Global Warming of 1.5°C:

Emission Pathways and System Transitions Consistent with 1.5°C Global Warming

INTERGOVERNMENTAL PANEL ON climate change

Robert van Waarden / Aurora Photos

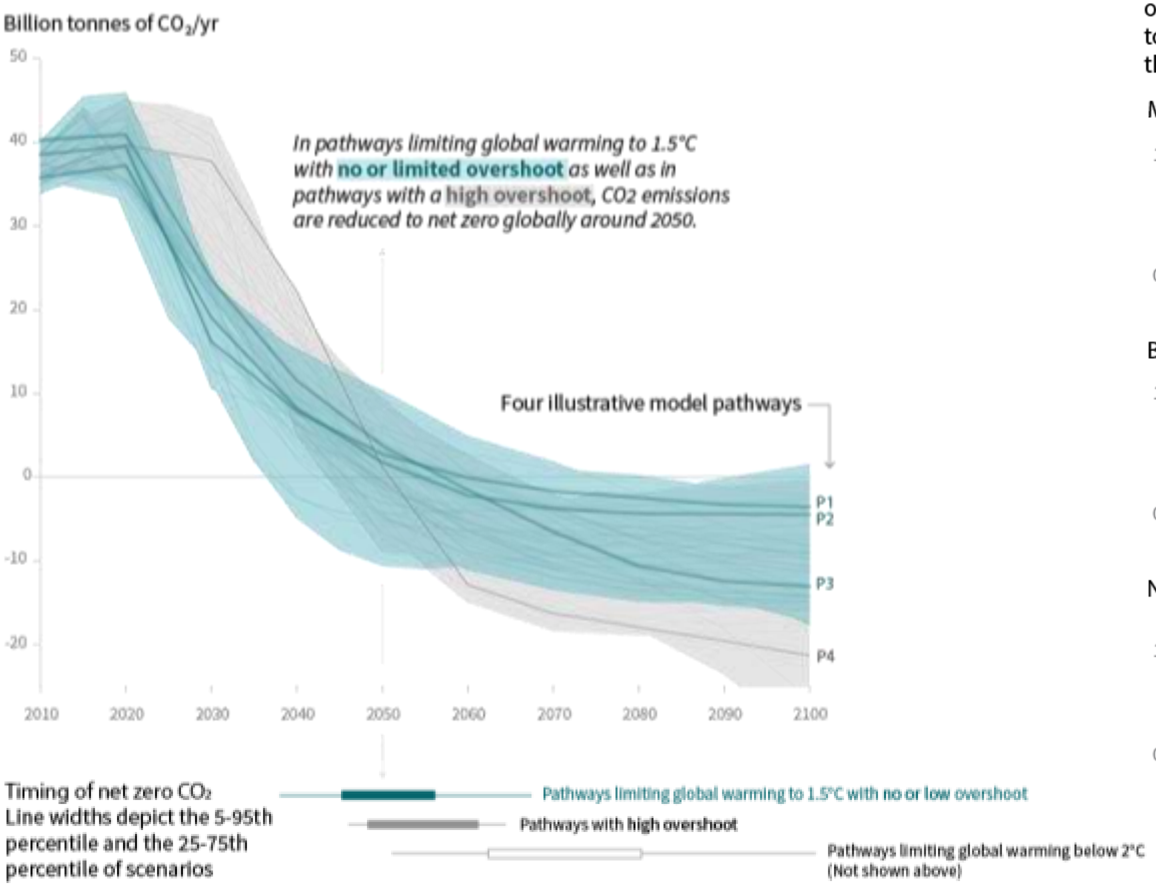
Where are we now?

- Estimates of the global emissions outcome of current nationally stated mitigation ambitions as submitted under the Paris Agreement would lead to global greenhouse gas emissions in 2030 of 52–58 $GtCO_2eq\ yr^{-1}$.

- Pathways reflecting these ambitions would not limit global warming to 1.5°C, even if supplemented by very challenging increases in the scale and ambition of emissions reductions after 2030.

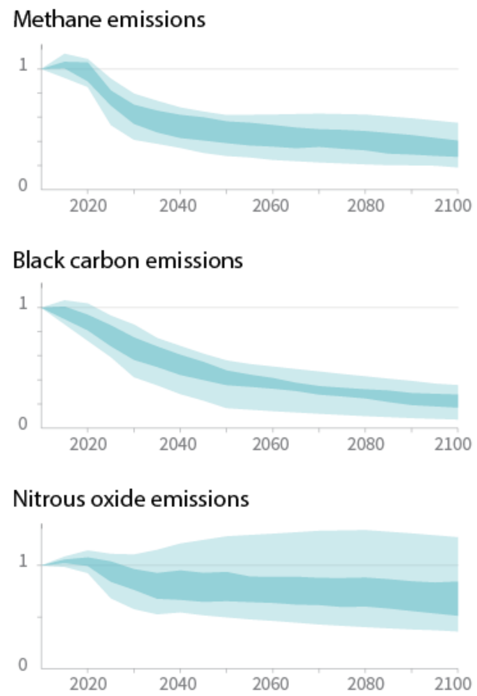
SPM3a | Global emissions pathway characteristics

Global total net CO_2 emissions



Non-CO_2 emissions relative to 2010

Emissions of non-CO_2 forcers are also reduced or limited in pathways limiting global warming to 1.5°C with **no or limited overshoot**, but they do not reach zero globally.



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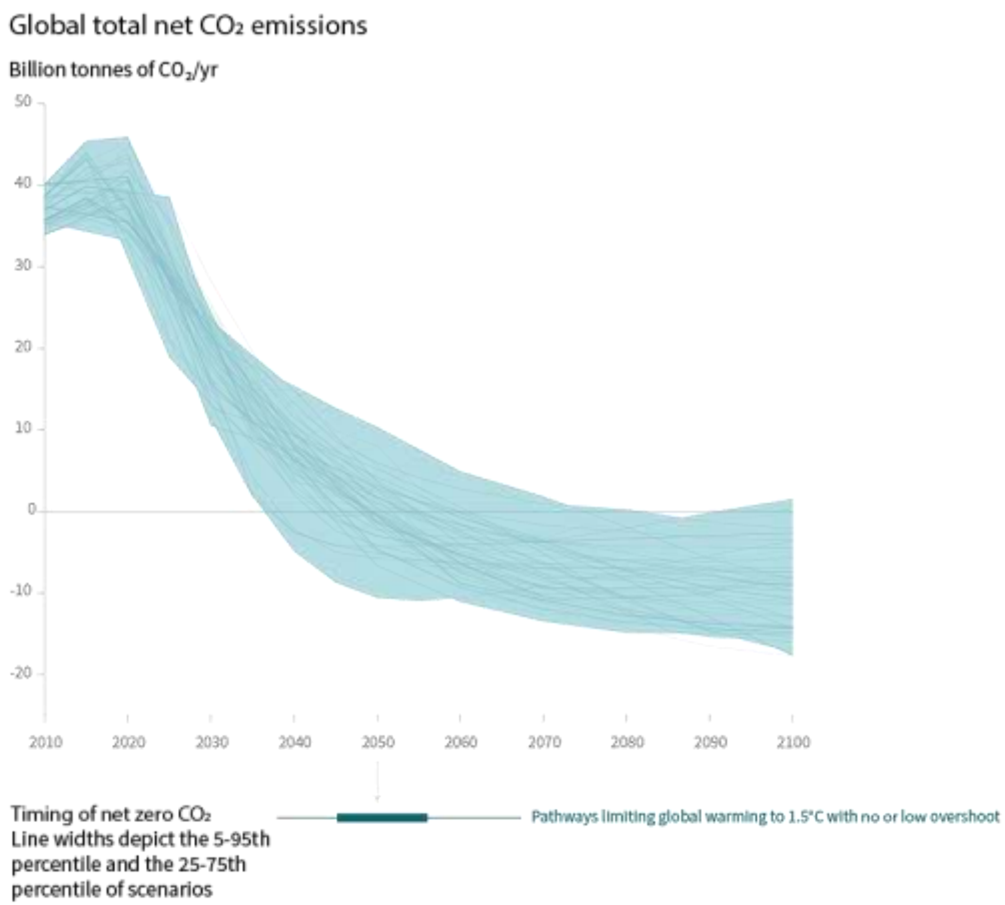

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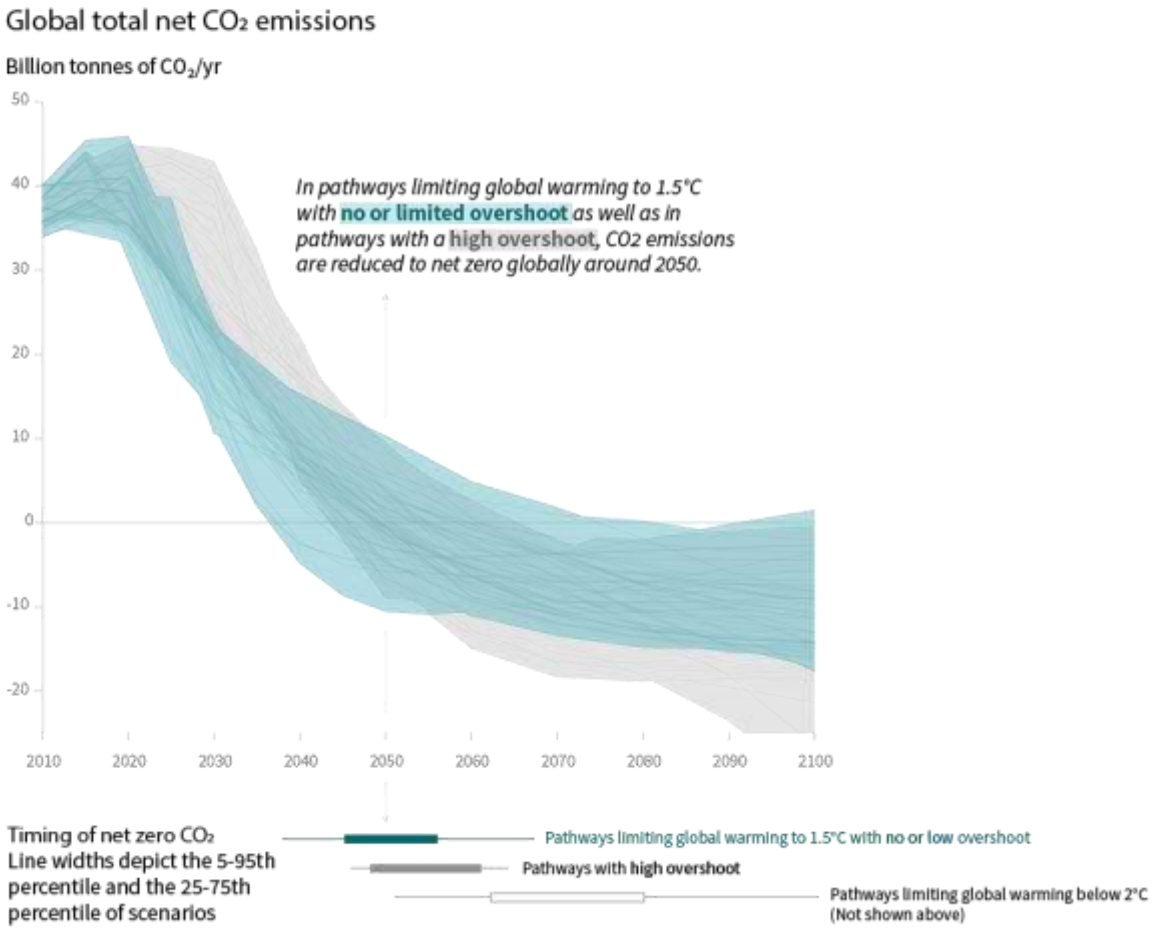

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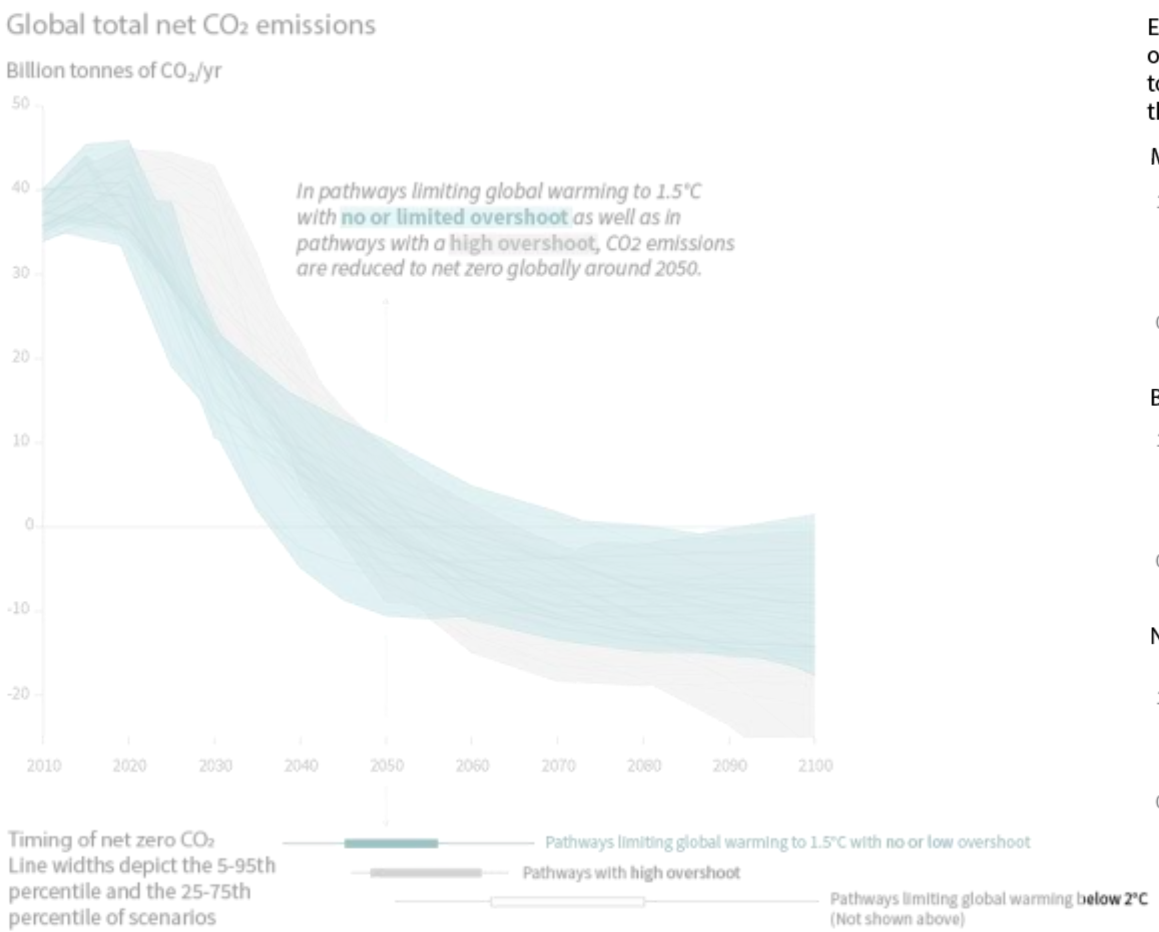

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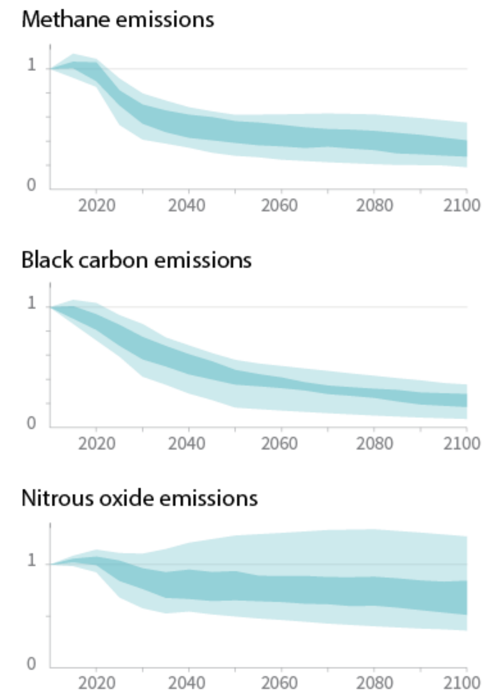

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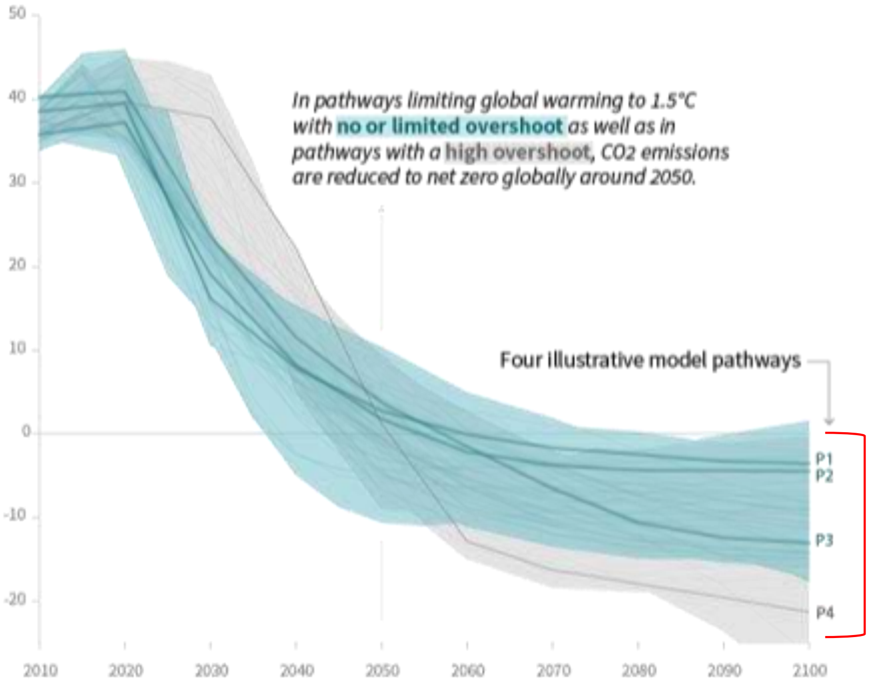
Global total net CO_2 emissions

Billion tonnes of CO_2/yr



Timing of net zero CO_2
Line widths depict the 5-95th percentile and the 25-75th percentile of scenarios

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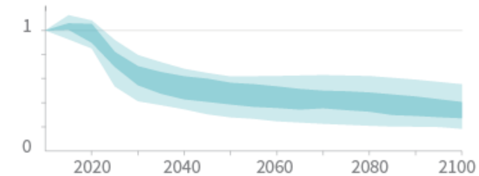
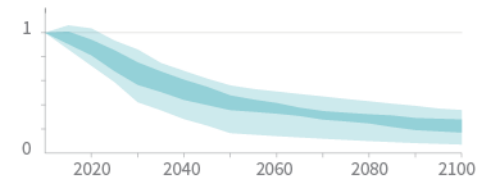
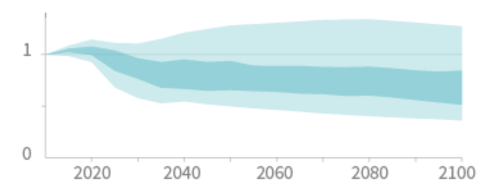
Methane emissions



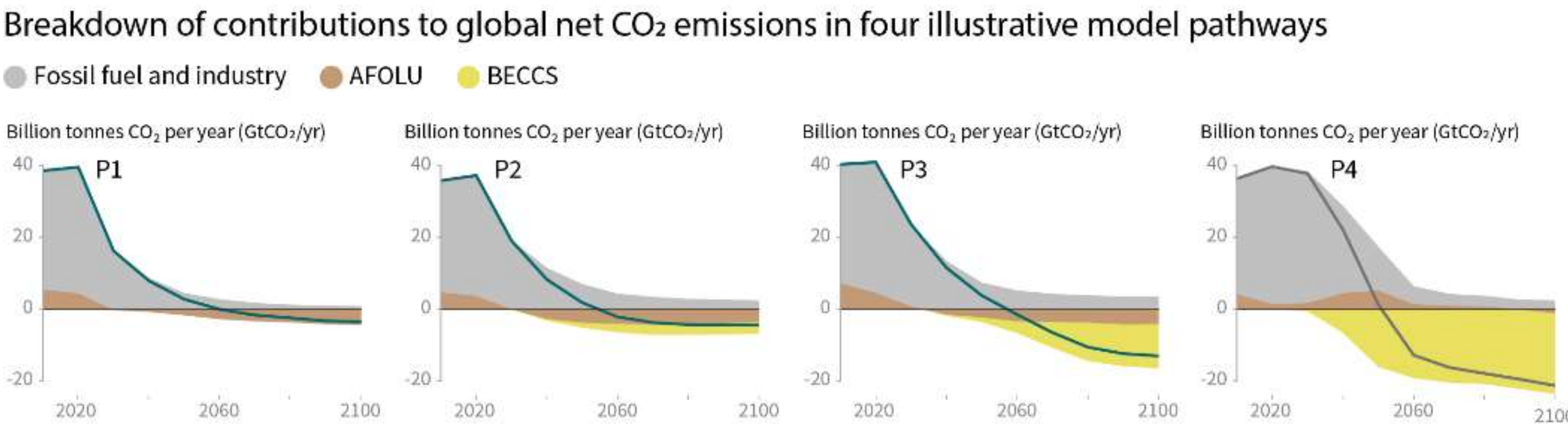
Black carbon emissions



Nitrous oxide emissions



SPM3b | Characteristics of four illustrative model pathways



P1: A scenario in which social, business and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A downsized energy system enables rapid decarbonization of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

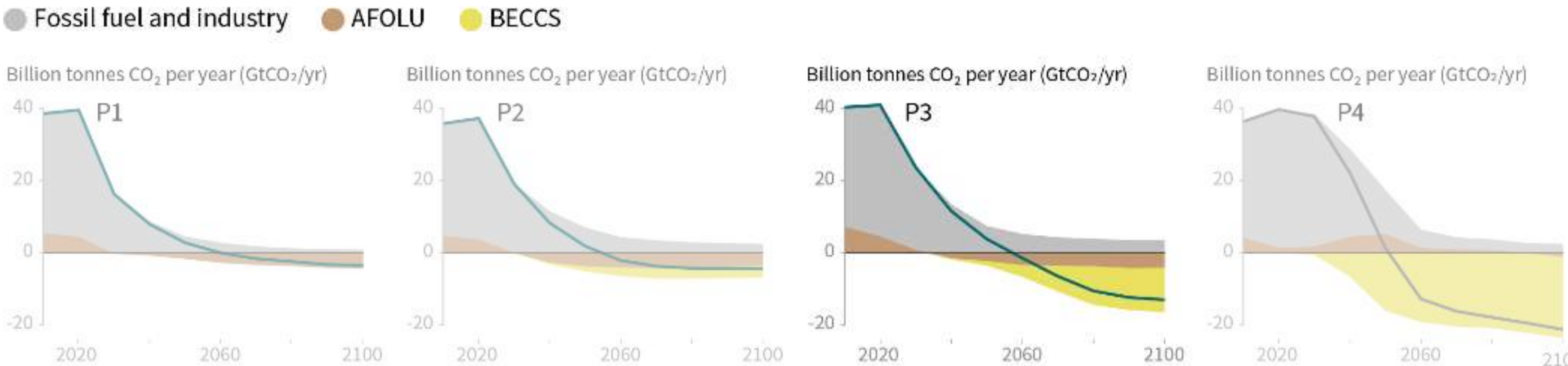
P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

P4: A resource- and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas-intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

SPM3b | Characteristics of four illustrative model pathways

Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways



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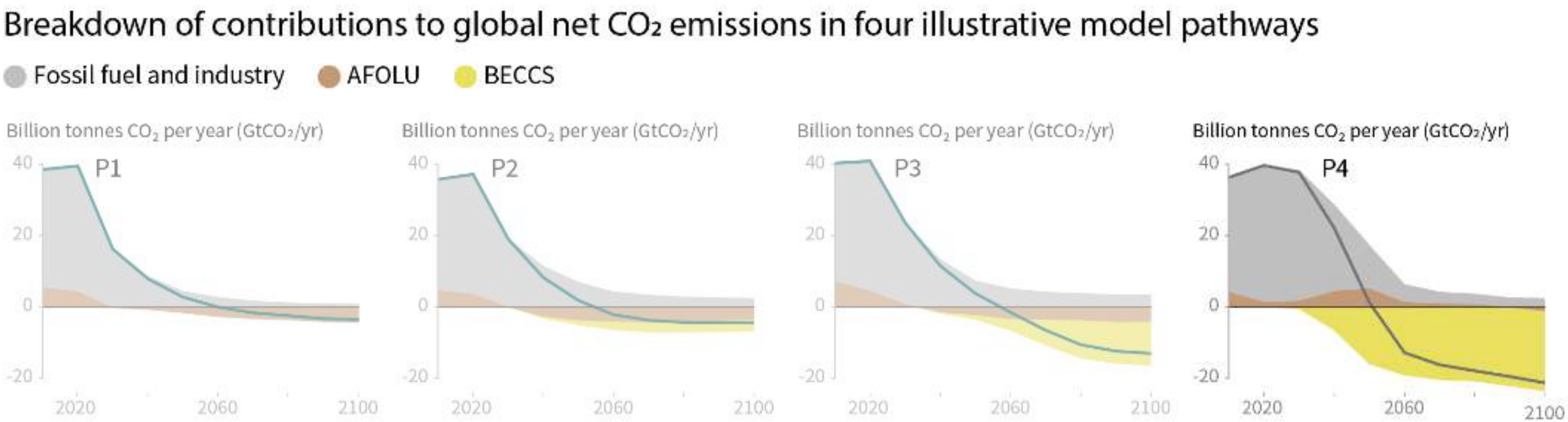

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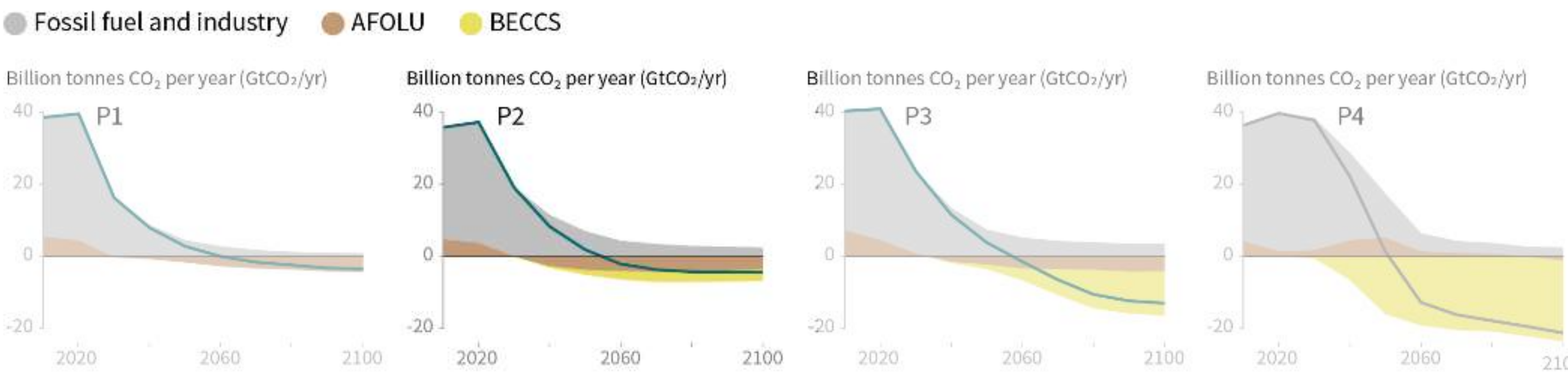

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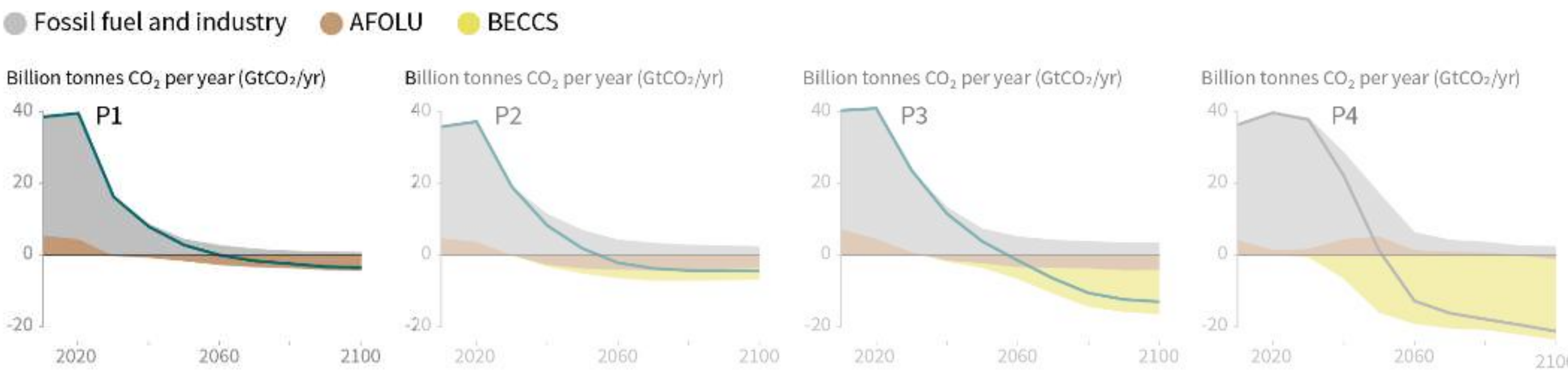

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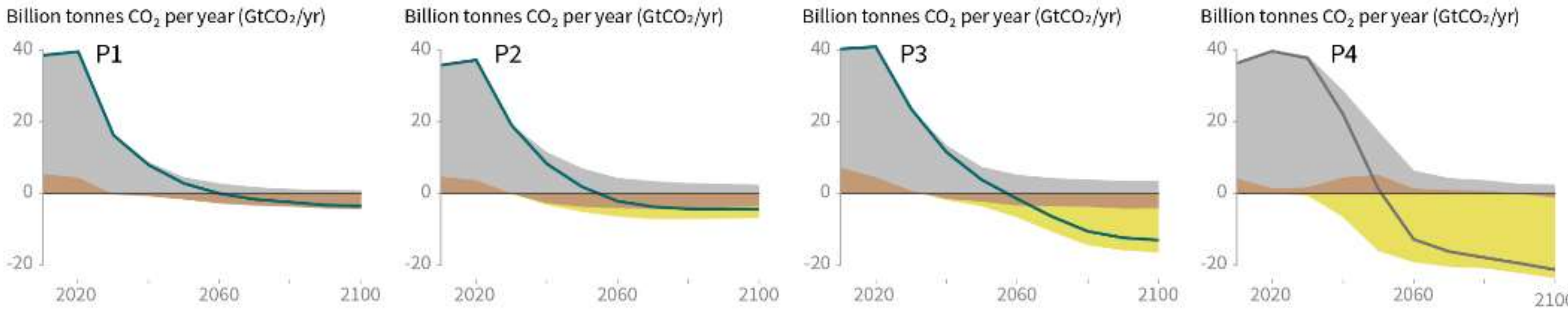
Fossil fuel and industry · AFOLU · BECCS



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Global indicators	P1	P2	P3	P4	Interquartile range
Pathway classification	No or low overshoot	No or low overshoot	No or low overshoot	High overshoot	No or low overshoot
CO_2 emission change in 2030 (% rel to 2010)	-58	-47	-41	4	(-59,-40)
└ in 2050 (% rel to 2010)	-93	-95	-91	-97	(-104,-91)
Kyoto-GHG emissions in 2030 (% rel to 2010)*	-50	-49	-35	-2	(-55,-38)
└ in 2050 (% rel to 2010)	-82	-89	-78	-80	(-93,-81)
*Final energy demand** in 2030 (% rel to 2010)*	-15	-5	17	39	(-12, 7)
└ in 2050 (% rel to 2010)	-32	2	21	44	(-11, 22)
Renewable share in electricity in 2030 (%)	60	58	48	25	(47, 65)
└ in 2050 (%)	77	81	63	70	(69, 87)
Primary energy from coal in 2030 (% rel to 2010)	-78	-61	-75	-59	(-78, -59)
└ in 2050 (% rel to 2010)	-97	-77	-73	-97	(-95, -74)
from oil in 2030 (% rel to 2010)	-37	-13	-3	86	(-34,3)
└ in 2050 (% rel to 2010)	-87	-50	-81	-32	(-78,-31)
from gas in 2030 (% rel to 2010)	-25	-20	33	37	(-26,21)
└ in 2050 (% rel to 2010)	-74	-53	21	-48	(-56,6)
from nuclear in 2030 (% rel to 2010)	59	83	98	106	(44,102)
└ in 2050 (% rel to 2010)	150	98	501	468	(91,190)
from biomass in 2030 (% rel to 2010)	-11	0	36	-1	(29,80)
└ in 2050 (% rel to 2010)	-16	49	121	418	(123,261)
from non-biomass renewables in 2030 (% rel to 2010)	430	470	315	110	(243,438)
└ in 2050 (% rel to 2010)	832	1327	878	1137	(575,1300)
Cumulative CCS until 2100 ($GtCO_2$)	0	348	687	1218	(550, 1017)
└ of which BECCS ($GtCO_2$)	0	151	414	1191	(364, 662)
Land area of bioenergy crops in 2050 (million hectare)	22	93	283	724	(151, 320)
Agricultural CH_4 emissions in 2030 (% rel to 2010)	-24	-48	1	14	(-30,-11)
in 2050 (% rel to 2010)	-33	-69	-23	2	(-46,-23)
Agricultural N_2O emissions in 2030 (% rel to 2010)	5	-26	15	3	(-21,4)
in 2050 (% rel to 2010)	6	-26	0	39	(-26,1)

Temperature and emissions

Energy systems

Carbon dioxide removal

Agriculture

NOTE: Indicators have been selected to show global trends identified by the Chapter 2 assessment. National and sectoral characteristics can differ substantially from the global trends shown above.

** Kyoto-gas emissions are based on SAR GWP-100*

*** Changes in energy demand are associated with improvements in energy efficiency and behaviour change*

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System transitions consistent with 1.5°C warming

Rapid, far-reaching and unprecedented changes in all systems

- A range of technologies and behavioural changes
- Renewables supply 70-85% of electricity in 2050
- Coal declines steeply, ~zero in electricity by 2050
- Oil and especially gas persist longer – gas use rises by 2050 in some pathways
- Deep emissions cuts in transport and buildings
- Transitions in global and regional land use in all pathways, but their scale depends on the mitigation portfolio
- Urban and infrastructure system transitions imply changes in land and urban planning practices

Carbon Dioxide Removal (CDR)

- All pathways that limit global warming to 1.5°C with limited or no overshoot use CDR
- The larger and longer the overshoot, the greater the reliance on CDR later in the century
- BECCS (bioenergy with carbon capture and storage) features in most scenarios but is avoided in a few
- CDR at large scale could have significant impacts on land, food and water security, ecosystems and biodiversity
- Some AFOLU-related CDR measures such as restoration of natural ecosystems and soil carbon sequestration could improve biodiversity, soil quality, and local food security

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Energy investment and emission pathways

- Energy investments are 1.8% of global GDP over the period 2015–35 in assessed baseline scenarios
- This rises to 2.1% in 2°C pathways and 2.2% in 1.5°C pathways
- Energy investments rise by 0.36% of global GDP compared to the baseline in 1.5°C pathways
- Annual investments in low-carbon energy and energy efficiency would roughly double in the next 20 years
- Annual investments in fossil fuel extraction and conversion would decrease by about a quarter in the next 20 years

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IAMC 1.5°C Scenario Explorer hosted by IIASA release 1.0

International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

IAMC 1.5°C Scenario Explorer hosted by IIASA

This Scenario Explorer presents an ensemble of quantitative, model-based climate change mitigation pathways underpinning the *Special Report on Global Warming of 1.5°C* (SR1.5) by the Intergovernmental Panel on Climate Change's (IPCC) 2018.

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The scenario ensemble is made publicly available to ensure reproducibility and transparency with respect to the scenario set that has been assessed in SR15. The Scenario Explorer allows for the re-use of scenario data by other research communities, under a derivative of the Creative Commons Attribution 4.0 License. Please read the guidance note and the license terms on the License page before downloading data or figures.

Background of the Scenario Explorer

IPCC Special Report on Global Warming of 1.5°C

As part of the IPCC's *Special Report on Global Warming of 1.5°C* (SR15), an assessment of quantitative, model-based climate change mitigation pathways was conducted. To support the assessment, the Integrated Assessment Modeling Consortium (IAMC) facilitated a coordinated and systematic community effort by inviting modelling teams to submit their available 1.5°C and related scenarios to a curated database. The compilation and assessment of the scenario ensemble was conducted by authors of the IPCC SR15, and the resource is hosted by the International Institute for Applied Systems Analysis (IIASA) as part of a cooperation agreement with Working Group III of the IPCC.

The scenario ensemble contains more than 400 emissions pathways with underlying socio-economic development, energy system transformations and land use change until the end of the century, submitted by over a dozen research teams from around the world. The criteria for submission included that the scenario is presented in a peer-reviewed journal accepted for publication no later than May 15, 2018, or published in a report determined by the IPCC to be eligible grey literature by the same date.