Expert Review

of The Intergovernmental Panel on Climate Change (IPCC) 2019 *Special Report Global Warming of 1.5° C* Chapter 2, "Mitigation . . . "

By Dave White of Climate Change Truth (cctruth.org)

Summary

Chapter 2 makes false statements about equilibrium and simulations, often using vague and unscientific terms. Furthermore, the report states that the IPCC emissions solution has only a 50-66 percent chance of lowering CO_2. Planting a tree is 100% (See Chapter 2 of the report at https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter2_Low_Res.pdf)

Equilibrium

One of the most important statements in the entire chapter has no references to other published works: "Available pathways that aim for no or limited (less than 0.1°C) overshoot of 1.5°C keep GHG (Greenhouse Gas) emissions in 2030 to 25–30 GtCO2e yr−1 (25-30 billion tons of carbon dioxide emissions per year) in 2030 (interquartile range)" (Page 95, 2nd column 1st paragraph). This statement appears to say that we need to lower the emissions to reach an equilibrium of 25-30 GtCO2e yr-1, but there are no published papers to support this assertion. When I challenged the accuracy of this statement, I received the following response from an IPCC research scholar and chapter scientist of *Special Report 1.5,* Chapter 2: "Mitigation . . . "

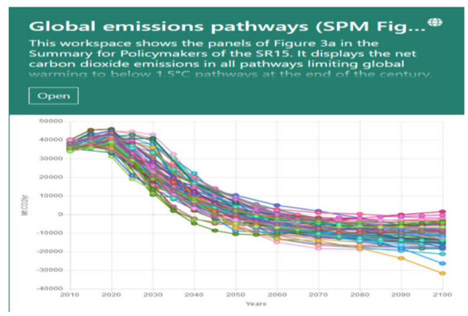
"Dear Dave,

Thank you very much for your question on the assessment of quantitative pathways in the SR15.
The statement is taken from Table 2.4, bottom section, third row, first column, rounded to multiples of 5.
The assessment in this table is based on the ensemble of quantitative pathways compiled by the IAMC and IIASA for the IPCC SR15 process (https://doi.org/10.22022/SR15/08-2018.15429). (https://data.ene.iiasa.ac.at/iamc-1.5c-explorer/#/workspaces)

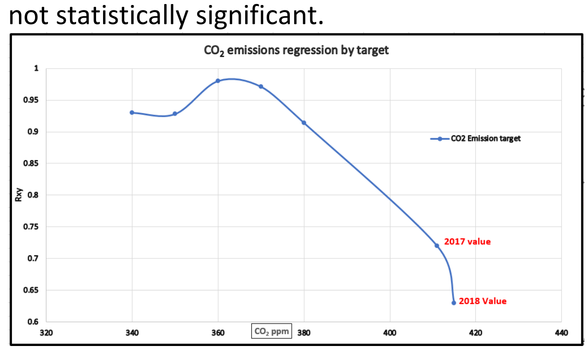
Neither the statement nor the table does make any assertion about an equilibrium; it is merely an assessment of the pathways at a specific point in time [bold added]**.**
I do hope that this clarifies your request.
The International Institute for Applied Systems Analysis (IIASA) Schlossplatz 1, A-2361 Laxenburg, Austria"

Simulations

A scenario is only as good as its inputs and constraints. This is especially true for predicting future values. The constraints for emissions must be natural emissions. These were not used; thus, wrong conclusions were obtained. It appears that IPCC is using only past data to predict future events. This explains why none of the previous IPCC predictions, including the so-called "Climate Emergency", worked or will ever yield the desired result.



I looked at their simulations and they are garbage because they don't have boundary conditions. Their simulation shows NetZero at zero to in 2050. However the IPCC and UN have started this false 12 year doomsday garbage. This is why nothing they have predicted has or will come true. Dr. Kevin Dayaratna testified at the Oregon Carbon group with the correct use of their simulations. He is correct about no relationship between emissions of CO2 and atmospheric CO2. They correlate to 363 ppm and are not statistically significant.



Use of Unscientific Terms

The document uses the unscientific terms *highly* (or otherwise) *likely* six times, *unlikely* three times, and *highly* (or otherwise) *confident* sixty-two times. In every case, percent probability must be used.

Net Zero

The document uses a term *Net Zero* with no definition.

Rare Use of Probability Page 100 top.

"For limiting global warming to below 2°C **with at least 66% probability** [bold added] CO2 emissions are projected to decline by about 25% by 2030 in most pathways (10–30% interquartile range) and reach net zero around 2070 (2065–2080 interquartile range).1 {2.2, 2.3.3, 2.3.5, 2.5.3, Cross-Chapter Boxes 6 in Chapter 3 and 9 in Chapter 4, 4.3.7} (p 95, 2nd column 1st paragraph).

"No pathways were available that achieve a greater than **50-66% probability of limiting warming below 1.5° C** [bold added] during the entire 21st century based on the MAGICC model projections" (see p. 100, Table 2.1). The probability is actually zero because the minimum residence time is hundreds of years.

(No business would spend such a significant amount of money (2.8 trillion dollars already spent worldwide) on a project with only a 50-66% chance of success.) Their probability is actually zero because the minimum residence time for atmospheric CO_2 is more than 200 years. (IPCC 2003) Some scientists say it is 300-500 years now.

Table 2.1 | Classification of pathways that this chapter draws upon, along with the number of available pathways in each class. The definition of each class is based on probabilities derived from the MAGICC model in a setup identical to AR5 WGIII (Clarke et al., 2014), as detailed in Supplementary Material 2.SM.1.4.

Pathway group	Pathway Class	Pathway Selection Criteria and Description	Number of Scenarios	Number of Scenarios
1.5°C or 1.5°C-consistent**	Below-1.5°C	Pathways limiting peak warming to below 1.5°C during the entire 21st century with 50–66% likelihood*	9	90
	1.5°C-low-OS	Pathways limiting median warming to below 1.5°C in 2100 and with a 50–67% probability of temporarily overshooting that level earlier, generally implying less than 0.1°C higher peak warming than Below-1.5°C pathways	44	
	1.5°C-high-OS	Pathways limiting median warming to below 1.5°C in 2100 and with a greater than 67% probability of temporarily overshooting that level earlier, generally implying 0.1–0.4°C higher peak warming than Below-1.5°C pathways	37	
2°C or 2°C-consistent	Lower-2°C	Pathways limiting peak warming to below 2°C during the entire 21st century with greater than 66% likelihood	74	132
	Higher-2°C	Pathways assessed to keep peak warming to below 2°C during the entire 21st century with 50–66% likelihood	58	

* No pathways were available that achieve a greater than 66% probability of limiting warming below 1.5°C during the entire 21st century based on the MAGICC model projections.

** This chapter uses the term 1.5°C-consistent pathways to refer to pathways with no overshoot, with limited (low) overshoot, and with high overshoot. However, the Summary for Policymakers focusses on pathways with no or limited (low) overshoot.

Section 2.3.5 (Where 45% reductions in emissions came from) "In contrast 1.5°C pathways with limited overshoot available to this assessment show an interquartile range of about 26-31 median 28 $GTCO_2e^{-1}$ in 2030." **This is from a simulation not based in reality!**

Citation

"This chapter should be cited as: Rogelj, J., D. Shindell, K. Jiang, S. Fifita, P. Forster, V. Ginzburg, C. Handa, H. Kheshgi, S. Kobayashi, E. Kriegler, L. Mundaca, R. Séférian, and M.V.Vilariño, 2018: Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press" (p. 93)

Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development — Chapter 2

Executive Summary

This chapter assesses mitigation pathways consistent with limiting warming to 1.5°C above pre-industrial levels. In doing so, it explores the following key questions: What role do CO_2 and non-CO_2 emissions play? {2.2, 2.3, 2.4, 2.6} To what extent do 1.5°C pathways involve overshooting and returning below 1.5°C during the 21st century? {2.2, 2.3} What are the implications for transitions in energy, land use and sustainable development? {2.3, 2.4, 2.5} How do policy frameworks affect the ability to limit warming to 1.5°C? {2.3, 2.5} What are the associated knowledge gaps? {2.6}

The assessed pathways describe integrated, quantitative evolutions of all emissions over the 21st century associated with global energy and land use and the world economy. The assessment is contingent upon available integrated assessment literature and model assumptions, and is complemented by other studies with different scope, for example, those focusing on individual sectors. In recent years, integrated mitigation studies have improved the characterizations of mitigation pathways. However, limitations remain, as climate damages, avoided impacts, or societal co-benefits of the modelled transformations remain largely unaccounted for, while concurrent rapid technological changes, behavioural aspects, and uncertainties about input data present continuous challenges. (*high confidence*) {2.1.3, 2.3, 2.5.1, 2.6, Technical Annex 2}

The Chances of Limiting Warming to 1.5°C and the Requirements for Urgent Action

Pathways consistent with 1.5°C of warming above pre-industrial levels can be identified under a range of assumptions about economic growth, technology developments and lifestyles. However, lack of global cooperation, lack of governance of the required energy and land transformation, and increases in resource-intensive consumption are key impediments to achieving 1.5°C pathways. Governance challenges have been related to scenarios with high inequality and high population growth in the 1.5°C pathway literature. {2.3.1, 2.3.2, 2.5}

Under emissions in line with current pledges under the Paris Agreement (known as Nationally Determined Contributions, or NDCs), global warming is expected to surpass 1.5°C above pre-industrial levels, even if these pledges are supplemented with very challenging increases in the scale and ambition of mitigation after 2030 (*high confidence*). This increased action would need to achieve net zero CO_2 emissions in less than 15 years. Even if this is achieved, temperatures would only be expected to remain below the 1.5°C threshold if the actual geophysical response ends up being towards the low end of the currently estimated uncertainty range. Transition challenges as well as identified trade-offs can be reduced if global emissions peak before 2030 and marked emissions reductions compared to today are already achieved by 2030. {2.2, 2.3.5, Cross-Chapter Box 11 in Chapter 4}

Limiting warming to 1.5°C depends on greenhouse gas (GHG) emissions over the next decades, where lower GHG emissions in 2030 lead to a higher chance of keeping peak warming to 1.5°C (*high confidence*). Available pathways that aim for no or limited (less than 0.1°C) overshoot of 1.5°C keep GHG emissions in 2030 to 25–30 GtCO2e yr^{-1} in 2030 (interquartile range). This contrasts with median estimates for current unconditional NDCs of 52–58 $GtCO_2e$ yr^{-1} in 2030. Pathways that aim for limiting warming to 1.5°C by 2100 after a temporary temperature overshoot rely on large-scale deployment of carbon dioxide removal (CDR) measures, which are uncertain and entail clear risks. In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO_2 emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net zero around 2050 (2045–2055 interquartile range). For limiting global warming to below 2°C with at least 66% probability CO_2 emissions are projected to decline by about 25% by 2030 in most pathways (10–30% interquartile range) and reach net zero around 2070 (2065–2080 interquartile range).[1] {2.2, 2.3.3, 2.3.5, 2.5.3, Cross-Chapter Boxes 6 in Chapter 3 and 9 in Chapter 4, 4.3.7}

Limiting warming to 1.5°C implies reaching net zero CO_2 emissions globally around 2050 and concurrent deep reductions in emissions of non-CO_2 forcers, particularly methane (*high confidence*). Such mitigation pathways are characterized by energy-demand reductions, decarbonization of electricity and other fuels, electrification of energy end use, deep reductions in agricultural emissions, and some form of CDR with carbon storage on land or sequestration in geological reservoirs. Low energy demand and low demand for land- and GHG-intensive consumption goods facilitate limiting warming to as close as possible to 1.5°C. {2.2.2, 2.3.1, 2.3.5, 2.5.1, Cross-Chapter Box 9 in Chapter 4}.

In comparison to a 2°C limit, the transformations required to limit warming to 1.5°C are qualitatively similar but more pronounced and rapid over the next decades (*high confidence*). 1.5°C implies very ambitious, internationally cooperative policy environments that transform both supply and demand (*high confidence*). {2.3, 2.4, 2.5}

Policies reflecting a high price on emissions are necessary in models to achieve cost-effective 1.5°C pathways (*high confidence*). Other things being equal, modelling studies suggest the global average discounted marginal abatement costs for limiting warming to 1.5°C being about 3–4 times higher compared to 2°C over the 21st century, with large variations across models and socio-economic and policy assumptions. Carbon pricing can be imposed directly or implicitly by regulatory policies. Policy instruments, like technology policies or performance standards, can complement explicit carbon pricing in specific areas. {2.5.1, 2.5.2, 4.4.5}

Limiting warming to 1.5°C requires a marked shift in investment patterns (*medium confidence*). Additional annual average energy-related investments for the period 2016 to 2050 in pathways limiting warming to 1.5°C compared to pathways without new climate policies beyond those in place today (i.e., baseline) are estimated to be around

[1] Kyoto-GHG emissions in this statement are aggregated with GWP-100 values of the IPCC Second Assessment Report.

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with a large fraction of this coal use combined with carbon capture and storage (CCS). From 2020 to 2050 the primary energy supplied by oil declines in most pathways (−39 to −77% interquartile range). Natural gas changes by −13% to −62% (interquartile range), but some pathways show a marked increase albeit with widespread deployment of CCS. The overall deployment of CCS varies widely across 1.5°C pathways with no or limited overshoot, with cumulative CO_2 stored through 2050 ranging from zero up to 300 $GtCO_2$ (minimum–maximum range), of which zero up to 140 $GtCO_2$ is stored from biomass. Primary energy supplied by bioenergy ranges from 40–310 EJ yr^{-1} in 2050 (minimum-maximum range), and nuclear from 3–66 EJ yr^{-1} (minimum–maximum range). These ranges reflect both uncertainties in technological development and strategic mitigation portfolio choices. {2.4.2}

1.5°C pathways with no or limited overshoot include a rapid decline in the carbon intensity of electricity and an increase in electrification of energy end use *(high confidence)*. By 2050, the carbon intensity of electricity decreases to −92 to +11 gCO_2 MJ^{-1} (minimum–maximum range) from about 140 gCO_2 MJ^{-1} in 2020, and electricity covers 34–71% (minimum–maximum range) of final energy across 1.5°C pathways with no or limited overshoot from about 20% in 2020. By 2050, the share of electricity supplied by renewables increases to 59–97% (minimum–maximum range) across 1.5°C pathways with no or limited overshoot. Pathways with higher chances of holding warming to below 1.5°C generally show a faster decline in the carbon intensity of electricity by 2030 than pathways that temporarily overshoot 1.5°C. {2.4.1, 2.4.2, 2.4.3}

Transitions in global and regional land use are found in all pathways limiting global warming to 1.5°C with no or limited overshoot, but their scale depends on the pursued mitigation portfolio *(high confidence)*. Pathways that limit global warming to 1.5°C with no or limited overshoot project a 4 million km² reduction to a 2.5 million km2 increase of non-pasture agricultural land for food and feed crops and a 0.5–11 million km² reduction of pasture land, to be converted into 0-6 million km² of agricultural land for energy crops and a 2 million km² reduction to 9.5 million km² increase in forests by 2050 relative to 2010 *(medium confidence)*. Land-use transitions of similar magnitude can be observed in modelled 2°C pathways *(medium confidence)*. Such large transitions pose profound challenges for sustainable management of the various demands on land for human settlements, food, livestock feed, fibre, bioenergy, carbon storage, biodiversity and other ecosystem services *(high confidence)*. {2.3.4, 2.4.4}

unscientific terms. must be probability

Demand-Side Mitigation and Behavioural Changes

Demand-side measures are key elements of 1.5°C pathways. Lifestyle choices lowering energy demand and the land- and GHG-intensity of food consumption can further support achievement of 1.5°C pathways *(high confidence)*. By 2030 and 2050, all end-use sectors (including building, transport, and industry) show marked energy demand reductions in modelled 1.5°C pathways, comparable and beyond those projected in 2°C pathways. Sectoral models support the scale of these reductions. {2.3.4, 2.4.3, 2.5.1}

Links between 1.5°C Pathways and Sustainable Development

Choices about mitigation portfolios for limiting warming to 1.5°C can positively or negatively impact the achievement of other societal objectives, such as sustainable development *(high confidence)*. In particular, demand-side and efficiency measures, and lifestyle choices that limit energy, resource, and GHG-intensive food demand support sustainable development *(medium confidence)*. Limiting warming to 1.5°C can be achieved synergistically with poverty alleviation and improved energy security and can provide large public health benefits through improved air quality, preventing millions of premature deaths. However, specific mitigation measures, such as bioenergy, may result in trade-offs that require consideration. {2.5.1, 2.5.2, 2.5.3}

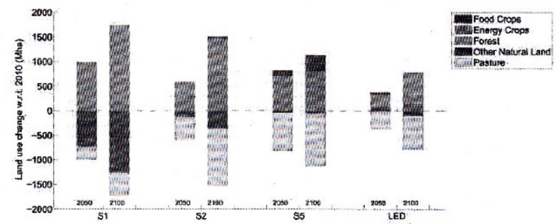

Figure 2.11 | Land-use changes in 2050 and 2100 in the illustrative 1.5°C-consistent pathway archetypes (Fricko et al., 2017; Fujimori, 2017; Kriegler et al., 2017; Grubler et al., 2018; Rogelj et al., 2018). Changes in land for food crops, energy crops, forest, pasture and other natural land are shown, compared to 2010.

2.3.5 Implications of Near-Term Action in 1.5°C Pathways

Less CO_2 emission reductions in the near term would require steeper and deeper reductions in the longer term in order to meet specific warming targets afterwards (Riahi et al., 2015; Luderer et al., 2016a). This is a direct consequence of the quasi-linear relationship between the total cumulative amount of CO_2 emitted into the atmosphere and global mean temperature rise (Matthews et al., 2009; Zickfeld et al., 2009; Collins et al., 2013; Knutti and Rogelj, 2015). Besides this clear geophysical trade-off over time, delaying GHG emissions reductions over the coming years also leads to economic and institutional lock-in into carbon-intensive infrastructure, that is, the continued investment in and use of carbon-intensive technologies that are difficult or costly to phase-out once deployed (Unruh and Carrillo-Hermosilla, 2006; Jakob et al., 2014; Erickson et al., 2015; Steckel et al., 2015; Seto et al., 2016; Michaelowa et al., 2018). Studies show that to meet stringent climate targets despite near-term delays in emissions reductions, models prematurely retire carbon-intensive infrastructure, in particular coal without CCS (Bertram et al., 2015a; Johnson et al., 2015). The AR5 reports that delaying mitigation action leads to substantially higher rates of emissions reductions afterwards, a larger reliance on CDR technologies in the long term, and higher transitional and long-term economic impacts (Clarke et al., 2014). The literature mainly focuses on delayed action until 2030 in the context of meeting a 2°C goal (den Elzen et al., 2010; van Vuuren and Riahi, 2011; Kriegler et al., 2013b; Luderer et al., 2013, 2016a; Rogelj et al., 2013b; Riahi et al., 2015; OECD/IEA and IRENA, 2017). However, because of the smaller carbon budget consistent with limiting warming to 1.5°C and the absence of a clearly declining long-term trend in global emissions to date, these general insights apply equally, or even more so, to the more stringent mitigation context of 1.5°C-consistent pathways. This is further supported by estimates of committed emissions due to fossil fuel-based infrastructure (Seto et al., 2016; Edenhofer et al., 2018).

All available 1.5°C pathways that explore consistent mitigation action from 2020 onwards peak global Kyoto-GHG emissions in the next decade and already decline Kyoto-GHG emissions to below 2010 levels by 2030. The near-term emissions development in these pathways can be compared with estimated emissions in 2030 implied by the Nationally Determined Contributions (NDCs) submitted by Parties to the Paris Agreement (Figure 2.12). Altogether, the unconditional (conditional) NDCs are assessed to result in global Kyoto-GHG emissions on the order of 52–58 (50–54) GtCO2e yr−1 in 2030 (e.g., den Elzen et al., 2016; Fujimori et al., 2016; UNFCCC, 2016; Rogelj et al., 2017; Rose et al., 2017b; Benveniste et al., 2018; Vrontisi et al., 2018; see Cross-Chapter Box 11 in Chapter 4 for detailed assessment). In contrast, 1.5°C pathways with limited overshoot available to this assessment show an interquartile range of about 26–31 (median 28) $GtCO_2e$ yr^{-1} in 2030[5] (Table 2.4, Section 2.3.3). Based on these ranges, this report assesses the emissions gap for a two-in-three chance of limiting warming to 1.5°C to be 26 (19–29) and 28 (22–33) $GtCO_2e$ (median and interquartile ranges) for conditional and unconditional NDCs, respectively (Cross-Chapter Box 11, applying GWP-100 values from the IPCC Second Assessment Report). From simulation

The later emissions peak and decline, the more CO_2 will have accumulated in the atmosphere. Peak cumulated CO_2 emissions – and consequently peak temperatures – increase with higher 2030 emissions levels (Figure 2.12). Current NDCs (Cross-Chapter Box 11 in Chapter 4) are estimated to lead to CO_2 emissions of about 400–560 $GtCO_2$ from 2018 to 2030 (Rogelj et al., 2016a). Available 1.5°C- and 2°C-consistent pathways with 2030 emissions in the range estimated

[5] Note that aggregated Kyoto-GHG emissions implied by the NDCs from Cross-Chapter Box 11 in Chapter 4 and Kyoto-GHG ranges from the pathway classes in Chapter 2 are only approximately comparable, because this chapter applies GWP-100 values from the IPCC Fourth Assessment Report while the NDC Cross-Chapter Box 11 applies GWP-100 values from the IPCC Second Assessment Report. At a global scale, switching between GWP-100 values of the Second to the Fourth IPCC Assessment Report would result in an increase in estimated aggregated Kyoto-GHG emissions of no more than about 3% in 2030 (UNFCCC, 2016).

Table 2.1 | Classification of pathways that this chapter draws upon, along with the number of available pathways in each class. The definition of each class is based on probabilities derived from the MAGICC model in a setup identical to AR5 WGIII (Clarke et al., 2014), as detailed in Supplementary Material 2.SM.1.4.

Pathway group	Pathway Class	Pathway Selection Criteria and Description	Number of Scenarios	Number of Scenarios
1.5°C or 1.5°C-consistent**	Below-1.5°C	Pathways limiting peak warming to below 1.5°C during the entire 21st century with 50–66% likelihood*	9	90
	1.5°C-low-OS	Pathways limiting median warming to below 1.5°C in 2100 and with a 50–67% probability of temporarily overshooting that level earlier, generally implying less than 0.1°C higher peak warming than Below-1.5°C pathways	44	
	1.5°C-high-OS	Pathways limiting median warming to below 1.5°C in 2100 and with a greater than 67% probability of temporarily overshooting that level earlier, generally implying 0.1–0.4°C higher peak warming than Below-1.5°C pathways	37	
2°C or 2°C-consistent	Lower-2°C	Pathways limiting peak warming to below 2°C during the entire 21st century with greater than 66% likelihood	74	132
	Higher-2°C	Pathways assessed to keep peak warming to below 2°C during the entire 21st century with 50–66% likelihood	58	

* No pathways were available that achieve a greater than 66% probability of limiting warming below 1.5°C during the entire 21st century based on the MAGICC model projections.

** This chapter uses the term 1.5°C-consistent pathways to refer to pathways with no overshoot, with limited (low) overshoot, and with high overshoot. However, the Summary for Policymakers focusses on pathways with no or limited (low) overshoot.

actually Ø because minimum residence time of CO_2 is more than 200 years IPCC 2003

ranging from very rapid and deep near-term decreases, facilitated by efficiency and demand-side measures that lead to limited CDR requirements, to relatively slower but still rapid emissions reductions that lead to a temperature overshoot and necessitate large CDR deployment later in the century (Section 2.3).

2.1.4 Utility of Integrated Assessment Models (IAMs) in the Context of this Report

IAMs lie at the basis of the assessment of mitigation pathways in this chapter, as much of the quantitative global scenario literature is derived with such models. IAMs combine insights from various disciplines in a single framework, resulting in a dynamic description of the coupled energy–economy–land-climate system that cover the largest sources of anthropogenic greenhouse gas (GHG) emissions from different sectors. Many of the IAMs that contributed mitigation scenarios to this assessment include a process-based description of the land system in addition to the energy system (e.g., Popp et al., 2017), and several have been extended to cover air pollutants (Rao et al., 2017) and water use (Hejazi et al., 2014; Fricko et al., 2016; Mouratiadou et al., 2016). Such integrated pathways hence allow the exploration of the whole-system transformation, as well as the interactions, synergies, and trade-offs between sectors, and, increasingly, questions beyond climate mitigation (von Stechow et al., 2015). The models do not, however, fully account for all constraints that could affect realization of pathways (see Chapter 4).

Section 2.3 assesses the overall characteristics of 1.5°C pathways based on fully integrated pathways, while Sections 2.4 and 2.5 describe underlying sectoral transformations, including insights from sector-specific assessment models and pathways that are not derived from IAMs. Such models provide detail in their domain of application and make exogenous assumptions about cross-sectoral or global factors. They often focus on a specific sector, such as the energy (Bruckner et al., 2014; IEA, 2017a; Jacobson, 2017; OECD/IEA and IRENA, 2017), buildings (Lucon et al., 2014) or transport (Sims et al., 2014) sector, or a specific country or region (Giannakidis et al., 2018). Sector-specific pathways are assessed in relation to integrated pathways because they cannot be directly linked to 1.5°C by themselves if they do not extend to 2100 or do not include all GHGs or aerosols from all sectors.

AR5 found sectoral 2°C decarbonization strategies from IAMs to be consistent with sector-specific studies (Clarke et al., 2014). A growing body of literature on 100%-renewable energy scenarios has emerged (e.g., see Creutzig et al., 2017; Jacobson et al., 2017), which goes beyond the wide range of IAM projections of renewable energy shares in 1.5°C and 2°C pathways. While the representation of renewable energy resource potentials, technology costs and system integration in IAMs has been updated since AR5, leading to higher renewable energy deployments in many cases (Luderer et al., 2017; Pietzcker et al., 2017), none of the IAM projections identify 100% renewable energy solutions for the global energy system as part of cost-effective mitigation pathways (Section 2.4.2). Bottom-up studies find higher mitigation potentials in the industry, buildings, and transport sectors in 2030 than realized in selected 2°C pathways from IAMs (UNEP 2017), indicating the possibility to strengthen sectoral decarbonization strategies until 2030 beyond the integrated 1.5°C pathways assessed in this chapter (Luderer et al., 2018).

Detailed, process-based IAMs are a diverse set of models ranging from partial equilibrium energy–land models to computable general equilibrium models of the global economy, from myopic to perfect foresight models, and from models with to models without endogenous technological change (Supplementary Material 2.SM.1.2). The IAMs used in this chapter have limited to no coverage of climate impacts. They typically use GHG pricing mechanisms to induce emissions reductions and associated changes in energy and land uses consistent with the imposed climate goal. The scenarios generated by these models are defined by the choice of climate goals and assumptions about near-term climate policy developments. They are also shaped by assumptions about mitigation potentials and technologies as well as baseline developments such as, for example, those represented by