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Promising climate progress from net-zero ambitions to the Paris Agreement goal

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Isabela S. Tagomori[1] ✉, Fabio A. Diuana[2], Luiz Bernardo Baptista[2], Christoph Bertram[3,4], Ioannis Dafnomilis[1], Laurent Drouet[5,6,7], Florian Fosse[8], Dimitris Fragkiadakis[9], Oliver Fricko[10], Elena Hooijschuur[1], Gokul Iyer[3], Jarmo S. Kikstra[10], Volker Krey[10], Gunnar Luderer[4], Yang Ou[11,12], Lara Aleluia Reis[5,6,7], Oliver Richters[4], Pedro R. R. Rochedo[13], Zoi Vrontisi[9], Matthias Weitzel[8], Matthew Zwerling[3], Bas van Ruijven[10], Roberto Schaeffer[2] & Detlef van Vuuren[1,14]

Climate targets require strong commitments from countries to be achieved. Using a multi-model analysis, we show that current net-zero pledges bring the world closer to a well-below 2 °C pathway, but an emission gap remains. Increasing ambition will be crucial: expanding the global coverage of net-zero pledges and speeding up action increases consistency with the Paris Agreement (1.5–2.0 °C range in model mean). However, reaching the 1.5 °C goal without overshoot seems increasingly unlikely. While net-zero pledges help reduce carbon-intensive energy sources, domestic policies aligned with strong climate commitments are needed to reduce the reliance on fossil fuels and increase renewable energy capacity. Our scenarios show that emission reductions are driven by gains in energy efficiency, a strong phase-down of coal use and the electrification of sectors such as transport and heavy industry.

The Paris Agreement aims to limit the increase of global mean temperature to well below 2 °C, and to pursue efforts to stay below 1.5 °C. The agreement requires that countries regularly formulate climate action plans through Nationally Determined Contributions (NDCs), outlining their emission targets and policy actions. Assessments of the GHG emissions gap have been conducted for over a decade, with the first United Nations (UN) Environment Programme Emissions Gap Report dating back to 2010[1]. So far, multiple studies have shown that, when put together, the NDCs fall short of achieving the Paris Agreement goal[2–10]. However, since the 26th UN Climate Change Conference of the Parties (COP), which took place in Glasgow in 2021, many countries have also set long-term goals—notably, net-zero emissions pledges—including major emitters such as China, India, Brazil and the European Union (EU) (a full list of net-zero pledges can be found in Supplementary Table 3). These pledges have been evaluated in studies that do not use integrated assessment models (IAMs)[8–10] and in studies focusing on a single model[7,11,12]. Nevertheless, up-to-date, robust multi-model assessments of the effectiveness of these ambitions[13]

[1]PBL Netherlands Environmental Assessment Agency, The Hague, the Netherlands. [2]Centre for Energy and Environmental Economics (Cenergia), Energy Planning Program (PPE), COPPE, Universidade Federal do Rio de Janeiro, Centro de Tecnologia, Rio de Janeiro, Brazil. [3]Center for Global Sustainability (CGS), School of Public Policy, University of Maryland, College Park, MD, USA. [4]PIK Potsdam Institute for Climate Impact Research, Potsdam, Germany. [5]RFF-CMCC European Institute on Economics and the Environment, Milan, Italy. [6]CMCC Foundation—Euro-Mediterranean Center on Climate Change, Milan, Italy. [7]CENSE—Center for Environmental and Sustainability Research & CHANGE—Global Change and Sustainability Institute, NOVA School of Science and Technology, NOVA University Lisbon, Caparica, Portugal. [8]Joint Research Centre (JRC), European Commission, Seville, Spain. [9]E3-Modelling SA, Athens, Greece. [10]IIASA International Institute for Applied Systems Analysis, Laxenburg, Austria. [11]College of Environmental Sciences and Engineering, Peking University, Beijing, China. [12]Institute of Carbon Neutrality, Peking University, Beijing, China. [13]Research and Innovation Center on CO2 and Hydrogen (RICH Center) and Department of Management Science and Engineering, Khalifa University, Abu Dhabi, UAE. [14]Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, the Netherlands. ✉e-mail: isabela.tagomori@pbl.nl

Table 1 | Description of scenarios (including action after 2030)

	Scenario description	Incremental changes between scenarios
Current policies	Current policies are defined as currently implemented policies adopted by governments (through legislation) or non-binding targets backed by effective policy instruments. Ambitions and pledges (for example, NDCs and net-zero pledges) are not considered current policies and are, therefore, not included in this scenario. After 2030, the ambition levels remain at least constant until 2100. The cut-off for policy inclusion is January 2023, based on the Climate Policy Database[30] and the Climate Policy Modelling Protocol (CPMP)[31].	
NDCs	The NDCs scenario builds on the current policies scenario and assumes the achievement of the NDCs, unconditional and conditional, in 2030. The ambition levels reached in the target year remain at least constant throughout the rest of the century. Further information can be found in the CPMP[31] and Supplementary Information.	In addition to currently implemented policies, countries' NDC pledges are also taken into account when constructing the emissions pathways.
LTS	The LTS scenario builds on the NDCs scenario, following the NDC pledges until 2030. After 2030, the scenario assumes the implementation of all announced net-zero targets (countries that do not yet have a net-zero target keep the ambition levels of their NDC). Gas coverage follows specification provided by the countries (for example, if a country set their target in terms of CO_2 emissions or GHG emissions), as detailed in the Supplementary Information.	After 2030, countries that have pledged net-zero emissions reach their goal in their respective net-zero years.
Expanded LTS	The expanded LTS scenario assumes the implementation of all announced net-zero targets and expands net-zero coverage to all countries. Countries can overachieve their 2030 NDC target (mitigation efforts surpass NDC targets) if this is cost-effective for reaching the long-term neutrality target. For expanding the net-zero coverage, countries that have not currently established a net-zero strategy assume a net-zero target year based on the net-zero target year of countries with a similar income level.	Countries can be more ambitious than their NDCs (overachieving their 2030 targets), and net-zero emissions targets are assigned to all countries.
Accelerated LTS	The accelerated LTS scenario builds on the expanded LTS scenario, but net-zero years should be reached 5–10 years earlier than the official pledges. For example, the EU's net-zero GHG pledge should be reached in 2040 rather than 2050.	Countries reach net-zero emissions 5–10 years earlier than in expanded LTS.

All scenarios are based on socioeconomic assumptions from middle-of-the-road Shared Socioeconomic Pathway 2[32].

and of ways to further strengthen them are scarce but necessary[14]. In this study, we perform a multi-model intercomparison exercise using eight state-of-the-art IAMs (COFFEE, GCAM, GEM-E3, IMAGE, MESSAGEix, POLES, REMIND and WITCH[15]) to explore the consistency of the announced net-zero targets with the Paris Agreement, as well as opportunities to strengthen them. We contribute to the literature by exploring the effectiveness of these ambitions in a systematic way, using a range of different modelling approaches (from cost optimization to recursive-dynamic simulation to general equilibrium models). These models allow us to compare net-zero targets and their consistency with global pathways limiting global temperature to 1.5 °C or 2 °C warming levels. Thus, we provide insight into the benefits of expanding net-zero coverage worldwide and accelerating action (earlier mitigation), identifying effective mitigation options (looking into sectors and regions) and the overall costs of mitigation. Furthermore, we explore the implementation of net-zero targets in light of the outcomes of the first global stocktake[16], also known as the 'UAE Consensus', which was concluded in 2023 during the 28th UN Climate Change COP in Dubai.

We present the following five scenarios (Table 1), ranging from the current policy landscape to more ambitious climate action: (1) a current policies scenario, (2) a 2030 NDCs scenario, (3) a long-term strategies (LTS) scenario, (4) an expanded LTS scenario and (5) an accelerated LTS scenario. A full description of the scenarios is provided in Methods and Supplementary Information.

Climate policy implications for global emission pathways

For GHG emissions, both the mean and the spread of the models are presented in Fig. 1. Supplementary Information includes an overview of each model's characteristics (Extended Data Table 1) and policy stringency (Extended Data Fig. 1). The results for the current policies scenario show that current policies worldwide are expected to more-or-less stabilize GHG emissions, leading to an increase in the global mean temperature of between 2.6 °C and 3.4 °C by 2100 (model range, 50th percentile). Thus, our results corroborate earlier findings[1,5,6,10,12,13,17], demonstrating that current policies are not yet in line with the NDCs or LTS scenarios, and emphasizing a clear implementation gap. The 2030 NDCs scenario shows that, if more ambitious policies are not implemented after 2030, GHG emissions at the global scale slightly decrease but remain far from reaching net-zero. This scenario would lead to a warming in the range of 2.3–2.8 °C by the end of century.

The LTS scenario indicates that, if expressed net-zero pledges are implemented, considerably more emission reductions can be achieved. The LTS scenario leads to GHG emissions of around 15–20 $GtCO_2e$ after 2050 (and warming in the range of 1.8–2.1 °C by 2100). However, there is still an ambition gap in meeting the long-term global climate goals and pursuing efforts to stay below 1.5 °C. Expanding the coverage of net-zero pledges to all countries worldwide (expanded LTS) leads to an alignment with the well-below 2 °C target, with a global mean temperature increase in the range of 1.4–1.8 °C by 2100. Still, even in this scenario it is very unlikely that we reach a 1.5 °C pathway without overshoot. Furthermore, accelerating the action to reach net-zero earlier (accelerated LTS) drives steeper emission reductions in the short and mid-term (between now and 2060), leading to an end-of-century global mean temperature increase of 1.4–1.7 °C by 2100. Emission reductions in the shorter term (2030–2040) resulting from early mitigation efforts are mostly driven by gains in energy efficiency and a faster transition away from coal. More specifically, higher fossil fuel prices (due to a carbon price) force a shift towards less carbon-intensive energy carriers: the electricity mix shifts towards greater production from renewable sources, while fossil-fuel-based electricity production declines, and the percentage of electric vehicles in transport increases, as does the amount of electrification in heavy industry, specifically in iron and steel production. Additionally, higher energy prices push a shift towards higher energy and service efficiency, thus reducing energy demand.

Strengthening climate policy and accelerating climate action

In total, 159 countries (accounting for over 50% of global methane emissions) signed the Global Methane Pledge, agreeing to work together to reduce global methane emissions by 30% (from 2020 levels) by 2030

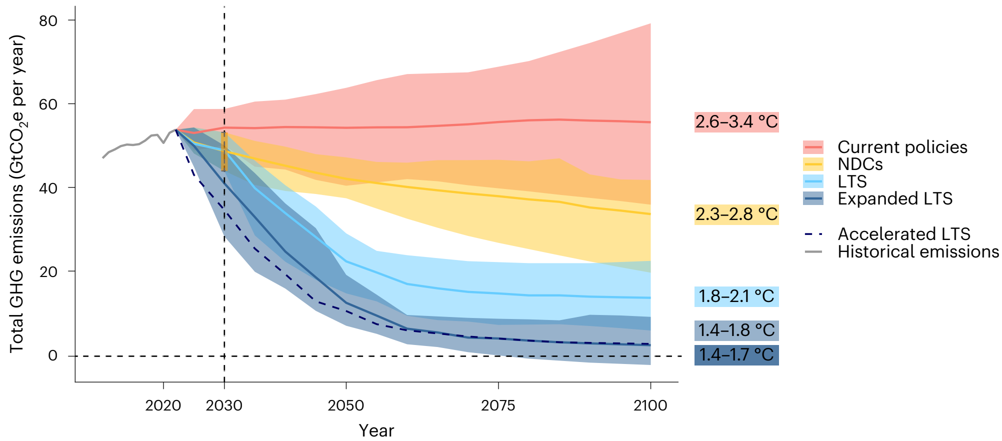

Fig. 1 | Global emission pathways. Global emission pathways under different policy scenarios. Ribbons represent model spread, lines represent model means and temperature ranges indicate change in mean global surface temperature per scenario, with 50% probability. Yellow bar at 2030 indicates the range of GHG emissions in the NDCs scenario, derived from how different models project emission reductions related to the NDCs in 2030.

(https://www.globalmethanepledge.org/). More recently, based on the outcomes of the recent global stocktake, this ambition was revised, with countries agreeing to commit to "tripling renewable energy capacity globally and doubling the global average annual rate of energy efficiency improvements by 2030" (in terms of reduction in energy intensity—that is, the amount of energy required to produce a unit of gross domestic product[18]), and "to transitioning away from fossil fuels in energy systems, in a just, orderly and equitable manner, accelerating action in this critical decade, so as to achieve net-zero by 2050 in keeping with the science"[16]. These goals are not directly implemented in our scenarios (for example, we do not ask the models to triple global renewable energy capacity by 2030)—rather, we check if current policies and pledges put forward by countries either domestically (national policies) or in the context of climate negotiations (for example, NDCs and net-zero pledges) lead to (or are on the path towards) reaching them.

As expected, the more ambitious the scenario, the closer it is to reaching the methane and renewable energy goals (Fig. 2). Current policies, NDCs and LTS scenarios show insufficient reductions in methane emissions. Current climate policies and pledges heavily rely on CO_2 mitigation. While CO_2 mitigation has strong synergies with energy-related methane emissions (which accounts for approximately one third of total methane emissions), direct mitigation is crucial for effectively reducing methane emissions[19]. Furthermore, modelling of non-CO_2 abatement remains limited, particularly due to constraints in the construction of marginal abatement cost curves[20]. Nonetheless, both expanded and accelerated LTS scenarios are found to be potentially in line with, and considerably closer to, the Global Methane Pledge target (Fig. 2a), suggesting that models account, to some extent, for readily available methane abatement options.

For the expansion of renewable energy capacity (Fig. 2b), most of the scenarios do not reach the tripling goals by 2030 (compared to 3,655 GW in 2023)[21], despite the fast growth of renewables in all scenarios. Key factors holding back the scaling up of renewables in the shorter term include the feasibility of moving away from fossils, which can delay their phase-out, capacity factors and constraints in the power system that determine how fast technologies can be ramped up and their penetration rates (especially for intermittent sources such as solar and wind), technology costs, different assumptions on electrification of end uses, with some models more optimistic than others, and difficulties in dealing with stranded assets. This highlights the importance of early interventions, which, in this study, were operationalized by anticipating the net-zero commitments of countries. Furthermore, it indicates the need for dedicated interventions, with concrete underlying policies to drive system transformation.

Trends in renewable energy capacity, however, do not fully capture the potential of the transition and the strong contribution renewable energy sources have in the scenarios. A comparison of scenario development up to 2050 (Fig. 2c) displays the proportion of fossil fuels and renewable energy for each scenario. Our results show a substantial expansion of renewables and reduction of fossil fuels, abated or unabated, in their share of primary energy. In the shorter term, current pledges do not exhibit large differences when compared to existing policies (60–80% fossil fuels, 20–40% renewables), while the more ambitious LTS scenarios show considerable changes in the energy mix towards renewable energy (20–50% fossil fuels, 45–80% renewables). REMIND exhibits more optimistic outputs in terms of renewable energy, reaching a share of over 76% of global primary energy in 2050 for both expanded and accelerated LTS, which, as of 2023, was around 30% of global electricity generation[22]. Other studies show even higher shares of renewables[23–25], especially for scenarios explicitly aimed at achieving such targets. While different models have different fingerprints[26]—that is, technological preferences—they all project a large expansion of renewable energy under climate policy scenarios[21], and the high end of the range of renewable energy shares in our scenarios illustrates how competitive these sources have become.

By the mid-twenty-first century, unabated fossil fuels are reduced from around 80% (MESSAGEix, IMAGE, COFFEE and POLES), estimated in the current policies scenario to drop below 40% in 2050 when current net-zero pledges are accounted for, and to under 20% with accelerated climate action. Models that favour the deployment of renewables due to decreasing costs of technology tend to achieve steeper reductions in fossil fuel use (for example, REMIND and POLES), while IMAGE shows a delay in dealing with stranded assets (restrictions to early retirement), due to its recursive-dynamic nature. Unabated coal is phased out by nearly all models by the end of the twenty-first century, except for GCAM and GEM-E3, with a substantial reduction by 2050 for the expanded and accelerated LTS scenarios. The remaining unabated fossil sources are split between oil and gas, mostly directed to the hard-to-abate sectors. GCAM, GEM-E3 and IMAGE show higher deployments of gas with carbon capture and storage, while MESSAGEix and WITCH prefer unabated natural gas. The inclusion of bioenergy in the renewable mix, and to what extent bioenergy is coupled with carbon capture and storage, varies per model and region. In 2050, MESSAGEix and REMIND exhibit the lowest employment of bioenergy (70–108 EJ), while the other models range between 158 EJ (POLES) and 250 EJ (GCAM) in the accelerated LTS scenario. These numbers show a substantial increase compared to current bioenergy supply (55 EJ in

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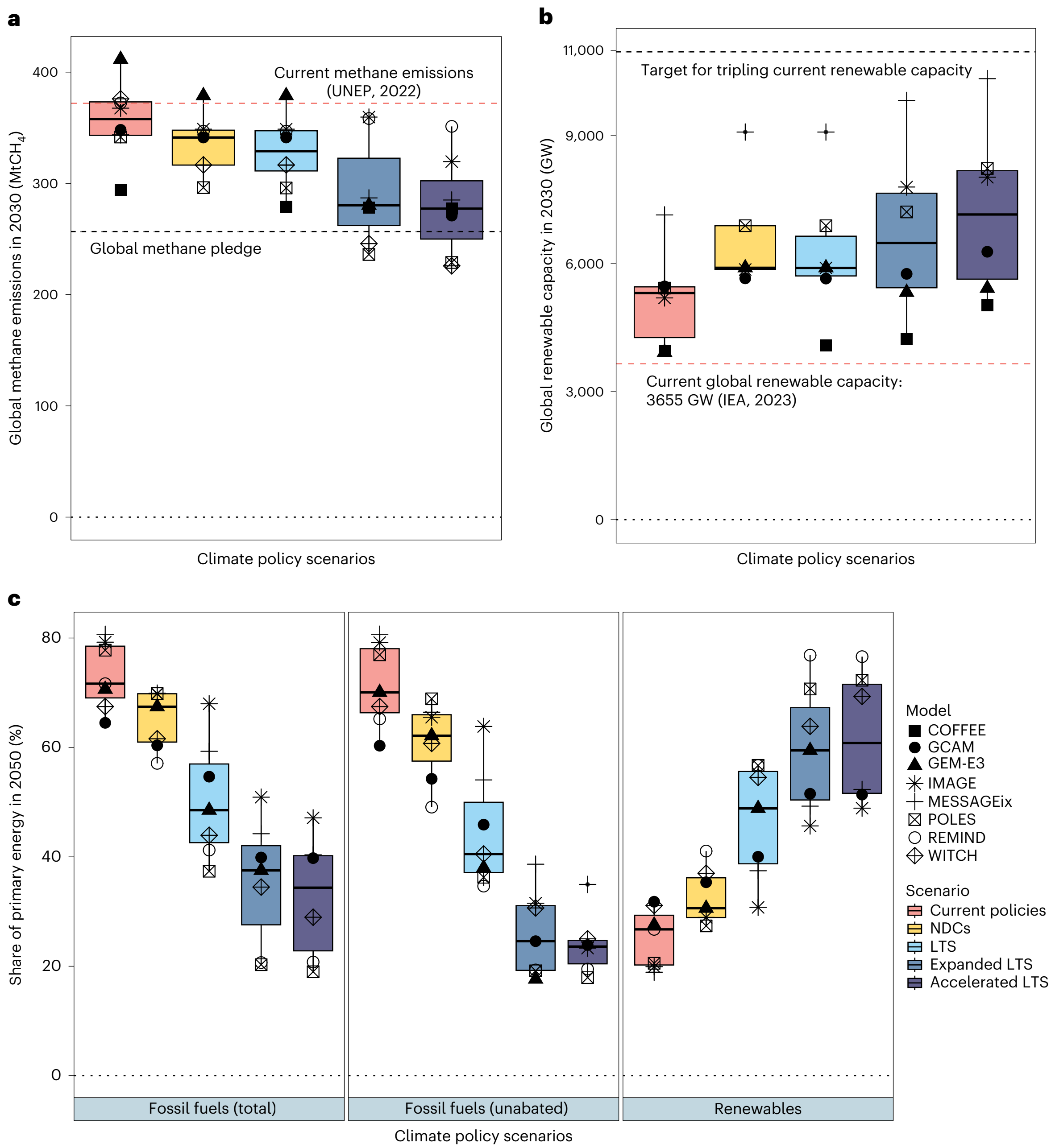

Fig. 2 | Methane emissions, renewable energy capacity and fossil fuel phase down. Performance of the climate policy scenarios. **a**, Global methane emissions in 2030 and the Global Methane Pledge[33]. **b**, Global renewable capacity in 2030 and tripling renewable capacity for electricity generation[21]. **c**, Share of renewables and fossil fuels in the primary energy mix in 2050, and the phasing down or out of fossil fuels. Renewables include biomass, with and without carbon capture and storage. Centre line of the box plots represents the median, box limits represent the upper and lower quartiles, and points represent the models ($n = 8$).

2022)[27] and to the International Energy Agency's net-zero emissions scenario[28] (100 EJ in 2050). Solar and wind have high agreement across models, expanding considerably by 2050. MESSAGEix, REMIND and WITCH exhibit the highest numbers for solar (3,264–5,292 GW), and GCAM, POLES and REMIND have the highest for wind (2,218–3,517 GW), in both the expanded and accelerated LTS scenarios. Nuclear is an important option for GCAM (8.5% and 9.0% of the energy mix in 2050 for expanded and accelerated LTS, respectively), POLES (9.0% of the energy mix in 2050 for expanded and accelerated LTS) and MESSAGEix (7.3% of the energy mix in 2050 for accelerated LTS). A detailed breakdown of global primary energy consumption for the years 2020, 2030, 2050 and 2100, and the role of different energy carriers, is presented in Supplementary Figs. 3 and 4.

Electrification plays a substantial role in decarbonizing the energy system. For most models in the accelerated LTS scenario, the share of electricity strongly picks up in 2040, accounting for more than 50% of final energy use by 2050 (Fig. 3). This outcome is mostly driven by the transport and building sectors. The more stringent the climate target, the more substantial the transitions towards electrification of the passenger fleet and the switch away from conventional fuels for heating, considerably reducing emissions.

From the global picture to regional strategies

While stabilizing global mean temperature increase is a collective effort, emission-reduction actions occur at the local and/or regional scale. In this study, we explore ten different global regions: the EU; Eastern

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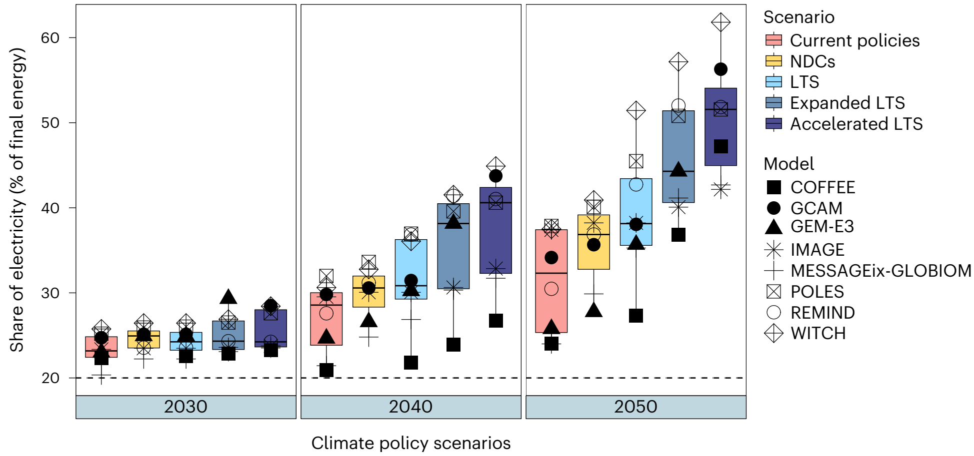

Fig. 3 | Share of electricity. Share of electricity in final energy use (2030–2050). Centre line of the box plots represents the median, box limits represent the upper and lower quartiles, and points represent the models ($n = 8$). Dashed line represents the 2023 global share of electricity[29].

Europe (including Russia); Japan, Korea and Oceania; East Asia (including China); South Asia (including India); Southeast Asia; the Middle East; North America; Latin America; and Sub-Saharan Africa.

Under current policies, most regions stabilize their GHG emissions (Fig. 4). Notable exceptions are regions with high economic and population growth—that is, South Asia, Sub-Saharan Africa and the Middle East—which continue to increase their emissions. In East Asia, emissions are projected to peak in 2030 and are already showing substantial reductions: 16.3% for current policies, 24.1% for NDCs, 74.2% for LTS, 81.6% for expanded LTS and 84.2% for accelerated LTS in 2050, relative to current emission levels. Moving towards more stringent scenarios, the results show high-income regions to reach net-zero earlier, driven by sharp emission reductions before 2050. Low- and middle-income regions show different behaviours, with some regions reaching net-zero later in the century (East Asia and Latin America), while others strongly reduce emissions but remain positive emitters (South Asia, Southeast Asia and Sub-Saharan Africa). The main reason for this is that most of the individual countries in these regions have either pledged net-zero after 2050 or do not yet have a net-zero target. Moreover, early declines in emissions in these regions strongly rely on international support.

Countries and regions are inherently diverse, resulting in diverse strategies towards reaching their emission-reduction targets. The key driver for emission reductions in the LTS scenario is the phasing down or out of fossil fuels, especially coal. Fossil sources such as coal and oil are mostly substituted by renewable sources (solar, wind or biomass) (Fig. 5). This has a substantial impact on emissions from developing regions like China (in East Asia) and India (in South Asia), and on global emissions in general. Gas remains an important energy source in Europe and the Middle East (being partly deployed with carbon capture and storage), but around the mid-twenty-first century both regions show an increase in renewables coming from non-bio renewables. Countries in Asia and Oceania have higher deployment rates of non-bio renewables under the current policies and NDCs scenarios, but shift towards more bioenergy once net-zero pledges come into effect, given the possibility of carbon dioxide removal. Bioenergy with carbon capture and storage mostly replaces fossil sources in the power (coal) and transport sectors (oil and gas products). Its employment is region specific, playing a bigger role in the energy system in Sub-Saharan Africa (cooking and heating), the EU, North America and Latin America (liquid biofuels). Interestingly, in East Asia, accelerating climate action reduces the employment of bioenergy with carbon capture and storage, shifting emission reductions to other sectors, particularly industry.

Such a transition in the energy system also has economic impacts. While NDC ambitions have only modest effects on gross domestic product (compared to current policies), the LTS scenario results in larger differences both globally (3–10% losses by 2100) and regionally, particularly for fossil fuel exporters (Supplementary Figs. 7 and 8).

International cooperation is key for closing the gap

There is a clear gap between the implementation of climate policies and pledges and the goals of the Paris Agreement. Current policies do not yet align with the NDC pathways or long-term strategies, resulting in implementation gaps in the near term (2030) and the mid- to long term (mid-twenty-first century to second half of the century). This means that if more ambitious policies are not implemented after 2030, emissions would at best stabilize at the global scale, resulting in warming well above the Paris Agreement goal. Moreover, while the announced long-term strategies are a substantial step forward compared to the 2030 NDCs, with a potential for 25–40 $GtCO_2e$ of emission reductions in 2050, relative to current emission levels, they alone do not lead to emission pathways fully compatible with the Paris Agreement.

Our work provides robust evidence from a multi-model analysis that moving towards Paris-aligned pathways requires a rapid expansion of renewables and a shift away from fossil fuels. Our analysis relies on IAM studies that capture a broad range of intersectoral linkages. As such, our intention is not to predict the future or provide definitive answers, but rather explore the effects of different policy assumptions on a range of interacting systems. In our scenarios, most of the observed emission reductions are driven by gains in energy efficiency, the strong phase down of coal use, the substitution of fossil fuels with renewable sources and the electrification of transport and heavy industry. Such transformation of the current system requires dedicated policies, as our study shows that the implementation of current pledges implies considerable improvement but still falls short of achieving the goal of tripling renewable energy capacity and phasing out fossil fuels. This outcome echoes findings from the International Energy Agency[29], and its call for countries to translate such goals into domestic policies, including strong energy efficiency policies and fossil fuel transition policies (for example, the phasing out of inefficient fossil fuel subsidies). In this context, and given the current geopolitical uncertainty related to the adoption and implementation of climate policies, achieving a well-below 2 °C pathway becomes increasingly challenging. Nonetheless, the substantial emission reductions achieved in the expanded LTS scenario highlight the importance of long-term commitments from all countries to keep the Paris Agreement within reach.

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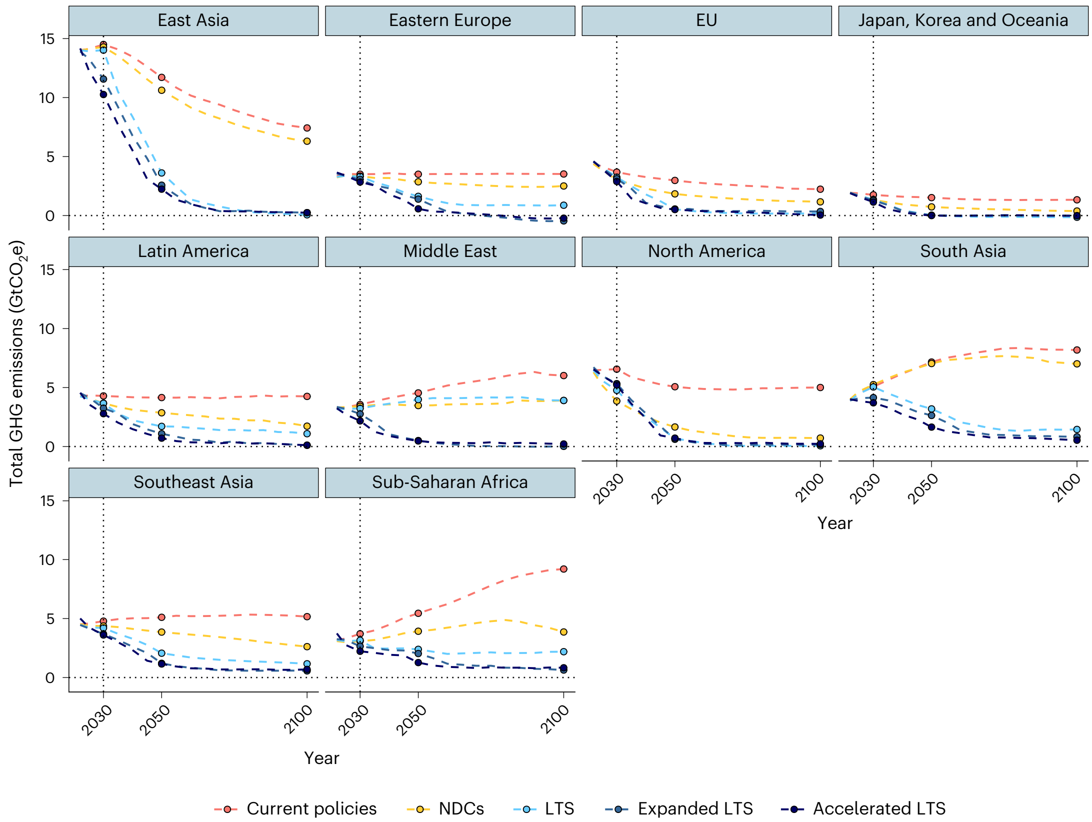

Fig. 4 | Regional emission pathways. Regional emission pathways (2020–2100) showing model means for each region (East Asia, including China; Eastern Europe, including Russia; the EU; Japan, Korea and Oceania; Latin America; the Middle East; North America; South Asia, including India; Southeast Asia; and Sub-Saharan Africa).

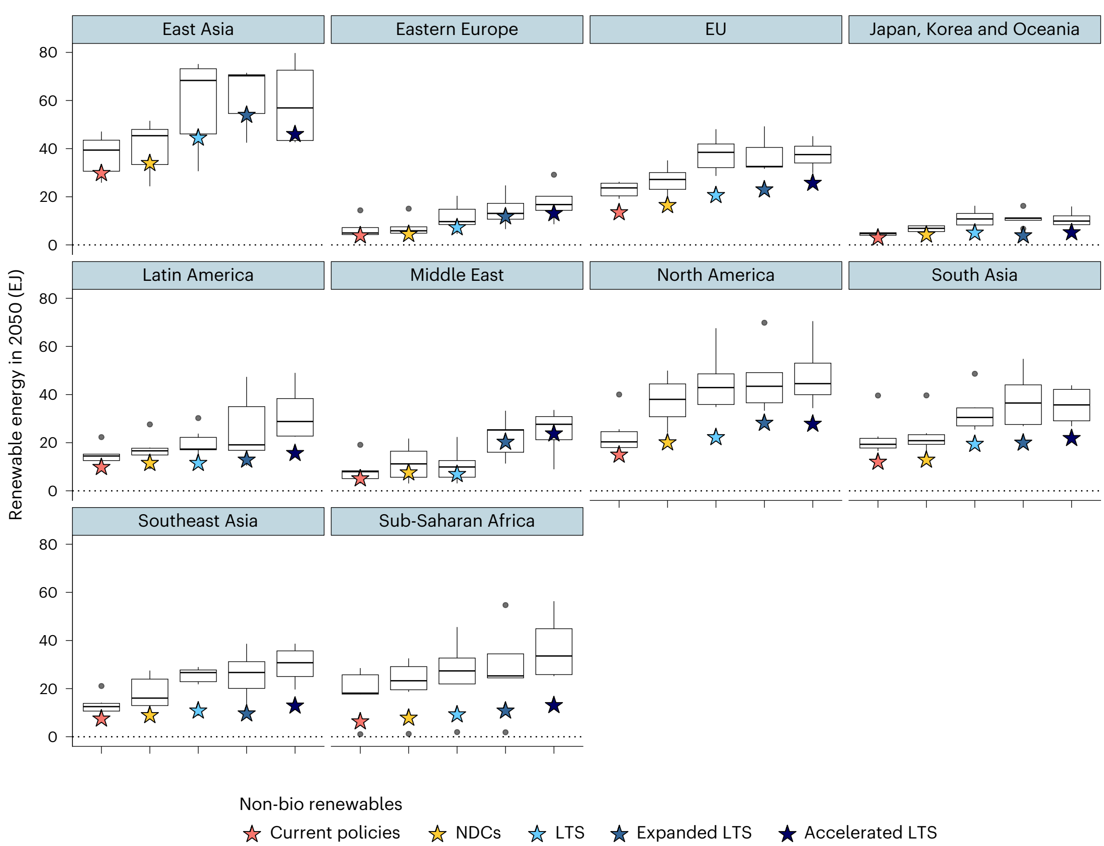

Fig. 5 | Regional deployment of renewable energy. Regional deployment of renewables in 2050 (boxes show model spread for total renewables, stars show model medians for non-biomass renewables). Non-biomass renewables include solar, wind, geothermal and hydro energy. Centre line of the box plots represents the median, box limits represent the upper and lower quartiles, and points represent the outliers.

Sectoral transformations under higher mitigation scenarios are closely related to regional specificities, and reduction potentials within these sectors and regions. In our scenarios, emissions in China (East Asia) are expected to peak by 2030, with steep reductions needed thereafter to reach its LTS target, most of which could come from phasing down coal in the electricity sector and increasing electrification in heavy industry. Developing regions such as Latin America, Southeast Asia, South Asia and Sub-Saharan Africa show lower rates of emission reductions between 2030 and 2050, with Latin America and Indonesia potentially contributing around a 45% reduction in global land-use-related emissions through strong commitments to reducing illegal deforestation. Finally, developed or wealthier regions need to strongly cut emissions in the short term, reaching net-zero around mid-century. Exploring the potential of sectoral transformation is challenging both from a technological perspective (given the limitations in terms of material use and storage requirements to manage the intermittency of renewable energy sources) and from an economic perspective, which heavily depends on international cooperation, including the use of market mechanisms, as well as finance, technology transfers and capacity building. While high shares of renewable energy are achievable, their emergence is not guaranteed, as political choices continue to play a role, particularly in fossil-resource-holding countries. Navigating national priorities towards effective cooperation is crucial to collectively achieving the global climate goal. Our work explores the implications of a more ambitious international setting for reaching net-zero emissions. Further work should include examining climate policy scenarios through the lens of effort-sharing, incorporating equity and justice considerations into how mitigation efforts are divided across countries, and how financial transfers can help in enabling the transition.

Online content

Any methods, additional references, Nature Portfolio reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at https://doi.org/10.1038/s41558-026-02615-y.

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Methods

This multi-model intercomparison study utilizes the following set of global IAMs: IMAGE, COFFEE, REMIND, WITCH, POLES, MESSAGEix, GCAM and GEM-E3. Brief model descriptions can be found in Supplementary Information, and in-depth model documentation can be found in ref. 15.

Scenario framework

Following a common modelling protocol, global models implement the scenarios as described below.

The current policies scenario defines current policies as those adopted by governments (through legislation) or non-binding targets backed by effective policy instruments. Ambitions and pledges are not considered current policies and, therefore, are not included in this scenario. The cut-off date for current policies included in this study is January 2023. After 2030, the ambition levels remain at least constant throughout the rest of the timeframe. To keep ambition levels after 2030, the following extension method was used: the equivalent carbon price in 2030 was extrapolated to 2100, using the gross domestic product growth rate of the different model regions, following ref. 12. This equivalent carbon price represents the carbon value that would yield the same marginal emission reductions as the current policies in a region. If a region has a zero-carbon price while implementing the current policies in 2030, a minimum carbon price of US$1 per tCO_2 in 2030 is assumed. This represents a continuation of policies (with equivalent effort) in the future.

The NDCs scenario aims to represent the goals of the NDCs (for this study, as of January 2023). Global modelling teams implemented a set of NDCs for selected countries or regions. For a comprehensive set of quantified NDC targets, see the CPMP[31] and Supplementary Table 3. The ambition levels reached in the target year remain at least constant throughout the rest of the century, using the same extension method as described for the current policies scenario.

For the LTS scenario, we consider the NDC pledges and the mid-century strategy pledges (net-zero) announced around the 26th UN Climate Change COP in Glasgow. Global modelling teams consider all net-zero pledges, aggregating them to their specific model regions. The methodology used to define the regional net-zero target year assumed that if the countries with net-zero pledges have a share of 50 of total s in the region, the region is set to have a net-zero target year equal to the average target year weighted by each countries' emissions.

The expanded LTS scenario considers the mid-century strategy pledges (net-zero) announced around the 26th UN Climate Change COP in Glasgow, and expands their coverage to all countries or regions. In this scenario, countries can overachieve their 2030 NDC target if this is cost-effective for reaching the long-term neutrality target. For countries or regions without an established net-zero strategy, the assumed net-zero target year is calculated based on a regression that is a function of their income level.

The accelerated LTS scenario builds on the expanded LTS scenario and anticipates the action (net-zero target year defined for each region) by 5–10 years, depending on the model's time steps. We derive the global temperature increase of each scenario (see 'Temperature assessment') and compare the overall outcomes of the scenarios with 1.5 °C and 2 °C benchmark scenarios.

Temperature assessment

Probabilistic temperature simulations are performed using the probabilistic MAGICC climate emulator, version 7.5.3[34], covering all the most important GHG emissions and short-lived climate forcers (for a full list, see Table 1 in ref. 35). The calibration of the model is the same as that used by Working Group III in the Intergovernmental Panel on Climate Change Sixth Assessment Report[35]. The emissions trajectories of IAM scenarios are also processed to enable the highest possible comparability in line with the Intergovernmental Panel on Climate Change methodology. Individual emissions species are harmonized to 2015 historical values, and if an emissions species is not reported for a scenario by an IAM, it is inferred from the CO_2 energy and industrial emissions pathway of the scenario (full details and description of the methodology applied here is described in ref. 35). This approach ensures comparability between scenarios produced using different models by (1) providing comprehensive coverage of climatically relevant emissions species, and (2) ensuring that future temperature pathways only differ as a result of differences in future pathways, not because of different historical emissions accounting, which can result from uncertainties in historical emissions estimates[35,36]. A comprehensive assessment of global mean temperature changes can be found in Supplementary Fig. 2.

Data availability

The underlying data is available via Zenodo at https://doi.org/10.5281/zenodo.10009463 (ref. 37). The CPMP, including all current policies considered and their respective targets used for this scenario, is publicly available in ref. 31. Source data are provided with this paper.

Code availability

The models are documented in the IAM documentation[15] and several have been published as open source code, such as REMIND available via GitHub at https://github.com/remindmodel/remind (ref. 38), MESSAGEix available via GitHub at https://github.com/iiasa/message_ix (ref. 39) and GCAM available via GitHub at https://github.com/JGCRI/gcam-core/releases (ref. 40).

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Author contributions

I.T., F.D., R.S. and D.v.V. conceived and designed the scenarios. I.T., F.D., L.B.B., C.B., I.D., L.D., F.F., D.F., O.F., E.H., G.I., J.S.K., V.K., G.L., Y.O., L.A.R., O.R., P.R.R.R., Z.V., M.W., M.Z. and B.v.R. produced the scenarios. I.T. analysed the data, produced the figures and was the lead author. All authors contributed to the idea, figure design, model development and to writing the paper.

Competing interests

The authors declare no competing interests.

Additional information

Extended data is available for this paper at https://doi.org/10.1038/s41558-026-02615-y.

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Correspondence and requests for materials should be addressed to Isabela S. Tagomori.

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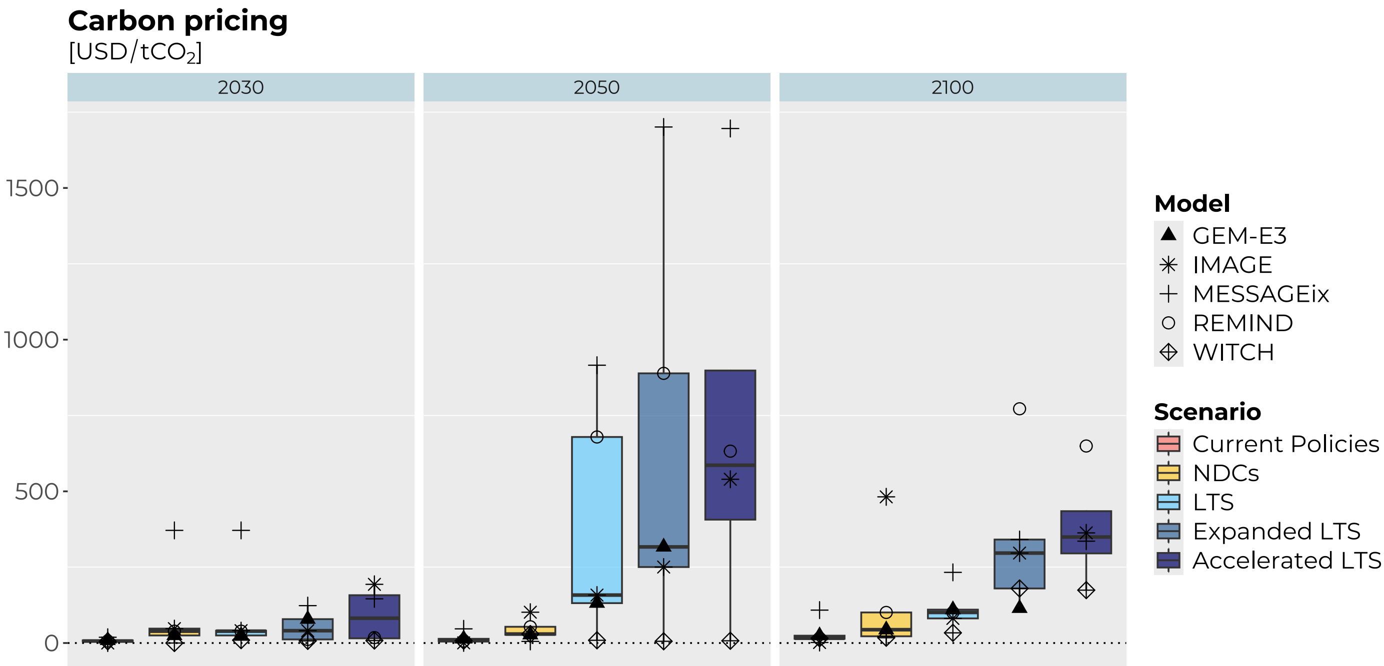

Extended Data Fig. 1 | Carbon pricing Carbon pricing in 2030, 2050 and 2100, for all scenarios. GCAM, COFFEE and POLES did not report carbon pricing. Box plots centre-line = median; box limits = upper and lower quartiles; n = 5.

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Extended Data Table 1 | Main model characteristics Main model characteristics

Model	Solution concept	Solution horizon and method	Spatial dimension	Energy technology choice/deployment
COFFEE	General equilibrium (closed economy)	Intertemporal optimization (foresight) Optimization	18 regions	Linear choice (lowest cost)
GCAM	General equilibrium (closed economy)	Recursive dynamic (myopic)	32 regions	Logit choice model
GEM-E3	General equilibrium (closed economy)	Recursive dynamic (myopic) Optimization	46 regions	Mostly high substitutability
IMAGE	Partial equilibrium (price elastic demand)	Recursive dynamic (myopic) Simulation	26 regions	Logit choice model
MESSAGEix-GLOBIOM	General equilibrium (closed economy)	Optimization	11 regions	Linear choice (lowest cost)
POLES	Partial equilibrium (price elastic demand)	Recursive dynamic (myopic) Simulation	66 regions	Logit choice model
REMIND	General equilibrium (closed economy)	Intertemporal optimization (foresight) Optimization	12 regions	Mostly high substitutability
WITCH	General equilibrium (closed economy)	Intertemporal optimization (foresight) Optimization	17 regions	No discrete technology choices