added.	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
56637	73	27	73	27	No building codes in the world limit floorspace. There are many building codes that limit energy use, including, for example, limiting window-to-wall area. But this would more traditionally be called efficiency, not sufficiency.	Rejected: the tetx proposes progressive building codes, which have higher demand in terms of energy performaces per square meter.	Government of United States of America	U.S. Department of State	United States of America
25057	73	27	73	38	Better building design using combination of different materials (e.g. steel; carbon, wood, and hemp fibres) can reduce cement and concrete use by 20–30% safeguarding building performance (Bataille et al. 2018a; Scrivener et al. 2018). Using wood as substitute for steel and concrete could save 14-31% of global CO2 embodied in new buildings emissions by using 34-100% of the world’s sustainable timber resources (Oliver et al. 2014), although the quantity should be traced because of the wood scarcity for transition pathways. High-rise buildings are increasingly being built using Cross Laminated Timber (CLT) instead of concrete and steel, with the additional benefit of shortening construction periods (examples: 18-storey UBA building in Canada; 18-storey mixed use building in Norway; 10-storey apartment in Melbourne, Australia.) Although CLT is superior to ordinary timber in terms of fire resistance, but when widely used, risk should be recognised as an issue.” The number of CLT high rise buildings of all new build in the world to the nearest percentage is 0%. It is therefore misleading to state "are increasingly being built using CLT". Furthermore, all of these "CLT" buildings still require substantial amounts of concrete. More accurate would be "There are more examples of high rise buildings where CLT is used for structure in combination with concrete and steel.(examples : 18 storey.....)	Rejected, CLT not discussed in this section on sufficiency	|Claude Lorea	GCCA	Belgium
56639	73	33	73	36	These examples describe a small fraction of residential space and no commercial space. This itself seems to indicate that the concept of sufficiency should be reframed in this chapter to provide more evidence-based and explicit examples.	Partly accepted. The concept of sufficiency is mainly addressed the residentail buildings. This section in particular assess the literature of sufficienct polices, wher some possible measures are proposed and discussed. "possible" has been added to the text to make clear this point.	Government of United States of America	U.S. Department of State	United States of America
56641	73	37	73	37	There are no building codes that limit floor space.	Accepted, "building codes" remove in this sentence.	Government of United States of America	U.S. Department of State	United States of America
56643	73	39	73	47	The citations for the discussion on efficiency gap are 25-30 years old. There has been much more recent work published on this issue. For example, the UK has wrestled with Performance Gap issues within their building regulations for the last decade. More recent data and discussion would make this narrative much more relevant.	Partly accepted, more recent references as, here there is a short sentence to introduce the Energy Efficiency gap, the Energy Performance Gap, which is a different concept is discussed in another section of 9.9. at pag 74 of the SOD	Government of United States of America	U.S. Department of State	United States of America
56645	74	15	74	46	This discussion on building energy codes seems to miss emerging trends related to outcome-based energy codes (advanced codes). Such outcome-based codes are being advanced both in the United States and Sweden. Outcome-based codes are increasingly important to consider because widely used prescriptive building energy codes (1) typically do not regulate all building energy uses (e.g., plug and process loads, domestic hot water) and (2) do not regulate measured operational energy use in buildings. Regulating all loads, especially plug and process loads, is important because they account for an increasingly large percentage of total energy use as building envelope, lighting, and space-conditioning equipment are becoming more efficient. In addition, regulating measured operational energy assures the building performs at the intended level. Outcome-based energy codes (advanced codes) being promulgated by groups such as the New Buildings Institute (NBI, https://newbuildings.org/code_policy/outcome-based-energy-codes/) should be considered for mention in the IPCC. There is considerable potential here. An NBI White Paper discusses cases from Sweden and the United States. (Frankel, M. 2012. Establishing a Pathway to Outcome-Based Codes Policy. Portland, OR: New Buildings Institute. Available at https://newbuildings.org/wp-content/uploads/2016/03/Establishing-a-Pathway-to-Outcome-Based-Codes-Policy-11-12.pdf)	Accepted, thank you for the comment, suggesteed text and three peer reviewed journal article citations have been added (the one suggested in the comment being grey literature).	Government of United States of America	U.S. Department of State	United States of America
56647	74	15	74	46	Buidling energy codes are an effective way to drive higher efficiencies in buildings as well as provide requirements for renewable energy supply. The 2021 International Energy Conservation Code (IECC) from the International Code Council recently adopted two appendices (one commercial, one residential) that would take new construction projects to net zero energy performance. In addition, NBI recently released an overay to the 2021 IECC that jurisdictions could adopt to require zero carbon building performance. The Building Decarbonization Code can be found at: https://newbuildings.org/resource/building-decarbonization-code/	Rejected, space limitation do not allow for this information to be added. Plus not possible to identify literature on this topic,	Government of United States of America	U.S. Department of State	United States of America
60613	74	15	75	19	There are several grammatical errors in this section: language editing is needed.	Accepted, language editing carried out	Evyatar Erell	Ben-Gurion University of the Negev	Israel
72957	74	15	75	7	Many building codes are not based on sound building physics and therefore not fit for purpose eg: SAP	partly accepted, not clear what the comment is about. Plus topic already covered in the new text.	David Gale	Gale & Snowden Architedcts Ltd	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56649	74	19	74	20	Important to mention the fact that ASHRAE Standard 90.1 has published prescriptive on-site renewable energy requirements for non-residential buildings that will be included in the 2022 version of the standard. No longer true that energy codes "can" include renewables but that codes "do" include renewables. See: https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/90_1_2019_by_ck_cp_20200731.pdf	Accepted text changed	Government of United States of America	U.S. Department of State	United States of America
56651	74	20	74	26	This section mentions that building energy codes are typically assessed before the construction of the building. That is true, but it understates the whole assessment process needed to determine if a building "as constructed" truly meets the building energy codes. In the U.S., the first step is plan review and approval by trained code officials or third party reviewers. If the building "as planned" does meet the energy code, there is little hope that the building "as constructed" will meet the energy code. The next step is field inspection that occurs while construction is taking places. If the building "as constructed" does not follow the approved plan, then there is again little hope that the the building "as constructed" will meet the energy code. An overview of the plan review and field inspection process may be found at https://www.energycodes.gov/sites/default/files/documents/BECP_Building%20Energy%20Codes%20Resource%20Guide%20Code%20Officials_October2010_v00.pdf. A third and final step to help ensure buildings "as constructed" meet the energy code is some sort of evaluation of plan review and field inspection process. The U.S. Department of Energy has conducted independent field studies for low-rise residential buildings, low-rise multi-family residential buildings, and commercial and high-rise multi-family residential buildings in an ongoing evaluation of whether or not U.S. buildings actually meet the energy codes they are built under, with emphasis on the energy savings that may be "left on the table" if buildings do not actually meet the energy code. Details of all three sets of studies may be found at https://www.energycodes.gov/compliance.	Accepted, for space reason we just indicated the importance of a compliance check when buildings in operations	Government of United States of America	U.S. Department of State	United States of America
31397	74	22			should read when building codes are issued	Thank you The sentence has been deleted	Jacob HALCOMB	UNEP Affiliate	France
4993	74	22	74	22	There is a typos at the line 22: "are issued…" should be substituted at "are issue…"	Thank you The sentence has been deleted	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
3305	74	23	74	23	Would be worth looking in more detail at mechanisms for ensuring on-going compliance with energy targets when a building is operational as there is often a significant achievment gap between design documents and real life ooperation. Many cities in America have mandated energy benchmarking and reporting for existing buildings e.g Denver, New York City, as you note in the following section however these cities look at not only residential but also commercial properties and it seems good to reference here.	Thank you, however for space reason we cannot expand on this topic here	Rachel Bannon-Godfrey	Stantec	United States of America
3313	74	23	74	23	Re the energy performance gap - there should be more value placed on the role of commissioning during the building design and construction phases, and retro-commissioning or re-commissioning during operations - many clients see commissioning as just a cost-add instead of an investment in quality control. Would be good to describe the inlfuence that commissioning has on supporting long-term efficiency.	Accepted, commissioning and retro/re-commissioning has been mentioned in a more relevant place in the chapter.	Rachel Bannon-Godfrey	Stantec	United States of America
56653	74	26	74	31	There are several empirical studies of building energy code performance in the United States that should be added, including at a minimum: Aroonruengsawat et al. - http://www.iaee.org/en/publications/ejarticle.aspx?id=2466 Deason and Hobbs - https://www.climatepolicyinitiative.org/publication/codes-to-cleaner-buildings-effectiveness-of-u-s-building-energy-codes/ Levinson - https://www.aeaweb.org/articles?id=10.1257/aer.20150102 Kotchen - https://www.journals.uchicago.edu/doi/full/10.1086/689703 Jacobsen and Kotchen - https://www.mitpressjournals.org/doi/abs/10.1162/REST_a_00243	Accepted, references added	Government of United States of America	U.S. Department of State	United States of America
31395	74	28			stringer -stringent	accepted thank you	Jacob HALCOMB	UNEP Affiliate	France
2243	74	28	74	28	"stringer" I think it the wrong word perhaps "more stringent" or "stringenter"	accepted thank you	Stephen Wilkinson	University of Wollongong in Dubai	United Arab Emirates
3303	74	28	74	28	correct 'stringer' to stringent'	accepted thank you	Rachel Bannon-Godfrey	Stantec	United States of America
56655	74	28	74	28	"more stringent" not "stringer"	accepted thank you	Government of United States of America	U.S. Department of State	United States of America
31399	74	34		39	Great to see this point raised. It is not just the modeled/anticipated savings that needs to be measured but there can be a "prebound" effect which over-estimates actual energy use in buildings, inflating the expected savings	accepted thanks	Jacob HALCOMB	UNEP Affiliate	France
3307	74	34	74	34	Could tie this section back to the earlier sections on appliance efficiency - in many cases the energy performance gap between the results of design-phase energy modelling and actual energy consumption once the building is operational is due either to errors in the model or, more often, a significant differenence between modelled plug loads and actual plug loads. In other words, human behaviour and appliances. So it might be worth suggesting a more robust and contemporary national / international database of plug loads found in typically buildings (most assumptions that modelers use are based on old data. I think PNNL has the most recent study, and even that is from before every charged their cell phones at work).	Accepted, the importance of plug load/appliances discussed.	Rachel Bannon-Godfrey	Stantec	United States of America
56657	74	35	74	41	In the U.S. at least, energy codes only cover the parts of the building that are "nailed down" -- i.e., envelope, HVAC systems, and lighting. Plug loads and operations in general are not covered. There is some discussion in the U.S. research community about "outcome based codes" -- codes that mandate maximum EUI levels for each building type in each climate. However, the logistical and political difficulties of levying fines to the parties responsible when a building exceeds its allotments have made these discussions purely academic at this point.	Accepted thanks	Government of United States of America	U.S. Department of State	United States of America
56659	74	40	74	40	Many countries even with relatively high rates of construction are beginning to consider building energy codes for existing buildings because they nonetheless have a large existing building stock. The challenge is to find an effective compliance mechanism. Countries developing regulations for existing buildings include Canada, the U.S. (specific cities), China, Singapore, and others.	Accepted thanks	Government of United States of America	U.S. Department of State	United States of America
28691	74	40	74	46	Suggest discussing the introduction of building energy and emissions performance standards for large buildings at the city level, with examples such as New York, NY, Washington, DC, and Boston, MA.	Rejected. It is already discussed at page 85 line 11 to 13 of the SOD	Asa Hopkins	Synapse Energy Economics	United States of America
56661	74	40	74	46	This paragraph emphasizes the importance of building energy code requirements for existing buildings in countries with low rates of new construction. However, this issue is also important even in countries with high rates of construction as "new" buildings become "existing" buildings very quickly. This is especially true if codes change rapidly. For example, in the U.S., the national model codes are updated every 3 years. While U.S. codes do have provisions in them for existing building renovations, what they lack is any mandate that existing buildings "must be renovated or retrofitted", so code only applies if and when the building owner chooses to undertake a renovation.	Accepted, what suggested has bene introduced	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
31401	74				Performance decay is an issue with any building code, even if code is correctly followed and measures correctly installed, savings will erode over time. This is not mentioned and gives the impression that energy can be saved permanently without further intervention. (e.g. insulation in cavaties can fall or shift, losing impact, mechanical savings can be lost through human over-ride or mechanical failure over time). I see no mention of performance decay in this chapter though there is an obvious place for it, e.g. discussion of energy audits and why they are important.	Accepted, see new text on retro-commissioning, which is to check on any Performance decay and take action.	Jacob HALCOMB	UNEP Affiliate	France
3679	75	1	75	7	China officially released the national standard "Technical Standards for Nearly Zero Energy Buildings" GB51350-2019 in 2019, which is the first standard for nearly zero energy buildings issued in the form of national standards in the world. The standard defines the definition and energy requirements of ultra-low energy, nearly zero energy, and zero energy buildings covering 5 climate zones in China, and it also includes public buildings and residential buildings. The standards provide technical guidance of nearly zero energy building. It is suggested to add “In 2019, China issued national standard Technical Standard for Nearly Zero Energy Building GB 51350-2019 (MoHURD, 2019). This is the first standard for NZEB in the form of national standards world widely. The standard defines the definition of ultra-low, nearly zero and zero energy building, as well as their energy consumption and indoor quality requirements for different climate zones and building types. ”before the sentence California has also adopted…” MoHURD, 2019. Technical Standard for Nearly Zero Energy Building GB 51350-2019. China Architecture & Building Press, Beijing, China, p. 135.	Accepted, text included.	Xinyan Yang	China Academy of Building Research	China
63087	75	1	75	7	Please add “In 2019, China issuednational standard Technical Standard for Nearly Zero Energy Building GB 51350-2019(MoHURD, 2019). This is the first standard for NZEB in the form of national standardsworld widely. The standard defines the definition of ultra-low, nearly zero and zero energy building, as well as their energy consumption and indoor quality requirements for different climate zones and building types.” before“California has also adopted…”.	Accepted, text included.	Changke WANG	National Climate Center, China Meteorological Administration	China
27797	75	9	75	13	Sentences to be edited as they are incomplete.	Accepted. Text corrected	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
4995	75	11	75	11	Check the sentence because it seems something does not work	Accepted. Text corrected	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
16499	75	20	75	20	repetitive use (Regulatory instruments)	Accepted. Text corrected	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
56663	75	20	76	33	Emissions Performance Standards have been adopted and implemented in several U.S. cities. Include it in the "regulatory instruments" discussion.	Accepted, text added	Government of United States of America	U.S. Department of State	United States of America
56665	75	21	75	33	Energy performance certificate is an EU-specific term. Recommend framing this more broadly as energy performance certificates and labels, and also referring to the term benchmarking in the text. Also, given the discussion of actual performance, it would be helpful to mention EPA Energy Star and NABERS, which are building performance labels based on performance, not modeled energy use. Singapore has mandatory building energy labels, as do many cities in the U.S. India and Brazil have mandatory labels for public buildings.	Accepted, text changed	Government of United States of America	U.S. Department of State	United States of America
14715	75	21	75	37	Suggest to reference recent EPC overview report for EU: Energy Performance Certificates: Assessing their Status and Potential. https://www.bpie.eu/wp-content/uploads/2020/06/X-TENDO-REPORT_FINAL_200519_pages.pdf	Rejected, grey literature	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
72959	75	21	75	37	EPCs as currently rated are not effective as they could be in promoting improvements to building fabric, especially in retrofit, due to low scoring of building envelope improvements	Partly accepted, limtitation of EPC already mentopned at pag 75 lines 22-24	David Gale	Gale & Snowden Architedcts Ltd	United Kingdom (of Great Britain and Northern Ireland)
16501	75	37	75	37	The contents below needes to be added. [Building Energy Statistic System] Accurate statistics related to energy use are very important for reducing GHG in building sector. However, an accurate statistical system for the energy use of buildings has not been established in many countries, It is important to develop policies for the building sector based on accurate statistics of energy sources and GHG for each purpose of use. And by sharing this, it must be used for energy consumption reduction. In 2015,Republic of Korean government established the National Building Energy Integrated Management System. 6.8 millions of building data and energy consumption information(electricity, gas, heating, etcs) are collected to be utilized to policy development and public information. Furthermore, In 2020, for the first time in the world, UNFCCC CDM's standard baseline for average GHG emissions from residential buildings was approved for the first time in the world(Specific CO2 emissions in Residential Buildings in Republic of Korea, ASB0048-2020). Based on this, Korean government is planning to implement GHG mitigation projects in building sector	Accepted text added	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
16503	75	37	75	37	The contents below needes to be added. [Carbon Offset] GHG offsets related to carbon allowance can be effectively applied to GHG mitigation in building sector by relating to GHG mitigation investment. International offset programs including CDM allow high-efficient LED conversion, cookstove, rising building energy efficiency and high-efficient electronic appliances in building sector for GHG mitigation project investment. It can be contributed to expansion of GHG mitigation technologies by acquiring GHG emission reduction credit in building sector.((refer to, https://cdm.unfccc.int/Registry/index.html). For example, LED lighting conversion, fuel conversion in building sector and heating system conversion GHG mitigation projects are actively implemented in Korean Offset Program related to national Emission Trading Scheme.	Accepted but discusses in another section of Ch. 9.	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
52335	75	39	75	39	Enhancing the role of ESCOs can benefit countries both environmentally and economically.	Accepted, the role of ESCO mentioned.	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
2823	75	39	75	46	Qualification and certification of energy auditors needs to be pursued more vigorously in order to facilitate the widespread use of audits	Accepted. Text integrated.	Leonardo Barreto	Head of center "EU&International"	Austria
56667	75	39	75	46	This section seems narrow because it only mentions Finland and New York. Many other countries also offer subsidized or free audits. In the U.S., the practice is much more widespread than New York State (many U.S. jurisdictions offer free audits, and the practice has been in place for years). The DSIRE website would be a good reference for the U.S., but this section would benefit from some information from Asia and elsewhere as well.	Accepted, text added	Government of United States of America	U.S. Department of State	United States of America
3309	75	40	75	40	Might need to explain what is meant by 'small firm buildings' as all previous sections descrobe buidlings by either size or type or use. I read it as buildings that are owned by or that accommodate small sized companies?	Accepted, clarifies in the text	Rachel Bannon-Godfrey	Stantec	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56669	75	45	75	46	New York City now has an audit mandate for commercial buildings also (Local Law 87).	Accepted and included in the text.	Government of United States of America	U.S. Department of State	United States of America
74975	75		75		Consider giving the Kenyan example in terms of Minimum Energy Performance Standards (MEPS) development to amplify the uptake options	Accepted Kenya added to the section	Government of Kenya	Kenya Meteorological Service	Kenya
9999	76	1		7	Energy labelling is important, for the affluent in particular, since it provides information to buyers on which appliances are more energy efficient in terms of electricity consumption as well as performance. Smart buyers will tend to buy more efficient appliances.	Rejected, not clear what requested by the comment	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
3311	76	1	76	7	Quite a few grammar issues in this section? Also, I believe ENERGYSTAR is always capitalized?	Accepted	Rachel Bannon-Godfrey	Stantec	United States of America
20035	76	34			For cost-effectiveness estimates of various energy efficiency policies, see: Giraudet, L.-G., Bourgeois, C., Quirion, P., 2021. Policies for low-carbon and affordable home heating: A French outlook. Energy Policy 151, 112140. https://doi.org/10.1016/j.enpol.2021.112140. Most subsidies in France induce leverage within 1.0 to 1.4 and reduce emissions at a cost within €300-800/tCO2-eq	Accepted, text added	Louis-Gaëtan Giraudet	CIRED, Ecole des Ponts ParisTech	France
56671	76	35	77	34	The description of the Finnish town seems to detract from the point because it is a small example. As noted, Tokyo and Korea have carbon allowances with trading. New York City also has new mandatory carbon targets for buildings.	Rejected. This is a very important exampe though small and geograpgically limited, as it is the fisrt real test of personal carbon allowances, which are different from building allowances as in Tolyo, Korea and New York,	Government of United States of America	U.S. Department of State	United States of America
72113	76	35	77	34	The opportunity related to carbon allowances is a very interesting mention, as an alternative to standard taxes and subsidies, but it would be worth providing more detailed feedback on existing case studies as the author mentions some existing initiatives in Japan and Finland.	Partly accepted. Personal carbon allowance exist only in theory and the Finnish experiment is the only one the authors are aware of. Different is the situation for building allowances, wher many schemes are in place.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
8425	76	35	77	8	Present GHG per capital exceeds the carrying capacity of the earth. Developed countries are energy rich (more emission) whereas developing countries are energy poor (less emission). Energy budget per capita or per building would be an effective way of meeting the +2.00C target. Voluntary measures cannot be effective. Statutory policy is needed. Governments should devise effective mechanism to achieve this goal.	Rejected. Although the author share the message of the comment, it cannot be introduced in the section as it would be policy prescriptive.	Otto Poon	President, Hong Kong Academy of Engineering Sciences.	China
72961	76		76		material content disclosure is required to enable visibility of chemical composition (and emodied energy and carbon) of building materials so that healthy building choices can be made possible - in a similar way as food contents disclosure legisiation	Accepted. Infromation could also include embedded carbon in material, added in the section about labelling	David Gale	Gale & Snowden Architedcts Ltd	United Kingdom (of Great Britain and Northern Ireland)
74977	76		76		Consider the UNDP & Kenyan Ministry of industrialisation "Nyota Msema Kweli" project, example for Kenya that comlements the MEPS process and has been widely adopted. https://www.ke.undp.org/content/kenya/en/home/ourwork/environmentandenergy/successstories/energy-efficiency-through-standards-and-labels-program-.html	Accepted. Add in tehsection about standards	Government of Kenya	Kenya Meteorological Service	Kenya
3315	77	9	77	21	New York City Local Law 97 sets a carbon emissions budget for each building based on type.	Accepted, added to the text	Rachel Bannon-Godfrey	Stantec	United States of America
3317	77	9	77	21	Boulder Commons, Boulder Colorado, USA and the Bullit Center, Seattle, USA are two examples of NZEB that have set plug load budgets for all tenants. The amount of solar PV the developer installed is based on every tenant meeting the budget. Energy consumption is checked monthly and any tenant that exceeds their budget is fined an amount that is correlated to the cost of additional green power the building owner must purchase to get the buildings back on track for net zero energy. Rocky Mountain Institute, USA, has a good paper on net zero leases, for more information.	Rejected. Although the two examples are very interesting and innovative, for space budget we cannot include them, in addition these are two private sector examples and in this section we are dealing with public policies.	Rachel Bannon-Godfrey	Stantec	United States of America
56673	77	9	77	21	New York City Local Law 97 established "Carbon Allowances" for buildings.	Accepted, added to the text	Government of United States of America	U.S. Department of State	United States of America
43687	77	10	77	10	Please use the term "carbon budget" instead of "carbon allowance"	Partly accepted, both terms can be used, so I have added also carbon budget.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
5469	77	13	77	13	at the end of the line, after "energies," add between brackets "(if CO2 emissions by these renewables are lower than the ones of energy delivered by the grid. If electricty delivered by te grid is very low carbon, it's not recommended to call for solar or wind electricity.)	Rejected. No space to add this clarification, on which I would agree.	Michel SIMON	Retraité/ Pdt d'association	France
56675	77	25	77	34	Energy Savings Feed in Tariff is an EU-focused term. In North America, this is called an Energy Efficiency Resource Standard (see https://database.aceee.org/state/energy-efficiency-resource-standards). Recommend more neutral terminology to describe similar practices across the world. This section also seems to significantly overlap with the Obligation section.	Rejected. There is a substantial differet between a feed-in tariff and EERS. In EERS the utility improve the efficiency in end-user premises (incetive to end-users), while in a FiT the end-user invest and sell the real energy savings to a utility.	Government of United States of America	U.S. Department of State	United States of America
20033	77	35			On energy efficiency obligations, see: Giraudet, L.-G., Finon, D., 2015. European experiences with white certificate obligations: A critical review of existing evaluations. Economics of Energy & Environmental Policy 4, 113–130. https://doi.org/10.5547/2160-5890.4.1.lgir	Accepted, reference added.	Louis-Gaëtan Giraudet	CIRED, Ecole des Ponts ParisTech	France
56677	77	35	77	35	Obligation is the EU term. Recommend changing the title. Also, it seems like this should be combined with the FIT section, since the actual program design in different countries spans a range of practices that these terms cover.	Accepted, title changed	Government of United States of America	U.S. Department of State	United States of America
60615	77	42	77	43	The sentence notes that the policy instrument has been investigated - but provides no details of the results of the studies.	Accepted, results of the studies added	Evyatar Erell	Ben-Gurion University of the Negev	Israel
10773	77	48	78	43	This discussion reminds one of the "gilets jaunes" (yellow vest) episode in France when low revenue population protested strongly agains an increase of taxes on gasolin. Is not there a strong connection between carbon taxes applied to building and to transport, respectively? The structure of the present report makes it clumsy to discuss similarities among sectors.	Accepted, yes there is a strong correlation between a crabon tax on transport and buildings. The main difference is that in trasnport theer could be alternatives, e.g. public transport, while in building the main alternative to higher eenrgyy prices is energy efficiency investments.	Philippe Waldteufel	CNRS	France
52401	77	48	78	43	The authors could make this section more comprehensive by looking at energy price/subsidy reform, which also involves raising energy prices. Just like a carbon or energy tax, energy price/subsidy reform reduces energy consumption and greenhouse gas emissions and encourages investment in energy efficiency.	Accepted, thanks, very relevant, point added	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
56679	77	48	78	43	No mention of New York State Independent Service Operator plan to incorporate a "Social Cost of Carbon" into the wholesale cost of electricity in New York State. Arguably this is tangential to taxation but is relevant to the the discussion.	Rejected. Thank you, indeed this si very relevant, but teher is not yet any pubished peer reviewed literature about this proposal.	Government of United States of America	U.S. Department of State	United States of America
72115	77	48	78	43	The different opportunities related to the use of taxes are well introduced and listed. It could have been interesting to have a table summarising the pros and cons for each possible use of the taxes.	Rejected, yoru suggestion is very good, but page budget does not allow to have this porposed table.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
74979	77		77		Consider including SWH regulations under the energy efficiency obligations section	Rejected appliance regulations included SWH is already discussed in another section.	Government of Kenya	Kenya Meteorological Service	Kenya
74981	77		78		Consider including recent development in subsidization of solar equipment in Kenya	Rejected not relevant for this section.	Government of Kenya	Kenya Meteorological Service	Kenya
52403	78	10	78	16	This is a very important point. While raising energy prices is an important climate change mitigation action, it adversely affects lower-income households and their access to basic energy services. Instead of recylcing the revenues from a carbon tax or energy subsidy reform to finance energy efficiency or invest in renewables, the first step should be to use the increased revenues to compensate lower-income households, through a cash transfer for example. This gives the lower-income households the option to invest in energy efficiency or use that cash transfer in whatever way suits them best. There is a growing strand of literature that looks at such compensation schemes, such as: Brenner et al 2007, Dennis 2016, Schaffitzel et al 2020.	Accepted, point added including one suggested reference.	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
20023	78	12			Bourgeois et al., 2019 can now be referenced as: [same authors], 2021. Lump-sum vs. energy-efficiency subsidy recycling of carbon tax revenue in the residential sector: A French assessment. Forthcoming, Ecological Economics. https://hal.archives-ouvertes.fr/hal-02073964	Accepted	Louis-Gaëtan Giraudet	CIRED, Ecole des Ponts ParisTech	France
10775	78	27	78	27	slightly what?	Accepted added word	Philippe Waldteufel	CNRS	France
27799	78	27	78	27	Sentence is incomplete.	Accepted, revised sentence	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
17073	78	44			The title should now include "new" - all of the discussed models are 10+ years old.	Accepted	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
56681	78	44	80	20	Recommend that this section first talk about ESPCs (EPCs), since they are one of the largest financing mechanisms in Asia, North America, Europe, and elsewhere. This section should also talk about green banks, wholesaling of EE loans (as happens in the mortgage market), and utility-financed programs (which are discussed earlier under obligations/FITs/EEPS). Recognize that the last category was discussed earlier but, as it is a major source of financing, it is worth mentioning here.	Accepted, section on EPC has been brought forward, uitlities programmes are mentioned here again as well as wholesaling of EE loans.	Government of United States of America	U.S. Department of State	United States of America
47519	78	44	82	45	There are no financing mechanism and new business models for implementing sufficiency policies mentioned in the text. I suggest including clear references and content on this point in this section.	Rejected. Sufficiency in principle does not require spefic financing. Some of the policies already described such as ES FiT and personal/building allowances can provide financing for sufficiency.	Gonzalo Sánchez	European Environmental Bureau	Belgium
56683	79	1	80	20	This is a robust discussion on energy efficiency financing; however, it does not include an important emerging financing solution: "efficiency as a service". According to the U.S. Department of Energy (DOE) Better Buildings Financing Navigator website (https://betterbuildingssolutioncenter.energy.gov/financing-navigator/option/efficiency-a-service#:~:text=What%20is%20Efficiency%2DAs%2DA,%2C%20construction%2C%20and%20maintenance%20costs), "Efficiency-as-a-service is a pay-for-performance, off-balance sheet financing solution that allows customers to implement energy and water efficiency projects with no upfront capital expenditure. The provider pays for project development, construction, and maintenance costs. Once a project is operational, the customer makes service payments that are based on actual energy savings or other equipment performance metrics, resulting in immediate reduced operating expenses. The energy services agreement (ESA) is the most common type of arrangement, but other models such as lumens-as-a-service and energy subscription agreements are also in use." Case studies can be accessed here: https://betterbuildingssolutioncenter.energy.gov/financing-navigator/option/efficiency-a-service#case-studies. Because this is off-balance sheet, requires no up-front investment by the customer, and savings are guaranteed, it overcomes many typical barriers to financing energy efficiency projects.	Accepted, section onESA and efficiency as a service has been added.	Government of United States of America	U.S. Department of State	United States of America
20025	79	5			Giraudet et al., 2019, can now be referenced as: Giraudet, L.-G., Petronevich, A., Faucheux, L., 2021. Differentiated green loans. Energy Policy 149, 111861. https://doi.org/10.1016/j.enpol.2020.111861	Accepted	Louis-Gaëtan Giraudet	CIRED, Ecole des Ponts ParisTech	France
56685	79	17	79	17	Text claims EIMs and EEMs "hold great potential" but, in the U.S., takeup of these specialty mortgages has been very low.	Accepted, text changed	Government of United States of America	U.S. Department of State	United States of America
56687	79	23	79	25	Recommend adding reference to Zimring et al. regarding on-bill financing: https://emp.lbl.gov/publications/financing-energy-improvements-utility	Rejected, it is an old document and not a journal publication. Some additional references have bene added.	Government of United States of America	U.S. Department of State	United States of America
17075	79	26	79	32	PACE should be referred to as an on-bill financing programme - additionally, while the specific pace model has not been used in Europe, research is underway and pilot porjects are in place throughout Europe to run similar pogrammes. There are also similar programmes in Australia and Canada.	Rejected, PACE is on-tax financing not on-bill.	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
56689	79	26	79	36	This paragraph discusses PACE and implies that it has finally taken off in the U.S.; however, while PACE may be available in the U.S., it is still very little used. A web page (not a journal article, admittedly) lists some of the pros and cons of PACE in the U.S. See: https://www.thebalance.com/pace-loans-financing-for-upgrades-4124071. Perhaps the biggest issue with PACE is discussed on this page under "Risk of Foreclosure and First Liens".	Accepted, text changed	Government of United States of America	U.S. Department of State	United States of America
5471	79	29	79	29	replace Renewables" by "low carbon sources"	Rejected, not clear what low carbon source may include beside renewabl energies	Michel SIMON	Retraité/ Pdt d'association	France
56691	79	30	79	32	Recommend adding a sentence along the lines of ""Residential PACE programs in California have been shown to increase solar PV deployment in jurisdictions that adopt these programs."" And cite the following: Kirkpatrick and Bennear (already cited) Ameli et al. - https://www.sciencedirect.com/science/article/abs/pii/S0304261917300454 Deason and Murphy - https://emp.lbl.gov/publications/assessing-pace-california-residential	Accepted, text added.	Government of United States of America	U.S. Department of State	United States of America
56693	79	32	79	32	Recommend adding ""Residential PACE has been subject to consumer protection concerns, and assessment volumes have declined notably in the past 2 years. Commercial PACE volumes and programs, however, continue to grow."" If a cite is needed regarding these claims, the only published sources involve direct data: https://www.treasurer.ca.gov/caeatfa/pace/activity.asp https://pacenation.org/pace-market-data/	Accepted, text added.	Government of United States of America	U.S. Department of State	United States of America
56695	79	32	80	14	Recommend a new paragraph at the sentence beginning "Loan guarantees ..." on line 32, as the remainder of this paragraph does not relate to PACE. In fact, this material might be best combined with the other ESCO-related material on page 80 in the paragraph beginning at line 14. Also, the discussion of ESCO project models is oversimplified. For example, at lines 35 and 36 on page 79, the claim is made that ESCO assumes full project performance risk, but this is only true of certain ESPC arrangements, not of all ESCO projects.	Accepted, text moved	Government of United States of America	U.S. Department of State	United States of America
2825	79	33	79	36	The Energy Service Company (ESCO) concept can be used in combination with Energy as a Service (EaaS) models, whereby customers pay for an energy service without having to make any upfront capital investment and energy efficiency financing credit lines	Accepted, text added.	Leonardo Barreto	Head of center "EU&International"	Austria
77319	79	41	79	47	Also in relation to page 77 (line 9-21), page 78 (line 1-43), carbon tax, emission trading system, carbon markets may be considered for treating under the title 'carbon pricing system' which covers over 22% GHG global emissions currently in aggregate. There are a number of other ETS systems in addition to Korea ETS system mentioned and other carbon market mechanisms in addition to CDM. State and Trends in carbon pricing available at https://openknowledge.worldbank.org/handle/10986/33809 is the most comprehensive source on carbon pricing including the prices realised.	Accepted, text added.	Gajanana Hegde	UNFCCC (Climate Change Secretariat)	Germany
63089	79	44	79	46	The description is outdate and does not conform to the current situation of China. With the completion of CDM project in China and the support of China in the field of green investment and financing, carbon finance business is gradually launching. It is suggested that the sentence be deleted.	Accepted, Refernce to China and CDM have been deleted	Changke WANG	National Climate Center, China Meteorological Administration	China
14717	80	14	80	20	For an overview of European initiatives see: https://www.bpie.eu/publication/benchmarking-of-promising-experiences-of-integrated-renovation-services-in-europe/	Accepted, reference considered	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
56697	80	14	80	20	The discussion of EPC (Energy Performance Contracting) is very limited. The U.S. Department of Energy maintains a very strong EPC for Federal buildings in its Energy Saving Performance Contracting (ESPC) program (https://www.energy.gov/eere/femp/energy-savings-performance-contracts-federal-agencies). There is a plethora of information on this page that could be cited. Many U.S. ESPC contractors also offer services to the private sector, with schools tending to be the primary customers in the U.S. It would also be useful to mention some examples of the "unintended behavior by building users" mentioned in the last sentence of this paragraph.	Accepted added some references highlighting the EPC trends in the US. For some examples of the "unintended behavior by building users" mentioned in the last sentence of this paragraph, please see the cited paper, unfortunately page budget does not allow to add them to the current text.	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
20027	80	18			"Giraudet et al., 2018" does not refer to the right reference. The correct one here is: Giraudet, L.-G., Houde, S., Maher, J., 2018. Moral Hazard and the Energy Efficiency Gap: Theory and Evidence. Journal of the Association of Environmental and Resource Economists 5, 755–790. https://doi.org/10.1086/698446	accepted, refernce corrected	Louis-Gaëtan Giraudet	CIRED, Ecole des Ponts ParisTech	France
16539	80	21	82	45	I suggest that 9.9.5 section movie to Chaper 6 (energy system).	Rejected, this text highlight the role of renewable energies in buildings	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17045	80	21	82	45	I suggest that 9.9.5 section movie to Chaper 6 (energy system).	Rejected, this text highlight the role of renewable energies in building	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
56699	80	21	82	45	This section seems biased toward European terminology and policies. This is particularly notable because many EU countries (starting with Germany) have moved away from FIT toward auctions and other mechanisms. The terminology should be more neutral and inclusive of global policies. Also, this section stands out because the EE finance section was not framed in terms of policies that support EE finance. This latter comment may be a simple fix to align the language across both finance sections.	Accepted, care has been taken to have a more " neutral and international" use of terminology and policy covereage. Title has been modified and now it indicated that it is about policies for the financing.	Government of United States of America	U.S. Department of State	United States of America
86655	80	22			2Section 9.9.5 discusses On site renewable energy generation as a key component for the decarbonisation of the building sector. This needs widening: - this could include on-site or (in the UK at least) near-to-site but connected by private wire generation. This allows includion of large wind up to 5MW or more - this could be a gorup fo buildings or campus (including public sector campus based institutions like hospitals, universities, prisons, or defence bases, or complex commercial or industrial sites, - it could include multi-megawatt arrays of solar mounted above car parks for EV charging, eg at airports, railways or shopping centres, for many thousands of cars on any given site. - in the UK, at several carplants, and increasingly airports, wind and solar play a combined role, providing power at different times.	Accepted, clarification added	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)
2531	80	27	80	29	Energy policies and incentives should allow for the flexibility to make it beneficial to install renewable energy (foremost PVs) supplying the building not only on site but also offsite.	Accepted, clarification added	Johanna Wikander	Company	Sweden
56701	80	27	80	29	It's no longer the case that building codes "could" include renewables. ASHRAE 90.1 has passed prescriptive on-site renewable requirements for commercial buildings. https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/90_1_2019_af_bc_cd_db_20201116.pdf This warrants mention as an important step forward for energy efficiency codes.	Accepted, already added in a previous section, abd here text modified	Government of United States of America	U.S. Department of State	United States of America
18457	80	36	80	37	'In 2014, the UK introduced the Renewable Heat Incentive (RHI) a support scheme' – specifically the Domestic RHI was launched in 2014, its Non-Domestic equivalent was launched in 2011	Accepted, suggsted clarification added	Government of United Kingdom (of Great Britain and Northern Ireland)	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
74221	80	42	82	13	This section references the use of renewable portfolio standards. Increasingly, some jurisdictions have adopted clean portfolio plans to incentivize the use of non-carbon generating electricity and not pick "winners and losers" by focusing only on wind and solar. https://www.rff.org/publications/issue-briefs/clean-energy-standards/	Accepted, we add in the US clean energy standards, though here in this section we are dealing with on-side renewable, there is no other clean on site technololy as CCS is by far too expensive,	Jeffrey Merrifield	Pillsbury Law Firm	United States of America
4997	80	44	80	44	Modify FIT into Fit	Accepted	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
25039	80				RPS is not viable for small end-users; FIT is more appropriate in such cases. Maybe this distinction should be elaborated on in this section	Accepted, text added.	Bassam AbuHijleh	The British University in Dubai	United Arab Emirates
72117	81	7	81	46	The definition of feed-in premium is missing. A short introduction could help the reader understanding the difference between feed in tariff and feed in premium.	Accepted, text added.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
4999	81	27	81	27	As for the previous comment	Accepted, text corrected	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
5001	81	29	81	29	As for the previous comment	Accepted, text corrected	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
5003	81	31	81	31	As for the previous comment	Accepted, text corrected	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
5005	82	1	82	1	As for the previous comment	Accepted, text corrected	Tiziana Susca	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy
19961	82	1	82	1	FIT' should be 'FiT'	Accepted, text corrected	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
2827	82	30	82	30	Regulatory frameworks for electricity markets are necessary to allow demand response to compete on equal footing with other forms of network flexibility and encourage new business models for the provision of flexibility to the electricity grid through demand response such as agregators, i.e. energy service providers, which can increase or reduce the electricity consumption of a group of consumers, and sell the resulting flexibility to the electricity market	Accepted, text added	Leonardo Barreto	Head of center "EU&International"	Austria
60617	82	35	82	35	development' should be either 'developed' or 'developing'.	Accepted, text corrected	Evyatar Erell	Ben-Gurion University of the Negev	Israel
72119	83	1	84	5	The different approaches for financing decarbonisation of buildings around the world are well introduced and there is a clear focus on differences between a preference based on private or public funds. Still, a general figure about the needs for funding at the global scale is missing.	SASHA	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
56703	83	7	83	7	What is "renewable energy heat"?	SASHA	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56705	83	12	83	16	Renewable heat seems a bit esoteric. Many regions of the world have limited demand for heat. In the U.S., there has been limited investment in biomass heating because (a) the criteria pollutants can exceed allowed levels, and (b) there is strong evidence that biomass without a carbon value on the land can actually increase net carbon emissions (e.g., doi: 10.1126/science.1168475). Thus, it has not become a policy thrust in the U.S. PV installation in buildings seems more relevant globally. Recommend framing this in more global terms, not in EU terms, e.g., the figure should look at all renewables in buildings (PV, geothermal, solar hot water, and renewable heat).	SASHA	Government of United States of America	U.S. Department of State	United States of America
27801	83	14	83	16	The title of Figure 9.21 should refer to the presented years (i.e. 2014-2019).	SASHA	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
14719	83	27	83	30	There is no final regulation nor political agreement on this matter, therefore the text "which regulates expenditure" is not correct.	SASHA	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
72121	83	29	83	30	The EC web site says "EU taxonomy "for" sustainable activities (not of)" ;	SASHA	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
56707	83	36	83	36	Seems out of context to mention Latvia as the only country that doesn't have private investment. Need a citation for this paragraph.	SASHA	Government of United States of America	U.S. Department of State	United States of America
56709	84	3	84	3	"Czech Republic" not "Czechia"	SASHA	Government of United States of America	U.S. Department of State	United States of America
74223	84	6	86	24	See previous comment on clean energy standards or clean energy portfolio standards rather than "renewable standards". IPCC should adopt the broader example of "clean" to maximize carbon reduction goals.	Rejected. Many countries, see EU, have specific renewable energy targets and policies. "Clean" is a too broad term and may include fossil fuels.	Jeffrey Merrifield	Pillsbury Law Firm	United States of America
2829	84	8	84	12	In EU context, besides the Energy Performance of Buildings Directive and the Energy Efficiency Directive, the EU Renewable Energy Directive 2018/2001 (Art. 15, 23, 21, 22, 24), which includes provisions for renewable energy in buildings, remewable heatng and cooling and renewable district heating, also has an impact on decarbonisation of buildings. A coordinated implementation of the 3 directives is necessary to achieve decarbonisation targets in the buidlings sector. Generally, it is necessary to exploit synergies between renewable energy policies, energy efficiency policies and policies specifically directed towards buildings ans well as consider linkages with CO2 policies such as carbon pricing to achieve decarbonisation. Developing a unified set of rules for energy efficiency and the use of renewables in the buildings sector is important to achieve decarbonisation.	Partly accepted. There are already too many references to EU policies in section 9.9. The EU RED will be mentioned in the box on EU policies on buildings in the supplementary material.	Leonardo Barreto	Head of center "EU&International"	Austria
5473	84	8	84	8	replace Renewables" by "low carbon sources"	Rejected, in this context the authors are discussing polices for renewable energies	Michel SIMON	Retraité/ Pdt d'association	France
47521	84	8	84	9	I suggest including sufficiency as a key point to develop, as it is mentioned in the same section below.	Sufficiency added in this section.	Gonzalo Sánchez	European Environmental Bureau	Belgium
5475	84	17	84	17	replace Renewables" by "low carbon sources"	Rejected, in this context the authors are discussing polices for renewable energies	Michel SIMON	Retraité/ Pdt d'association	France
56711	84	21	84	24	Need to mention other countries and jurisdictions beyond the EU.	Accepted, some other countries have been added, though most of the pubisged literature is based on European countries.	Government of United States of America	U.S. Department of State	United States of America
72123	84	22	84	24	It looks like the sentence is not finished. It might be useful to mention the renovation wave initiative and the Member States Long Term Renovation Strategy	Accepted, tthe Member States Long Term Renovation Strategy have been added, while the he renovation wave initiative is mentioned in the supplementary material.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
2831	84	23	84	24	Renewable energy and energy efficiency policies in buildings must be combined and implemented in coordination with each other and with climate policies. For example, through the inclusion of renewable energy in building codes or the implementation of minimum renewable levels in Nearly-Zero Energy Buidlings standards. In addition, financing instruments targetting both renewables and energy efficiency are necessary.	Partly accepted, the integration between EE and RE policies is discussed in another section. Here the discussion is about climate and energy policies.	Leonardo Barreto	Head of center "EU&International"	Austria
17077	84	23	84	24	Mention of LTRS/Recovery and Resilience Plans would be possible, in addition to the NECPs.	Accepted LTRS has been added, we cannot add to many details about EU policies	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
19963	84	37	84	37	Correct author name in caps	Accepted, thank you.	Keith Baker	Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University	United Kingdom (of Great Britain and Northern Ireland)
22083	84	40	84	41	"Phasing out" should be replaced by "phasing down" as per the Kigali amendment	Accepeted	Government of France	Ministère de la Transition écologique et solidaire	France
22085	84	48	84	48	The meaning of this sentense seams reversed, "in cheking" istead of "in avoiding" ?	Accepted, thank you corrected	Government of France	Ministère de la Transition écologique et solidaire	France
20349	85	10	85	15	The New York and Seoul examples need to be further developed - for instamce, it would be good to know more about the results of these policies	Accepted, some info added on NYC case, buy spave limitation do nto allow to fusrther expand the text.	Thibaud Voïta	IFRI	Germany
10001	85	12		20	This paragraph could add another goverment policy about green building to emphasized this concept. In Indonesian case, there is a new policy where a building should mplement green building concept and certification based on class and total area (buildings with gross floor area more than 5000 square meters are required to implement green building concept and certification). This policy is mandatory although still progressing in the implementation, together with the procurement in human resources as an evaluator required in green building certification.	Rejected. Unfortunately space limit impede the inclsuion of this national example. It is also difficult to find peer reviewed literature supporting this.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
16541	85	13	85	14	Please change; "In South Korea, there is ad green building certification system called G-SEED (Green Standard for Energy and Environmental Design) operated by the government."	Accepted, change done	Government of Republic of Korea	Korea Meteorological Administration (KMA)	Republic of Korea
17047	85	13	85	14	Please change; "In South Korea, there is ad green building certification system called G-SEED (Green Standard for Energy and Environmental Design) operated by the government."	Accepted, change done	Young Sun JEONG	Korea Institute of Civil Engineering and Building Technology	Republic of Korea
49719	85	18	85	20	The sentence here touches on the discussion about greenfield and brownfield development and urban expansion, a few references and insights on this discussion would be great.	Accepted, references added	Nikola Medimorec	SLOCAT Partnership on Sustainable, Low Carbon Transport	Republic of Korea
79459	85	18	85	20	The sentence here touches on the discussion about greenfield and brownfield development and urban expansion, a few references and insights on this discussion would be great.	Accepted, references added	Mark MAJOR	Partnership on Sustainable Low Carbon Transport	Spain
3319	85	21	85	32	More emphasis should be placed in the text on the role of architecture and engnieering professional bodies (e.g. American Institute of Architects) in mandating their members support energy efficiency and decarbonization of new and existing buildings. There is a significant lack of accountability for professional architects and engineers to meet and exceed standards of efficiency. For example the AIA states in their code of ethics that architects must inform clients of climate risks and opportunites for sustainability but there is no enforcement of that requirement. Hence many of the world's largest, signature, building projects are highly inefficient and have large embodied carbon footprints.	Accepted, text added	Rachel Bannon-Godfrey	Stantec	United States of America
28689	85	33	86	24	This is another location to address the question of capaicty of workforce and building contruction, retrofit, and service firms to execute on the transition in building systems discussed in the chapter.	Accepted, text added	Asa Hopkins	Synapse Energy Economics	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
17079	85	34	86	24	Although local government is once mentioned on p86 line 1, it could be stressed somewhere that the lacking capacity is even more severe on local /implementation level as on the national level, and that this is something requiring special attention.	Accepted, already prensent in the SOD at page 86, line 11-12	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
5477	86	2	86	2	replace Renewables" by "low carbon sources"	Accepted	Michel SIMON	Retraité/ Pdt d'association	France
3321	86	7	86	13	As above, if that comment is more relevant to this section.	Accepted, already inserted in the previosu section.	Rachel Bannon-Godfrey	Stantec	United States of America
56713	86	9	86	11	Are there data for national/regional energy code compliance rates?	Party accpeted, unfortunately teher is no sucha data.	Government of United States of America	U.S. Department of State	United States of America
76561	86	13	93	1	The section lacks a discussion of how policies affect embodied or life-cycle emissions of buildings. It seems that the focus is purely on energy use. There is an emerging literature. For a review and discussion, see https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change and for policy recommendations, see https://www.iea.org/reports/globalabc-roadmap-for-buildings-and-construction-2020-2050	Noted. There is existing discussion of policies affecting embodied emission and life cycle perspective in section 9.9	Edgar Hertwich	Norwegian University of Science and Technology	Norway
72125	86	26			There is a focus on the consideration of embodied energy and carbon in the introduction of the chapter 9 but the topic seems to be missing from the conclusion and from the research gap.	Accepted, text has been entered in the research gaps section referring to the recent inclusion of embodied emissions in global emissions scenarios.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
28325	86	28	86	28	Again, even in the opening of the conclusions only the 28% of emissions due to energy demand is mentioned, rather than offering the whole 39% figure or at least the 11% embodied. It almost feels as if embodied emissions are disregarded and their importance diminished. It is not a zero sum game and the two are not mutually exclusive. In fact, only understanding how one influences the other, through a whole-life approach can ensure that effective mitigation is implemented and burden-shifting avoided.	Noted, the referred section of text has been removed from the chapter since the second order draft.	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
43689	86	28	86	28	Terms, system boundaries and figures on the buildings' share of GHG emissions are not consistent in Chapter 9!	Noted: Text revised and clarified.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
61137	86	28	86	30	Mentioning only the contribution of building's energy demand to climate change seems to – once again – undermine the important contribution (11%) of embodied GHG emissions in materials to global warming.	Noted, the referred section of text has been removed from the chapter since the second order draft.	Marcella Saade	Graz University of Technology	Austria
5479	86	31	86	31	replace Renewables" by "low carbon sources"	Rejected/ reference is made to integrated solutions to buildings	Michel SIMON	Retraité/ Pdt d'association	France
22087	86	36	86	36	Aren't they both too rare and still insufficient?	Noted - conclusions were completed rewritten. Comment takent into consideration	Government of France	Ministère de la Transition écologique et solidaire	France
47523	86	42	86	45	It is not clear which innovative policies are referenced in this section.	Noted - conclusions were completed rewritten. Comment takent into consideration	Gonzalo Sánchez	European Environmental Bureau	Belgium
22089	87	4	87	5	What is "possible" ? At what cost? this sentence is unclear.	Noted - conclusions were completed rewritten. Comment takent into consideration	Government of France	Ministère de la Transition écologique et solidaire	France
64347	87	7	87	12	Introduce the potential for buildings to reuse thermal energy rejected from nearby buildings, e.g., heat rejected from air conditioning being reused for space heating by another building.	Noted - conclusions were completed rewritten. Comment takent into consideration	Peter North	Imperial College (part-time PhD student) /Calorem Ltd	United Kingdom (of Great Britain and Northern Ireland)
56715	87	8	87	8	What does "active for the building envelope" mean?	Noted - conclusions were completed rewritten. Comment takent into consideration	Government of United States of America	U.S. Department of State	United States of America
22091	87	8	87	9	buildings becoming power plants able to export energy matches with low density environement, according to feedback (with some exceptions) not in high and dense urbanisation. Urban density offers numerous other avantages (share).	Noted - conclusions were completed rewritten. Comment takent into consideration	Government of France	Ministère de la Transition écologique et solidaire	France
52405	87	25	87	27	There was not enough discussion throughout Chapter 9 about the relationship between energy sufficiency and distribution and equity.	Noted - conclusions were completed rewritten. Comment takent into consideration	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
56717	87	35	87	35	Major uncertainties also exist regarding future emissions based on different socio-economic pathways. This is why it is so important to have a comprehensive review of the literature in the first section of this chapter regarding future emissions and energy use in buildings. Based on the literature, these socio-economic factors outweigh all other uncertainties and have also limited policy decisionmaking (e.g., countries afraid to commit to targets because they do not understand the potential future emissions).	Accepted: additional scenarios have been included and the full list of scenarios assessed is included in Annex III, section 4	Government of United States of America	U.S. Department of State	United States of America
22093	87	37	87	38	Is it assessed that in a enumeration, the impact on building structure shall be placed before the impact on indoor thermal comfort ? The global report is rather focused on the last.Should the sentense be reversed ?	Noted - conclusions were completed rewritten. Comment takent into consideration	Government of France	Ministère de la Transition écologique et solidaire	France
56719	87	37	87	38	Consider broadening the statement to indoor comfort, or better yet to indoor environmental quality, as multiple impacts of climate change on individual endpoints take place through buildings, and thermal comfort is only one of them.	Noted - conclusions were completed rewritten. Comment takent into consideration	Government of United States of America	U.S. Department of State	United States of America
61139	87	37	87	44	It seems valuable to mention in this section how buildings can be interpreted as an "area of opportunity", as they permeate a number of different sectors. This might increase the complexity of a coordinated strategy to lower climate-related impacts – which brings us back to the need of not focusing solely on the energy demand.	Noted - conclusions were completed rewritten. Comment takent into consideration	Marcella Saade	Graz University of Technology	Austria
22095	87	43	87	43	Please note that it can also avoid dead ends (adaptations relates to bioclimatic conception)	Noted - conclusions were completed rewritten. Comment takent into consideration	Government of France	Ministère de la Transition écologique et solidaire	France
52407	87	45	88	3	Chapter 9 was generally missing a discussion on the cost-benefit analyses of some of the suggested climate change mitigation actions, such as efficiency or sufficiency policy actions. It seems as though the report assumes that all of these actions will be net-positive. While many studies find this to be true, several studies, such as Davis et al (2014), have found energy efficiency retrofit programs for example to be very expensive, reducing GHG emissions at a cost of over $500 per ton. A more in-depth discussion around this will add a lot of value to this chapter.	Noted - conclusions were completed rewritten. Comment takent into consideration	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
28327	88	8	88	11	Once again the only options conceived and mentioned for the "de-carbonisation of the building sector" are those linked to operational energy. In this way a huge opportunity is missed for researchers, policy-makers, decision-makers and wider stakeholders to finally reconcile the embodied and operational and start seeing buildings as a unified entity. A commentary, where this need is explained far more extensively and with plenty of high quality references, if useful, can be found at: https://doi.org/10.35241/emeraldopenres.13838.1	Noted, the conclusions section of text has been removed from the chapter since the second order draft.	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
22097	88	11	88	13	What about training of the building sector workforce? This topic has not been adressed in this chapter but a link could possibly be made.	Noted - conclusions were completed rewritten. Comment takent into consideration	Government of France	Ministère de la Transition écologique et solidaire	France
11939	88	29	88	29	From documentation, understand, conducting scientific/meta studies with data to validate as without that proceeding with refurbishing doesn't make sense.	Rejected - comment not clear	Anjali Sharma	Research, Projects and Collaborative initiatives, Delhi.	India
77129	88	29	88	34	The WGIII report rightly admits that it is far too developed-country-centric.	Accepted - huge efforts were made to correct this problem	Jim O'Brien	Expert Reviewer AR6 SOD WG1	Ireland
2835	88	30	88	30	Please add the following to Research needs: Benefits of renewable energy communities for decarbonisation, benefits of integrated district approaches for buidling renovation/new buildings to achieve decarbonisation and increase flexibility of the energy system at the neighbourhood level, how EE and RES measures can be combined and / or coordinated to achieve zero energy districts (ZEDs)	Reject - authors did add the gaps that feel should be included	Leonardo Barreto	Head of center "EU&International"	Austria

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
52409	88	31	88	45	The authors noted that most of the literature they relied on focused on countries in North America, Europe, and China. It is important to highlight this. Neverthelsss, there are papers in the literature that focused on other countries in the developing world -- whether on energy efficiency, energy demand, energy prices, and so on -- that have been missed by the authors in this chapter. A good example is the discussion on cooling, which attributed increased demand for cooling in the future to a rise in temperatures. This seems to be a European perspective on the growth in demand for cooling and its drivers.	Accepted - huge efforts were made to correct this problem	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
3323	88	35	88	37	"The contribution of indigenous knowledge in the evolvement of buildings is not well appreciated. There is a need to understand this contribution and provide methodological approaches for incorporation of indigenous knowledge." Yes, excellent point! Could it be addressed in more detail, and succeful examples given, in the many body of text for this chapter? Such an important topic, and fully in support of the increasing need to address climate justice.	Accepted, but due to lack of space it could not be extended	Rachel Bannon-Godfrey	Stantec	United States of America
30503	88	35	88	37	This point is much appreciated and agreed on the importance of indigenous knowledge. Nevertheless, acknowledging to incorporate such knowledge shall not need to wait until it reaches the kind of scientific structure of other formal knowledge. Because this kind of knowledge is not parallel across, more impromptu in nature and value-based, so it is qualitative data. We propose, it would be a good start to add even one small section for this knowledge in the AR6, so it can be further matured in future reports.	Noted	Kum Weng Yong	KW Yong Architect (Professional architect practice)	Malaysia
56721	88	35	88	37	The assessment in this chapter has concentrated primarily on Europe without necessarily doing basic searches from the published literature regarding developing countries. There may not be broad studies covering all developing countries, but a more extensive review of the existing literature (which tends be organized by individual countries) would greatly add to this chapter. There is significant research available on costs, policies, building types, and other issues in the published literature by country.	Accepted - huge efforts were made to correct this problem	Government of United States of America	U.S. Department of State	United States of America
43691	88	38	88	38	There are research gaps in the area of embodied emissions for constructed assests (roads, bridges, ...)	Rejected. Embodied emissions are now referred to in the research gaps section. Embodied emissions for constructed assets such as roads and bridges is indeed a research gap, but this would fit better in the urban and transport chapters.	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
3509	88	41	88	41	Please, add a new bullet with the following paragraph: "Literature on climate change impacts on buildings does not consider the potential carbon dioxide uptake by concrete. The cement and concrete industries have much to offer in terms of circular economy goals. There is need for further consideration of cement-based materials as carbon dioxide sinks (CEMBUREAU 2020; Sanjuán et al. 2020)." CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.A.; Argiz, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake in the Roadmap 2050 of the Spanish Cement Industry. Energies 2020, 13, 3452. https://doi.org/10.3390/en13133452	Reject - authors did add the gaps that feel should be included	Miguel Angel Sanjuán	IECA	Spain
10399	88	41	88	41	Please, add a new bullet with the following paragraph: "Literature on climate change impacts on buildings does not consider the potential carbon dioxide uptake by concrete. The cement and concrete industries have much to offer in terms of circular economy goals. There is need for further consideration of cement-based materials as carbon dioxide sinks (CEMBUREAU 2020; Sanjuán et al. 2020)." CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.A.; Argiz, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake in the Roadmap 2050 of the Spanish Cement Industry. Energies 2020, 13, 3452. https://doi.org/10.3390/en13133452	Reject - authors did add the gaps that feel should be included	Aniceto Zaragoza	Oficemen	Spain
11555	88	41	88	41	Please, add a new bullet with the following paragraph: "Literature on climate change impacts on buildings does not consider the potential carbon dioxide uptake by concrete. The cement and concrete industries have much to offer in terms of circular economy goals. There is need for further consideration of cement-based materials as carbon dioxide sinks (CEMBUREAU 2020; Sanjuán et al. 2020)." CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.A.; Argiz, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake in the Roadmap 2050 of the Spanish Cement Industry. Energies 2020, 13, 3452. https://doi.org/10.3390/en13133452	Reject - authors did add the gaps that feel should be included	PEDRO MORA PERIS	UNIVERSITY	Spain
2833	88	42	88	42	Please add the following to Research needs: Tropical architecture, hurricane-proof buildings and technologies, buildings that are robust to extreme climate events (e.g. extreme cold spells), technologies that combine energy efficiency and water conservation/water harvesting for vulnerable regions (e.g. the Caribbean), Integration of energy efficiency into climate change adaptation strategies	Reject - authors did add the gaps that feel should be included	Leonardo Barreto	Head of center "EU&International"	Austria
2837	88	42	88	42	Please add the following to Research Needs: new concepts for affordable housing for the poorest, including affordable indigenous sustainable materials, financing mechanisms, methods to keep constrution costs low while guaranteeing a minimum quality, community solutions (e.g. co-housing with common, shared spaces for cooking) and approaches to facilitate the large-scale, rapid deployment of affordable hosuing such as prefabricated buildings	Reject - authors did add the gaps that feel should be included	Leonardo Barreto	Head of center "EU&International"	Austria
11941	88	42	88	45	The lack of scientific reporting is essentially due to [a] lack of resources/ funding [b] opportunities limited to only government institutions and no additional incentive thus professional often lack the motivation to pursue. [c] Identification of professionals to be in place as currently neither they have access nor facilitated or even granted funding, considering there is no dearth of such professionals.	Noted	Anjali Sharma	Research, Projects and Collaborative initiatives, Delhi.	India
11225	88	43	88	45	Regarding quantified assessment of the mitigation potential of energy efficiency in buildings : French TSO RTE and Environmental Agency ADEME conducted together a study on emission reduction potential from buildings through retrofits, shifting to heat pumps, biomass and district heating, with a main focus on the electrification part and its precise impact on the electricity system (resilience, peak management). https://assets.rte-france.com/prod/public/2021-02/Rapport%20chauffage_RTE_Ademe.pdf The study considers two types of "renovation waves" throughout the country to 2035 : a "slow" renovation wave with shallow retrofits and a "massive" renovation wave with deep retrofits, based on the best available data on past retrofits in France (costs and performances collected by ADEME (https://www.ademe.fr/renovation-energetique-logements-etude-prix). In the case where the shift to biomass and heat pumps is combined with the "deep" renovation wave electricity demand increase is compensated by retrofits (including the installation of heat pumps) and decarbonisation of the electricity system allows 14 MtCO2/year avoided in 2035 (mid-term to 2050). If the shift to biomass and heat pumps occurs with a "slow and shallow" renovation wave, about half of the CO2 emissions reduction is lost. In all cases, a substantial rebound effect is considered in order not to overestimate energy savings and CO2 emissions reductions. An economic analysis is also conducted quantifying abatement costs from close to 0 €/tCO2 for the low-hanging fruits to about 400 €/tCO2 for the greenest transition scenario in line with government objectives.	Accepted - this comment was considering when rewriting the chapter	Bianka SHOAI-TEHRANI	RTE Réseau de Transport d'Electricité, CentraleSupelec Paris Saclay University	France
56723	88	43	88	45	Suggested reference for a guidebook with 15 case studies packed with best practices for high-performance, energy efficient buildings in India: https://eta.lbl.gov/publications/building-innovation-guide-high Singh, Reshma, Baptiste Ravache, and Dale A Sartor. Building Innovation: A Guide For High-Performance Energy Efficient Buildings In India. 2018. LBNL-2001147.	Accepted - this comment was considering when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
22099	89	5	89	5	Add two points at 9.10.2 “research gaps” : Line 5: The co-construction of new concepts and new methods to model the causality of practices numerically is essential in order to theorise, simplify and test energy consumption models. This research field is more important than ever. ; Three obstacles must be overcome to develop knowledge about the energy consumption of buildings and their effects on climate change. The first is the availability of data, as we currently do not have databases covering both the technical characteristics of material objects (from the building to transport) and energy-related behaviors. The second is the static nature of the approaches, which means that the models do not integrate the impact of the flexibility of domestic practices on consumption. The third obstacle is the disconnection between heuristic models and models on design support, which poses the crucial problem of global generic models and their inability to take into account the diversity of local contexts.	Reject - authors did add the gaps that feel should be included	Government of France	Ministère de la Transition écologique et solidaire	France
2533	89	5	89	7	The importance of climate change impacts related to energy and emissions associated with the use of materials and construction process is important for further research and scope of this or coming reports.	Accepted - this comment was considering when rewriting the chapter	Johanna Wikander	Company	Sweden
28329	89	5	89	7	While I agree with the ethos behind what is written in these lines, I would be great if the "little" literature available in such areas were considered in the chapter.	Accepted - this comment was considering when rewriting the chapter	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
56725	89	5	89	7	Suggest adding the need for research on impact on public health mediated by buildings, beyond thermal stress.	Reject - authors did add the gaps that feel should be included	Government of United States of America	U.S. Department of State	United States of America
43693	89	9	89	9	It is suggested to also address the issue of external costs (e.g. climate cost as damage cost)	Rejected - due to lack of space	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
56727	90	1	90	1	In Table 9.7, note the slightly different colors used for HVAC and appliances rows under Employment Effects and Economic Growth.	Noted - Table has been completely redone	Government of United States of America	U.S. Department of State	United States of America
72127	90	1	90	2	It is difficult to understand the link between the assessment and the measures. For instance, why the changes in construction materials have a negative impact on biodiversity? At least, it was not demonstrated in the text.	Noted - Table has been completely redone	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
11943	90	9	90	9	1. Mitigation measure of Geo-Physical may include the geo-political as it impacts through policy decisions’. 2. Technological may include access and resources for regular up gradation 3. Environmental-ecological may add availability and access to water 4. Socio-cultural- behaviour of local communities can prove to be insightful as there is ample scientific data and meta studies conducted; also public acceptance varies whereas behavioural responses are active at ground and impact the energy demand. 5. Institutional may not be limited to government sector while among the developing nations most of the development is under taken by private players and that significant volume.	Noted - Table has been completely redone	Anjali Sharma	Research, Projects and Collaborative initiatives, Delhi.	India
79131	91	23	92	21	This chapter contains many important and exciting conclusions about the scope and economics of saving energy in buildings. They deserve at least one FAQ.	Noted - limited number of FAQ could be added	Amory B. Lovins	Rocky Mountain Institute; also Adjunct Professor of Environmental & Civil Engineering, Stanford University	United States of America
9345	91	24	91	40	I think this FAQ would be more useful for readers from a variety of backgrounds, if you could explain why it is important to know what kind of emissions buildings are responsible for, what the proportions are for the three categories and how relevant they are for emissions reductions (also over time).	Accepted - text rewritten	Maike Nicolai	Helmholtz Centre Geesthacht	Germany
46481	91	24	91	32	FAQ 9.1: please give an indication of what type of these emission is the most relevant in terms of mitigation.	Nubmers of three types of GHG emissions from buildings have been added.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
4291	91	30	91	30	Add the following text “Those include the necessary emissions to extract, produce, transform, transport and install the materials and goods in their final location” REASON: It should be clear that these embodied emissions are from “cradle to gate”.	thanks, this suggestion has been adopted and revised in the FAQs	Pulido Arcas Jesús Alberto	The University of Tokyo	Japan
43695	91	30	91	30	also construction and transport processes contribute to embodied emissions	thanks, this has been improved	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
9347	91	33	91	33	Can the question be adjusted so that readers understand for what or for whom the co-benefits and trade-offs are supposed to be important? If I understand your message correctly, I would simply ask "What are the co-benefits and trade-offs..." and start the answer by explaining that even if energy savings might be small, there are large benefits.	yes, the question has been rephrased.	Maike Nicolai	Helmholtz Centre Geesthacht	Germany
9355	91	33	92	6	The way I read this FAQ, it seems to assume that current ways of building will continued to be used in the future. But can't novel materials or building styles also influence mitigation potential, benefits and trade-offs? Is this worth addressing in an FAQ, not just because it might be another reason for uncertainty, but also to point out there are options to adjust buldings in response to climate change impacts or mitigation options?	Noted - This FAQ highlights the several co-benefits and some trade-offs associated with the mitigation actions planned to be implemented in the sector of buildings. The use of novel materials is also included in this analysis and their implications are discussed in various parts of the main text.	Maike Nicolai	Helmholtz Centre Geesthacht	Germany
9349	91	40	91	40	Are you able to explain more precisely where the rebound effect lies in?	Taken into account - Text revised. Also, rebound effects are discussed in details in section 9.9.2	Maike Nicolai	Helmholtz Centre Geesthacht	Germany
9351	92	1	92	2	The sentence sounds as if climate change is the only reason for uncertainty in this context. What about human behaviour, habits, life styles, values, consumption patterns for example?	Taken into account - Text revised highlighting additional aspects of uncertainty.	Maike Nicolai	Helmholtz Centre Geesthacht	Germany
9353	92	3	92	3	What about sea level rise or increasing temperatures? If the aspects you mention are only examples, I would point this out.	Rejected - due to lack of space	Maike Nicolai	Helmholtz Centre Geesthacht	Germany
9357	92	7	92	8	I would suggest to rephrase the question to "What are effective policies and measures to decarbonise the building sector?" Does this FAQ address "complete" decarbonisation or rather emissions reductions?	The question has been rephrased. This FAQ address general measures and policies to decarbonize the building	Maike Nicolai	Helmholtz Centre Geesthacht	Germany
46485	92	7	92	21	FAQ 9.3: this FAQ uses language that can be interpreted as being policy-prescriptive. Please avoid phrases like "shall be" or "are needed".	thanks, the languanges have been rephrased.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
5481	92	11	92	11	after "on-site Renewables", add : "or low carbon enrgies from the grid."	Editorial - text revised	Michel SIMON	Retraité/ Pdt d'association	France
22101	92	11	92	11	Does on-site renewables mean renewable energies? It could read unclear	Editorial - text revised	Government of France	Ministère de la Transition écologique et solidaire	France
9359	92	15	92	15	What is the "decarbonisation target" you refer to? Where does it come from?	it means decarbonisation taget for building sector from nations	Maike Nicolai	Helmholtz Centre Geesthacht	Germany
43697	137	3	137	3	Please give here - but also elsewhere - the complete list of co-authors	Editorial - text revised	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
28697	139	19	139	20	The chapter relies very heavily on this one source, which has not yet been publicly published. 7 full-page figures, plus one additional figure, all cite this one source, which in turn relies on just one projection of different future world energy pathways (from the IEA WEO), whichis not freely available. Citing to a range of sources and other future enegry pathways would provide an illustration of the range of potential outcomes, and the different potential pathways, beyond those examined and modeled by the IEA.	Accepted: additional scenarios have been included and the full list of scenarios assessed is included in Annex III, section 4	Asa Hopkins	Synapse Energy Economics	United States of America
43699	155	1	155	1	To indicate a percentage of energy saved when using insulating materials is only useful to a limited extent. The extent of the savings is influenced by the initial situation, the climate, etc.	Noted - no more details can be given due to lack of space	Thomas Lützkendorf	Karlsruhe Institute of Technology (KIT) University	Germany
43015	155	1	158	1	We propose, to add other passive elements like Jack roofs; Roof / Attic ventilation; Small internal courtyards; Louvred walls; Walls with ventilation openings. These would encourage more reference to historical and heritage buildings, and indigenous knowledge. In our humble opinion, this shall be one of the way forward to prioritize embarking on past wisdom in mitigation.	Rejected - in that table we discuss the technologies themself and not passive vernacular architecture system,s which could be done in another entire table. In that specific case authors wanted to summarize the technological options ones. And moreover for space format of the chapter, more informatin can't be added.	Doris Toe	Universiti Teknologi Malaysia	Malaysia
44093	159	1	159	4	Table SM9.2 Technology strategies contributing to efficiency aspects, under Disadvantages of Heat Pumps add mention of the risk of increasing use of electricity in summer if policy makers lock-in reverse-cycle air-conditioners [5], and the also please note that outdoor air-source evaporators demand defrosting [6]. Under Evaporative Condensers, efficiency opportunities would be more broadly served by renaming the typology/technology as “Adiabatic/Evaporative Condensers” and noting the advantages of pre-coolers that draw ambient air through spray mist or porous humidification pads. Adiabatic evaporation of water in the entering airstream boosts the cooling capacity of direct expansion vapour-compression refrigeration, or reduces work load of the compressor. Perhaps subdivide into two typologies: keeping “Evaporative Condensers” and add “Spray Mist Adiabatic Cooling Nominally Air-Cooled Condensers” with the advantage that such can work as retrofit of existing plant and equipment [7-10]. Under “Evaporative Condensers”, presumably of the factory manufactured type, please not the risk of frost is avoidable by adiabatic precooling by drawing air through wetted porous cellulose deck media [11-14]. 5.Raynaud, M., et al., Evidence of an indirect rebound effect with reversible heat pumps: having air conditioning but not using it? Energy efficiency, 2016. 9(4): p. 847-860. 6.Zhu, J., et al., Developing a new frosting map to guide defrosting control for air-source heat pump units. Applied thermal engineering, 2015. 90: p. 782-791. 7.TCT, T.C.T., How to add adiabatic cooling to your refrigeration plant. Fitting adiabatic cooling to your air-cooled refrigeration plant will improve its efficiency and save you both energy and money. 2012, The Carbon Trust: 4th Floor, Dorset House, 27-45 Stamford Street, London SE1 9NT. 8.Jassim, N.A., Performance Enhancement of an Air Cooled Air Conditioner with Evaporative Water Mist Pre-cooling. Journal of Engineering, 2017. 23(1): p. 48-62. 9.Casvendi, B., U. Calli, and A. Hebpasli. Improving the Energy Performance of Air-Cooled Chillers with Water-Spray Mist Pre-Cooling: An Application. in International Conference “Clima. 2010. 10.Yu, F.W. and K.T. Chan, Modelling of improved energy performance of air-cooled chillers with mist pre-cooling. International Journal of Thermal Sciences, 2009. 48(4): p. 825-836. 11.Hilton, G., CASE STUDY: COMPARING EVAPORATIVE CONDENSERS WITH ADIABATICALLY ASSISTED AIR COOLED CONDENSERS. Airah Ecolibrium, 2007(October): p. 20-26. 12.López Núñez, J., et al., Study of the performance of an adiabatic cooling pad in an air cooling system. 2016. 13.Sarntichartsak, P. and S. Thepa, Modeling and experimental study on the performance of an inverter air conditioner using R-410A with evaporatively cooled condenser. Applied Thermal Engineering, 2013. 51(1): p. 597-610. 14.Dhamneya, A.K., S. Rajput, and A. Singh, Theoretical performance analysis of window air conditioner combined with evaporative cooling for	Accepted - Figure 9.12, and Table SM9.2 were modified.	Eric Peterson	University of Leeds	United Kingdom (of Great Britain and Northern Ireland)
331	161				In the first row of the table "Reduction of pollutant emissions" is more adequate.	Rejected - the authors consider that is more understable the current way	Sandro Fuzzi	ISAC CNR	Italy
14721	166	4	167	40	Please reference BPIE's updated (2020) comprehensive policy overview for the EU: A guidebook to European building policy. https://www.bpie.eu/publication/a-guidebook-to-european-building-policy-key-legislation-and-initiatives/	Accepted - text revised	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
17081	166	6	166	8	Sentence to be reframed for langauge, 50-20? and reference to be added	Accepted - text revised	Sheikh Zuhaib	Buildings Performance Institute Europe asbl (BPIE)	Germany
3625	169	0	179	0	Table SM9.5 is thorough but the point of putting stuff in a table is rather lost because of the amount of information/words contained in this table. Splitting the table over multiple pages does not help with comprehension.	Noted - Table has been completely redone	Parag Rastogi	arbnco Ltd.	United Kingdom (of Great Britain and Northern Ireland)
14723	181		181		In row1, col1'Technological scalability', Please refer BPIE (2020): Covid 19 Recovery: Investment opportunities in deep renovation in Europe. https://www.bpie.eu/wp-content/uploads/2020/05/Recovery-investments-in-deep-renovation_BPIE_2020.pdf	Noted - Table has been completely redone	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
14725	184		184		In row1, col1, Please refer BPIE (2020): Covid 19 Recovery: Investment opportunities in deep renovation in Europe. https://www.bpie.eu/wp-content/uploads/2020/05/Recovery-investments-in-deep-renovation_BPIE_2020.pdf	Noted - Table has been completely redone	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
14727	184		184		In row1, col1,Refer work from ENTRANZE project for field "Envelope improvement/costs for 2030" : https://www.entranze.eu/files/downloads/D3_3/131015_ENTRANZE_D33_Cost_Energy_Curves_Calculation_v18.pdf	Noted - Table has been completely redone	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
14729	184		184		In row1, col4, Refer BPIE (2018): Building 4 People: Quantifying the benefits of energy renovation investments in schools, offices and hospitals. https://www.bpie.eu/wp-content/uploads/2018/12/BPIE_methodology_031218.pdf	Noted - Table has been completely redone	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
14731	184		184		In row1, col2, Refer Building Renovation: A kick-starter for the EU Recovery. https://www.renovate-europe.eu/wp-content/uploads/2020/06/BPIE-Research-Layout_FINALPDF_08.06.pdf	Noted - Table has been completely redone	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
14733	184		184		In row 1, col 1, Refer scenario work from H2020 EUCalc project: https://www.european-calculator.eu/deliverables/	Noted - Table has been completely redone	Oliver Rapf	BPIE - Buildings Performance Institute Europe	Belgium
28317	188	1	211	38	not all references used in the text seem to appear in the bibliography. I am assuming this might be due to some errors showing as references not found and will be dealt with during copyediting but I thought it was worth flagging it.	Editorial - text revised	Pomponi Francesco	Edinburgh Napier University	United Kingdom (of Great Britain and Northern Ireland)
85605	191	1	191	40	First author name is missing.	Editorial - text revised	San Win	Environmental Conservation Department, Ministry of Natural Resources and Environmental Conservation	Myanmar

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
9969		7		10	It is interesting that the building sector plays a central role in the low carbon transition in the long run, as opposed to data showed in chapter 2 page 2-40.	Noted - taken into consideration when rewriting the chapter	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
9967					In general, discussion on building energy performance should be made distinct among different climates rather than among different continents or between developed and developing countries. Climate is a prominent factor influencing the energy performance such as heat insulation, and windows for cooling and ventilation. Other than the matters of indoor air quality and temperatures, building energy performance also relates to natural lighting. In terms of health co- benefit, sufficient daylight is necessary for good eyesight to conduct daily activities within the house, most importantly for studying and working which becomes more crucial during Covid-19 pandemic.	Noted - taken into consideration when rewriting the chapter	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
25041					FiT and FIT are used interchangeably in different parts of this chapter. Best to use a consistent abbreviation.	Noted - taken into consideration when rewriting the chapter	Bassam AbuHijleh	The British University in Dubai	United Arab Emirates
56729					The additional focus on energy sufficiency is valuable, but limiting the indicators to m2 per person for residential and energy use per EVA for commercial is over simplifying this important element. Behavior change is also important, such as adjusting temperatures; use of air movement, radiant measures, and localized space conditioning are also important. This is a big focus in India in particular.	Rejected: m^2 per capita is the indicator used to proxy sufficiency in resisdnetial buildings only. For non-residential buildings, due to lack of data, we couldn't proxy and assess the sufficiency impacts	Government of United States of America	U.S. Department of State	United States of America
56731					There needs to be more discussion on the role of smart appliances, equipment, and buildings on the grid. Load reduction and demand flexibility are going to be critical as more buildings and mechanical cooling are installed over the coming decades. Appliance efficiency improvements alone can't address the issue of grid capacity and intermittency issues.	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56733					There should be more emphasis on the retrofit of existing buildings, including challenges and opportunities. There needs to be more innovation in technology, retrofit practices, and business models in order to increase the annual renovation rate from 1 to 3% which is the rate the IEA says is needed to meet the Paris targets. Energiesprong was the only mention of technical approach to addressing this.	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56735					With more and more organizations, both public and private, setting science-based targets (SBTs) building decarbonization will surely become more of a priority. A recommendation to provide research and tools to support the development of decarbonization plans at an enterprise and building level would be helpful.	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56737					While ESPC (ESCOs) are mentioned in the finance section, a new business model based on Efficiency as a Service (and variations like Cooling as a Service, Buildings as a Service) are gaining momentum and they are more effective at meeting the requirements for private-sector and single building applications.	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56739					U.S. DOE published a study recently that lighting energy savings in the future would come in the commercial sector from connected lighting: https://www.energy.gov/eere/ssl/connected-lighting-systems	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56741					The chapter would be well-served by a more concentrated focus on connected buildings. It isn't mentioned in the outline, and only briefly comes up in other places without a more complete explanation of the technologies and benefits (e.g., focus on residential sector only). Connected buildings are incredibly important for renewable energy integration. Policies that provide financial incentives for connected buildings including time-of-use rates and demand response, both of which also need a more clear description.	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56743					It is not really clear what the chapter means by sufficiency. In several points, it mentions policies to limit per capita floorspace, but this seems like a policy recommendation, not a review of policies. It also, in most places, seems very theoretical -- e.g., specific policies (such as zoning for construction in dense transit corridors), for which there is relevant experience, are not mentioned. Likewise, the description on sufficiency does not appear relevant to commercial space as described. The description needs clear, evidence-based analysis on how this concept would be applied so as not to exacerbate existing problems in the developed world with lack of affordable housing. Finally, this chapter seems to gloss over the challenges sufficiency would create in developing country or poorer communities, where housing is insufficient today.	Accepted: Sufficienc concept is better defined in box 9.1. Sufficiency is relevant for all end-use sectors. However, a large part of the existing literature on sufficiency relates to housing and mobility. Sufficiency is about avoiding the over-consumption in developed countries to allow for development of teh global South within the reamining carbon budget	Government of United States of America	U.S. Department of State	United States of America
56745					In general, this chapter seems to downplay technology innovation. It focuses on passive technologies and behavioral measures, and that is not what the literature finds.	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56747					One area to emphasize is the time-varying nature of carbon intensity of the electricity grid. The same amount of electricity use will have different GHG emissions due to the varying mix of electricity sources for the grid. For example, during the mid sunny day, solar PV produces lots of electricity leading to no carbon intensity of the electric grid. So buildings are encouraged to use or move or store energy during such period of the day. This triggers the essential needs of energy flexibility of buildings for decarbonization. Also, IEA EBC has several large international collaborative projects -- e.g., EBC Annex 53, Annex 66, Annex 67, Annex 79 -- that tackled whole building energy use, occupant behavior, and energy flexibility. These efforts should be mentioned as part of the global collaboration aiming to address the building sector energy use and related GHG emissions. A few references for consideration: 1. H. Yoshino, T. Hong, N. Nord. IEA EBC Annex 53: Total Energy Use in Buildings -- Analysis and Evaluation Methods, Energy and Buildings, 2017. 2. D. Yan, T. Hong, B. Dong, et al. IEA EBC Annex 66: Definition and Simulation of occupant behavior in buildings, Energy and Buildings, 2017. 3. W. O'Brien, A. Wagner, M. Schweiker, A. Mahdavi, J. Day, M.B. Korgaard, S. Carlucci, B. Dong, F. Tahmasebi, D. Yan, T. Hong, B. Gunay, Z. Nagy, C. Miller, C. Berger. Introducing IEA EBC Annex 79: Key challenges and opportunities in the field of occupant-centric building design and operation. Building and Environment, 2020. 4. S.O. Jensen, et al. IEA EBC Annex 67 Energy Flexible Buildings. Energy and Buildings, 155:25-34, 2017. https://doi.org/10.1016/j.enbuild.2017.08.044	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56749					The key policy mechanism for building codes is adequately described for new construction in developed countries. So much more could be discussed about the enormous gap with emerging economies and the opportunity that exists to raise the level of construction practices globally through government and industry partnerships. Furthermore, the Executive Summary implies that building codes for existing buildings are widespread and effective (page 9-5, line 37), which is just not true. Most building codes for existing buildings have significantly lower compliance than new construction. Addressing existing building is essential, and this implies an effective tool in place which really is not the case.	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56751					The chapter highlights the growing demand for cooling, both behaviorally and climatically, which is very important, yet the chapter woefully addresses decarbonization of heating. The entire building envelope does not have sufficient attention applied to it. There should be significant discussion about the need for electrification through heat pumps to mitigate direct fossil fuel usage. Decarbonizing of heating in existing building through a comprehensive approach including deep energy renovation needs to be a major focus. There are pieces here and there about zero energy buildings, renovation, etc., but it does not have this as a comprehensive requirement and focus. How will all the direct carbon emissions in existing buildings be mitigated? In several areas it mentions condensing boilers (Figure 9.15) which is a marginal technology at best, but rather should mention gas thermal heat pumps as a key bridging technology for the next 30 to 40 years when electrification is not possible. Heat pump water heaters and solar thermal are also key elements to reduce direct emissions for heating water.	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
56753					The building envelope should be more prominently and comprehensively addressed. Some elements are mentioned in Figure 9.11; Section 9.2.2 is very basic; and Section 9.5.3.1 is so abstract it does not offer much value. The need for high performing windows and benefit of passive energy and daylighting is very weak in the chapter. There is not any discussion about at least the top-level elements of the building envelope such as air leakage, comprehensive attics, exterior wall insulation, low-e glass, cool roofs, yet the chapter goes into great detail about types of lighting. This is great, but with building envelope being so critical about reducing heating and cooling loads, along with the extremely inferior building stock that over 80% will still be in-service in 2050, it needs much more attention. Not just buried in the bottom of one figure or under the appliance and lighting section (9.4.3.2). If the authors lack data or resources, they can easily find comprehensive building envelope information here: https://www.iea.org/reports/technology-roadmap-energy-efficient-building-envelopes	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56755					Financing is critical and it is mentioned in several places, but not really focused on the biggest challenge. Getting buildings renovated comprehensively while decarbonizing will be key. This could be more focused on the need to finance deep energy renovation that also offers property value escalation along with electrification and decarbonization of direct carbon emissions from heating by around 80%. The financing sections seem fragmented on how policy and consumers should be focused. Do they just finance PV, or do they finance a comprehensive renovation, heat pump and PV, thus resulting in zero-carbon existing buildings and houses.	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56757					Lots of excellent work here, but needs more focus on mitigating direct fossil fuel emissions in the building sector.	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56759					In general, the chapter does not substantively address the importance of building energy efficiency and flexibility as a cost-effective power grid resource that is needed to support deep grid-scale renewable penetration with widespread electrification. Multiple studies have discussed the potential advantages of demand-side management (DSM) strategies from the buildings sector that reduce or shift the timing of electric loads, including lower capital and investment costs and reduced technical/environmental risks; previous work has also demonstrated that DSM technologies can be deployed beneficially alongside energy storage to meet grid flexibility needs in a high renewable electricity future while deferring investments in new fossil electricity generation, transmission, and distribution capacity. In the U.S., the recent FERC Order 2222 enables participation of aggregated distributed energy resources (DERs) in wholesale electricity markets, which portends an important role for DSM technologies in future electricity systems. The authors are encouraged to review relevant studies on this topic listed below and to include more direct discussion in the chapter of the role buildings can play in enabling and supporting a highly decarbonized power sector: https://www.sciencedirect.com/science/article/abs/pii/S0301421512004521?via%3Dihub https://www.sciencedirect.com/science/article/abs/pii/S0301421511000292 https://rmi.org/insight/the-economics-of-demand-flexibility-how-flexiwatts-create-quantifiable-value-for-customers-and-the-grid/ https://rmi.org/wp-content/uploads/2018/02/Insight_Brief_Demand_Flexibility_2018.pdf https://www.nrel.gov/docs/fy19osti/70630.pdf https://www.sciencedirect.com/science/article/abs/pii/S1364032115000672 https://www.nrel.gov/docs/fy13osti/52409-ES.pdf https://ieeexplore.ieee.org/document/6578160 https://www.sciencedirect.com/science/article/abs/pii/S0301421512008142 https://www.sciencedirect.com/science/article/abs/pii/S0301421508004606 https://www.sciencedirect.com/science/article/abs/pii/S1364032114005504 https://www.ferc.gov/media/ferc-order-no-2222-fact-sheet https://www.energy.gov/sites/prod/files/2019/04/f61/bto-geb_overview-4.15.19.pdf https://www.aceee.org/files/proceedings/2008/data/papers/5_297.pdf https://www.ferc.gov/sites/default/files/2020-05/06-09-demand-response_1.pdf	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56761					Since this chapter discusses both direct, indirect, and embodied emissions, it needs to be consistent with text in Chapter 6 on Energy Systems and Chapter 11 on Industry.	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56763					The linkages between buildings and transportation and between buildings and electricity grid are critical in deep decarbonization scenarios. This chapter needs more discussion on sectoral linkages and demand response.	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56765					This chapter is primarily based on IEA analysis. It should compare IEA projection with other studies in literature (at national or global level) and compare IEA analysis with scenarios used in Chapter 3 (not treat them independently).	Noted - taken into consideration when rewriting the chapter	Government of United States of America	U.S. Department of State	United States of America
56767					In addition to SDGs, it's also important to discuss job implications of building sector mitigation. Some recent analyses estimated job growth from energy efficiency investment, including building sector investment, for example, https://www.aceee.org/white-paper/2020/09/growing-greener-economy-job-and-climate-impacts-energy-efficiency-investments	Noted - This issue is discussed in section 9.8.5.3 providing specific examples. No space available for a more detailed discussion.	Government of United States of America	U.S. Department of State	United States of America
70091					Fig.9.11 – What is the percentage referring to?	Accepted: Figure revised	Cellura Maurizio	University of Palermo	Italy
70093					Table 9.2 could be integrated with more details	Noted - All figures and tables have been re-elaborated according to IPCC guidelines.	Cellura Maurizio	University of Palermo	Italy
70097					I feel that the the subparagraph 9.4.2 could use more space and in detail discussions, it could for sure become a stand-alone 9.5 paragraph	Rejected - due to lack of space	Cellura Maurizio	University of Palermo	Italy
70101					8. “Steel is the strongest building material” page 27, line 4” This is vague, I would clarify more the context;	Accepted - text revised	Cellura Maurizio	University of Palermo	Italy
70103					9. Par. 9.6.3.4 “Embodied emissions” only briefly mentions the issue of point 5. This could be expanded to be more effective	Rejected. This short section of text has been removed, but the treatment of embodied emissions in 9.6 as a whole has expanded.	Cellura Maurizio	University of Palermo	Italy
70105					I also think that the following topics and discussion points should be further clarified throughout the chapter: • Absolute and relative growing part of embodied emissions • Buildings as prosumer (producer and consumer of energy) • Involved actors, decision making process, options to act • Flow of information along supply chain • The role of the life cycle assessment in increasing the sustainability of the building sector.	Rejected. Some of the suggestions have been incorporated in the revised draft or were already present in the second order draft, such as the assessment of future embodied emissions and buildings as prosumers (section 9.9.5), and decision making progress and options to act (9.9 and 9.6)	Cellura Maurizio	University of Palermo	Italy
70107					11. It is worth mentioning that (9.54 – par. 9.7.1) the modeling of climate change effects on the building sector (either Heating and cooling and/or extreme events) is an important challenge from both a research perspective and a practitioner one	Taken into account - text revised	Cellura Maurizio	University of Palermo	Italy
86265					Figure 9.19: Is 90% of time spent indoor really representative for the world popoulation, isn't it only in cities and/or at mid-high latitudes?	Taken into account - This point in figure has been revised to better reflect reality in various parts of the world.	Sophie Szopa	LSCE	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviwer Name	Reviewer Affiliation	Reviewer Country
86701					The Buildings chapter needs a lot of work •It was much harder to read than for example the Transport chapter. Its also much longer (211 pages v 165). •It is not well signposted through the chapter about what it does when and where it leads to. It doesn't draw enough on AR5, and seems to want to distinguish itself from AR5 rather than build on it. •It is difficult to see the wood for the trees sometimes and there is too much detail in many places. Ive flagged a few places where text boxes or Graphics appear to be in the wrong place. •The section on technology is a hard read. The section policy is much more fluent but doesn't relate back well to delivering the technical potential in the previous section. •The executive summary needs to give a better road map and key findings for the chapter.	Noted - taken into consideration when rewriting the chapter	Mark Hinnells	Ricardo Energy and Environment	United Kingdom (of Great Britain and Northern Ireland)