IPCC Special Report on Global Warming of 1.5°C

– An energy perspective –

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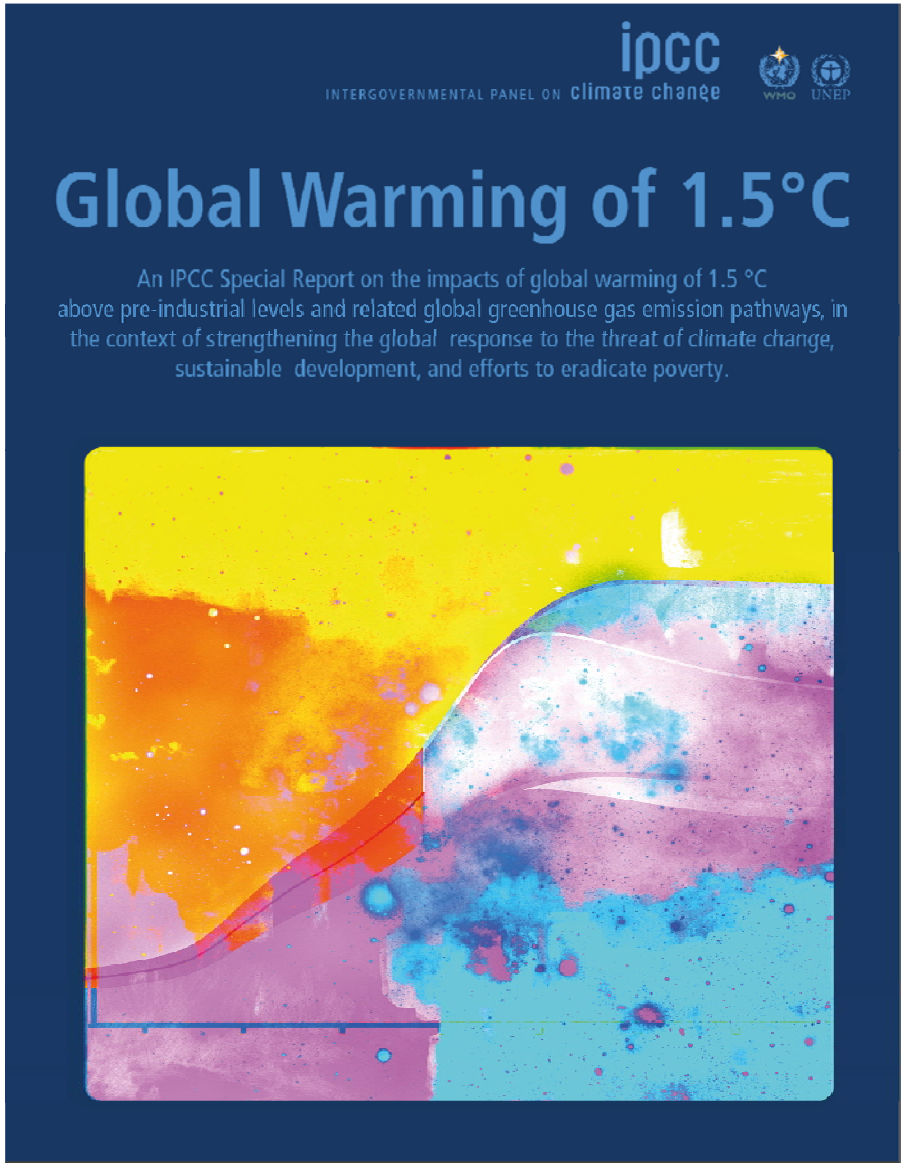

An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

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The report in numbers

91 Authors from **40** Countries

133 Contributing authors

6000 Studies

1 113 Reviewers

42 001 Comments

General context: Understanding Global Warming of 1.5°C

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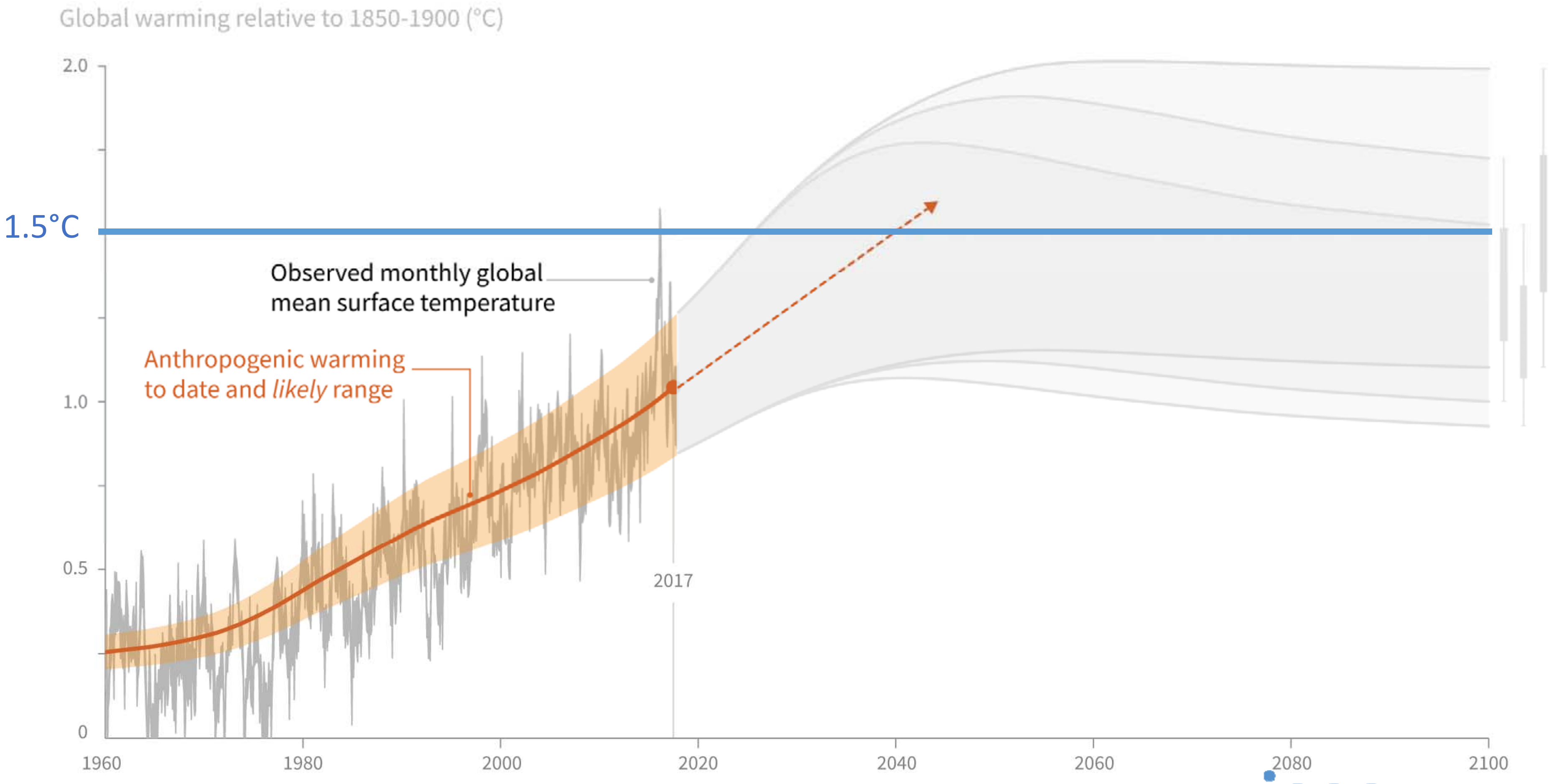
SPM1 | Cumulative emissions of CO_2 and future non-CO_2 radiative forcing determine the probability of limiting warming to 1.5°C



Understanding 1.5°C: Where are we now?

Since pre-industrial times, **human activities** have caused approximately 1.0°C of global warming.

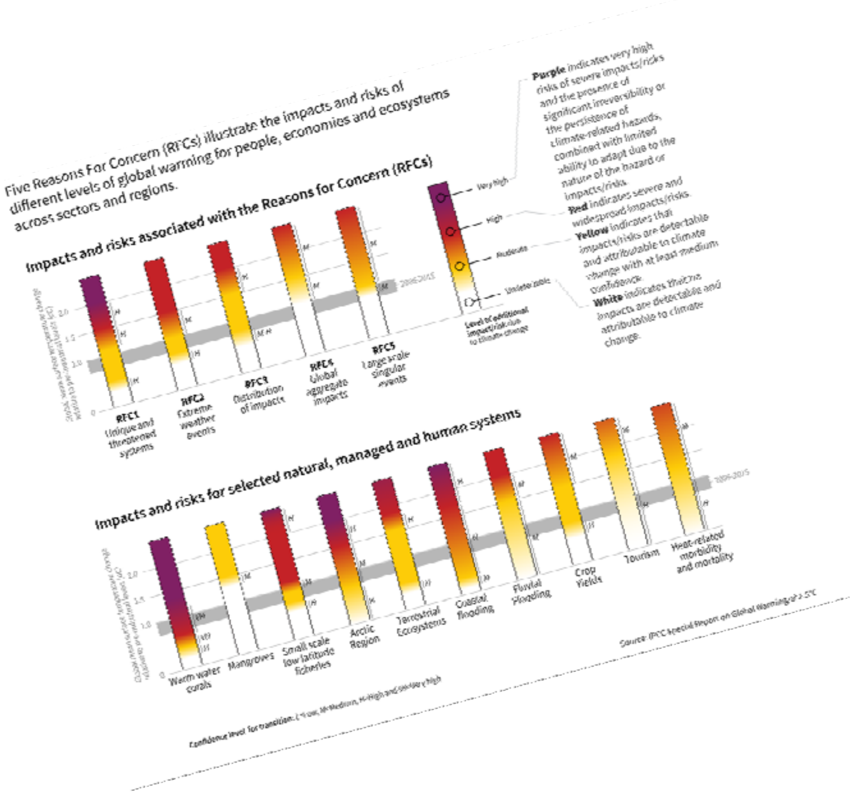
- Already seeing consequences for people, nature and livelihoods

- At current rate (0.2°C per decade), global warming would reach 1.5°C around 2040 (range: 2030 to 2052)
- Effects of past emissions will persist for centuries to millennia, causing long-tem changes like sea-level rise
- *But* past emissions alone do not commit the world to 1.5°C

- Halting global warming requires:
  reaching and sustaining **net-zero global anthropogenic CO_2 emissions** and **declining non-CO_2 radiative forcing**

General Context:
Projected Climate Change, Potential Impacts and Associated Risks

SPM2 | How the level of global warming affects impacts and/or risks associated with the Reasons for Concern and selected natural, managed and human systems



Key message:
clear difference between
1.5°C and 2°C of warming

- Less extreme weather including extreme heat and rainfall
- Lower impact on biodiversity and species
- Global population exposed to increased water shortages is up to 50% less
- Lower risk to fisheries and the livelihoods that depend on them
- Up to several hundred million fewer people exposed to climate-related risk and susceptible to poverty by 2050
- …

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

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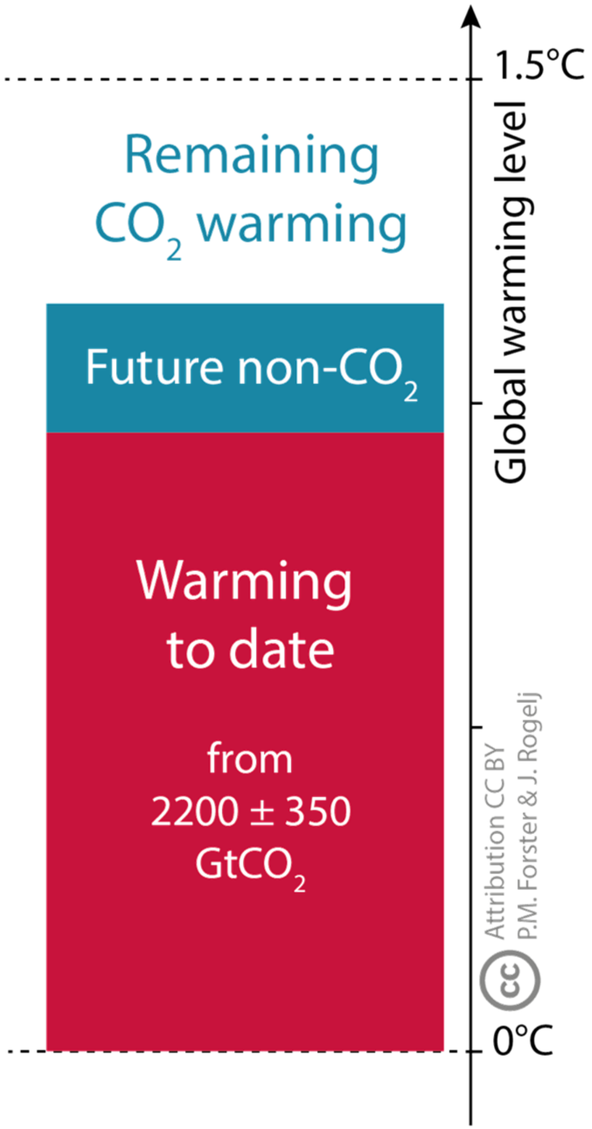


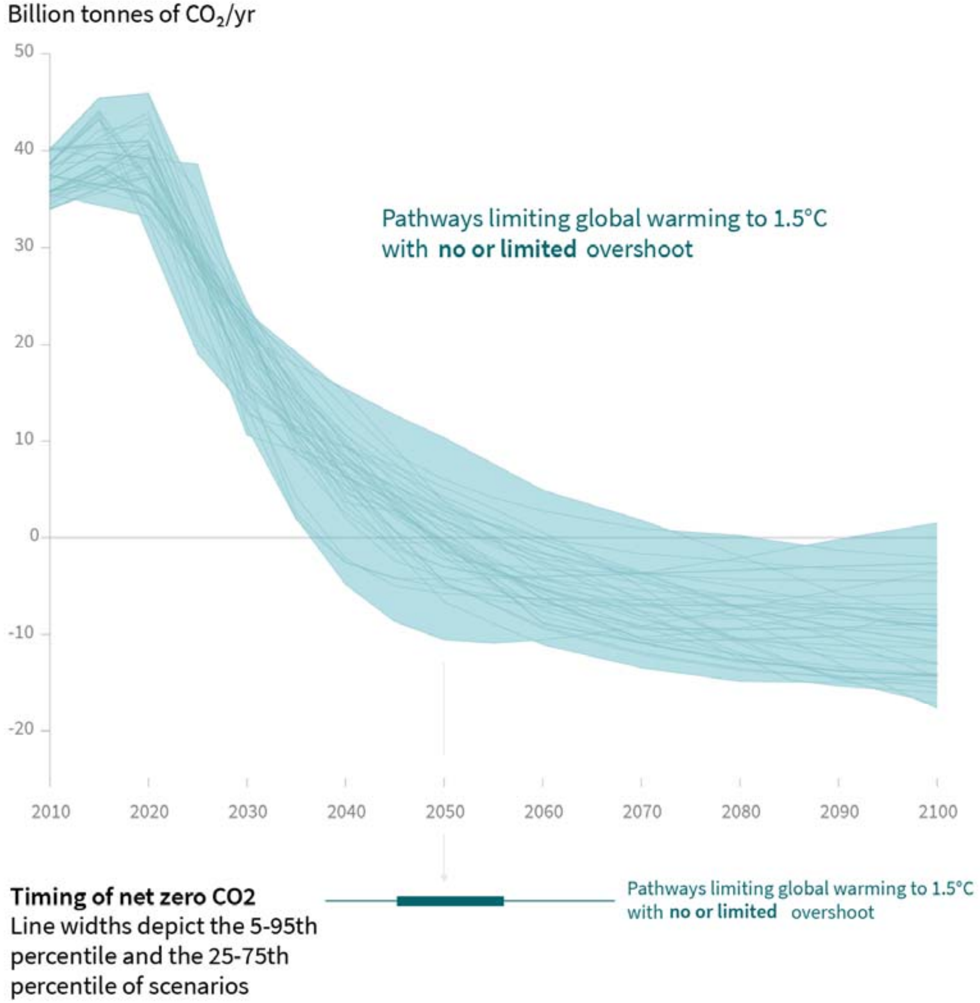
Remaining carbon budget

- 580 $GtCO_2$ left (50% chance of 1.5°C)
  420 $GtCO_2$ left (66% chance of 1.5°C)
  +- 400 $GtCO_2$ geophysical uncertainty
  +- 250 $GtCO_2$ depends on what is done on non-CO_2

- Currently, 42 +- 3 $GtCO_2$/yr annually

- 200 $GtCO_2$ budget differences are about 5 year of current emissions and imply roughly a 10 year variation in the mid-century timing of reaching net zero CO_2 emissions.

SPM3a | Global CO_2 emissions pathway characteristics

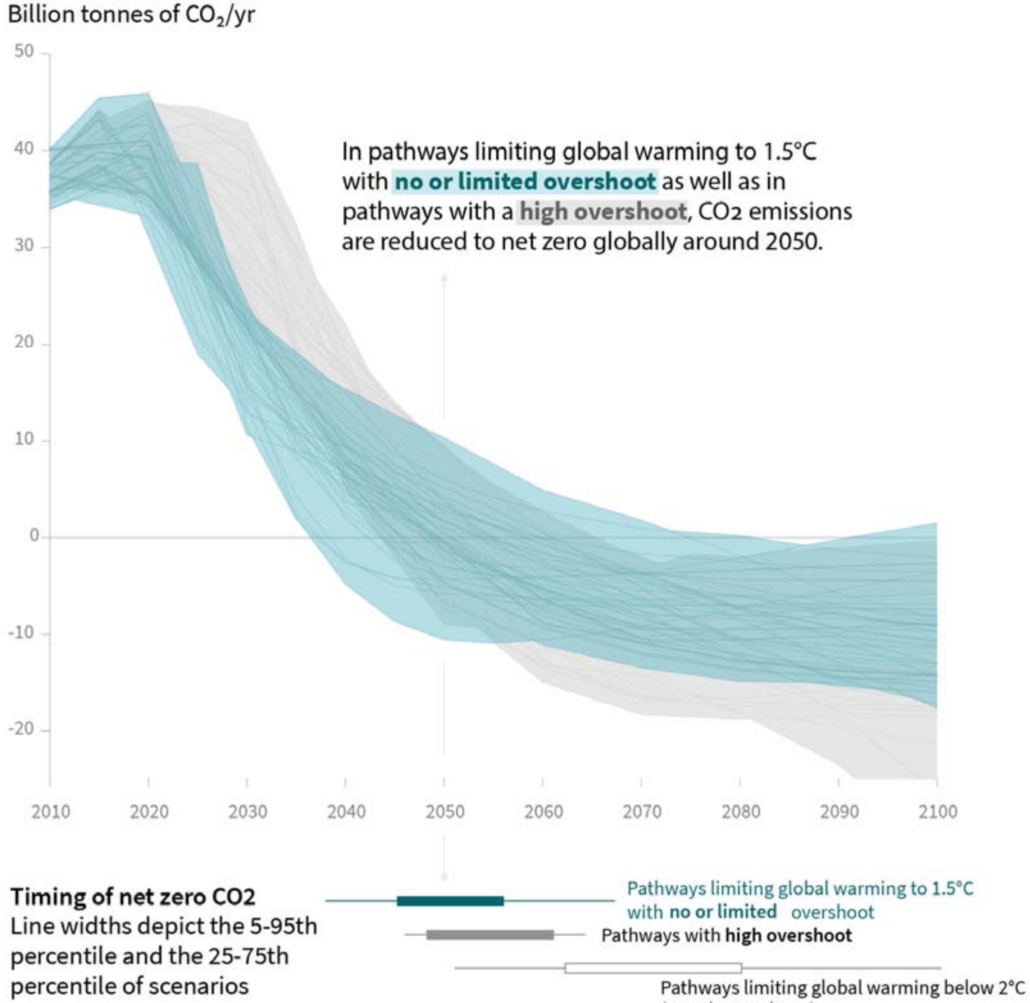


Source: IPCC Special Report on Global Warming of 1.5°C

1.5°C with no or limited overshoot (less than 0.1°C):

- Robust declining trend in next decade
- Varying levels of carbon-dioxide removal after 2050
- Reach net-zero CO_2 around mid-century

SPM3a | Global CO_2 emissions pathway characteristics

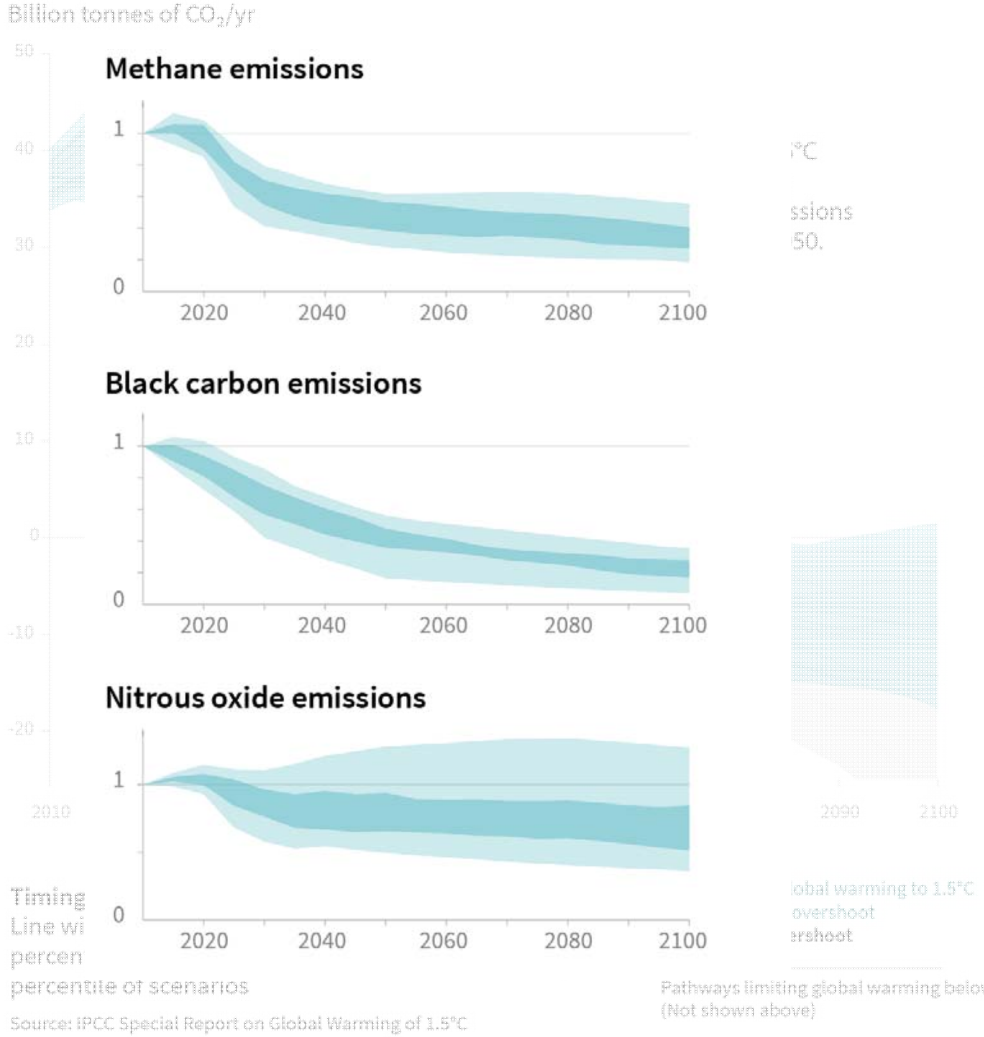


Source: IPCC Special Report on Global Warming of 1.5°C

1.5°C with higher overshoot:

- Robust decline delayed by a decade
- More carbon-dioxide removal after 2050
- Also reach net-zero CO_2 around mid-century

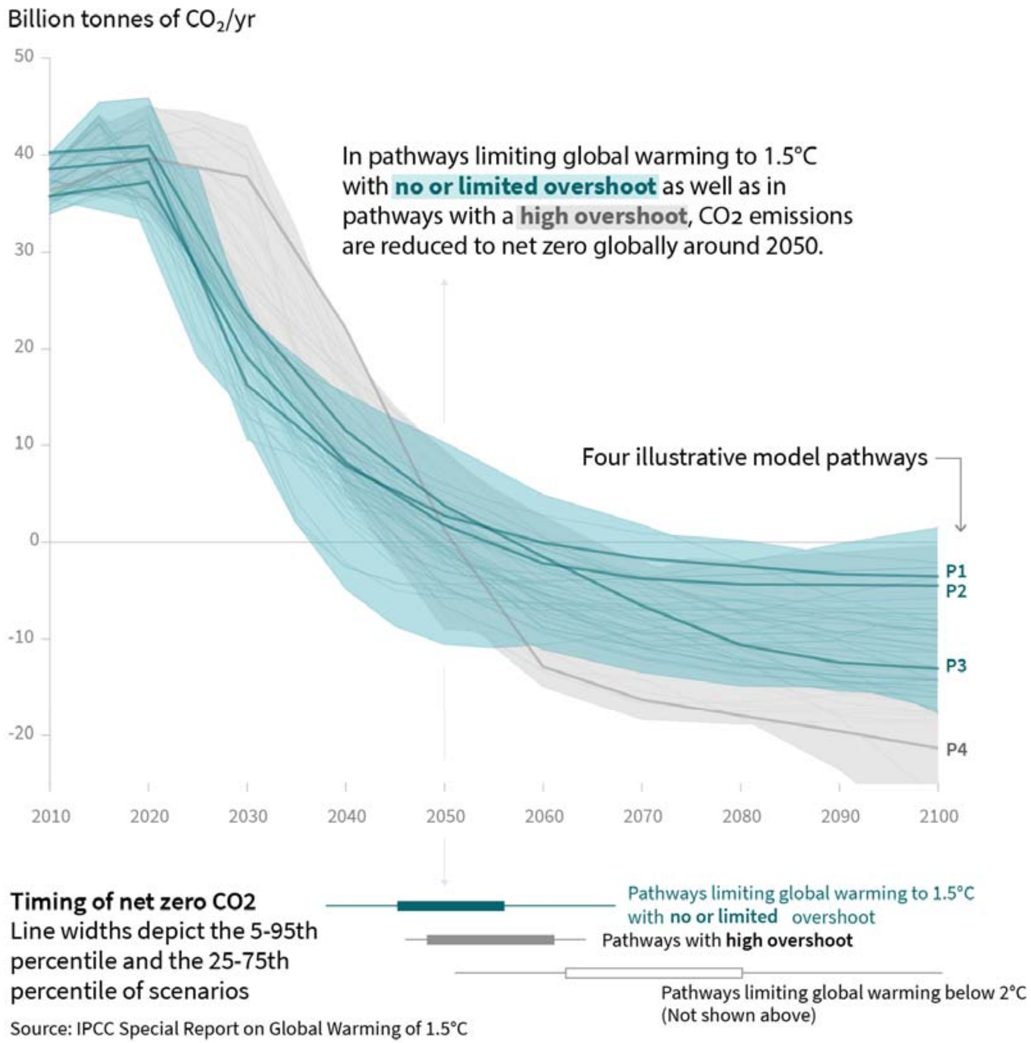
SPM3a | Global emissions pathway characteristics



Non-CO_2 emissions relative to 2010

Emissions of non-CO2 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.

SPM3a | Global CO_2 emissions pathway characteristics



Four illustrative pathways that allow to explore the variations in underlying system transitions

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Greenhouse gas emissions pathways

To limit warming to 1.5°C:

- CO_2 emissions reduced by about 45% by 2030 (from 2010 levels, range 40-60%)
  - → Compared to 20% (10-30%) for 2°C
- CO_2 emissions would need to reach 'net zero' around 2050
  - → Compared to around 2075 for 2°C
- Energy system CO_2 emissions would also need to reach 'net zero' around 2050

Gerhard Zwerger-Schoner / Aurora Photos

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Greenhouse gas emissions pathways

- National pledges under the Paris Agreement are not enough to limit warming to 1.5°C. They lead to 52-58 $GtCO_2eq/yr$ in 2030, whereas 1.5°C pathways show a 25-30 $GtCO_2eq/yr$ range.
- Avoiding warming of more than 1.5°C would require CO_2 emissions to decline substantially before 2030
- Planning to temporarily exceed and later return warming to 1.5°C (overshoot) comes with substantial risks and implies a firm commitment to large-scale carbon-dioxide removal (CDR)

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1.5°C Mitigation Pathways: Implications for energy

Systems transitions

- Limiting warming to 1.5°C would require rapid, far-reaching changes on an unprecedented scale:
  - → Deep emissions cuts in all sectors
  - → A range of technologies
  - → Behavioural changes
  - → Increase investment in low carbon options

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System transitions - general trends

I. Improve energy efficiency
   Limiting final energy demand in 2050
   to +20 to -10% rel. to 2010 levels
II. Decarbonize the power sector
   (carbon-intensity of electricity about 0 or negative in 2050)
III. Electrify energy end use
   (mobility, buildings, industry)
IV. Subs. residual fossil fuels with low-carbon options
   (e.g. gas for heating, petrol for driving with bio-based fuels)

- Different roles for different type of fuels

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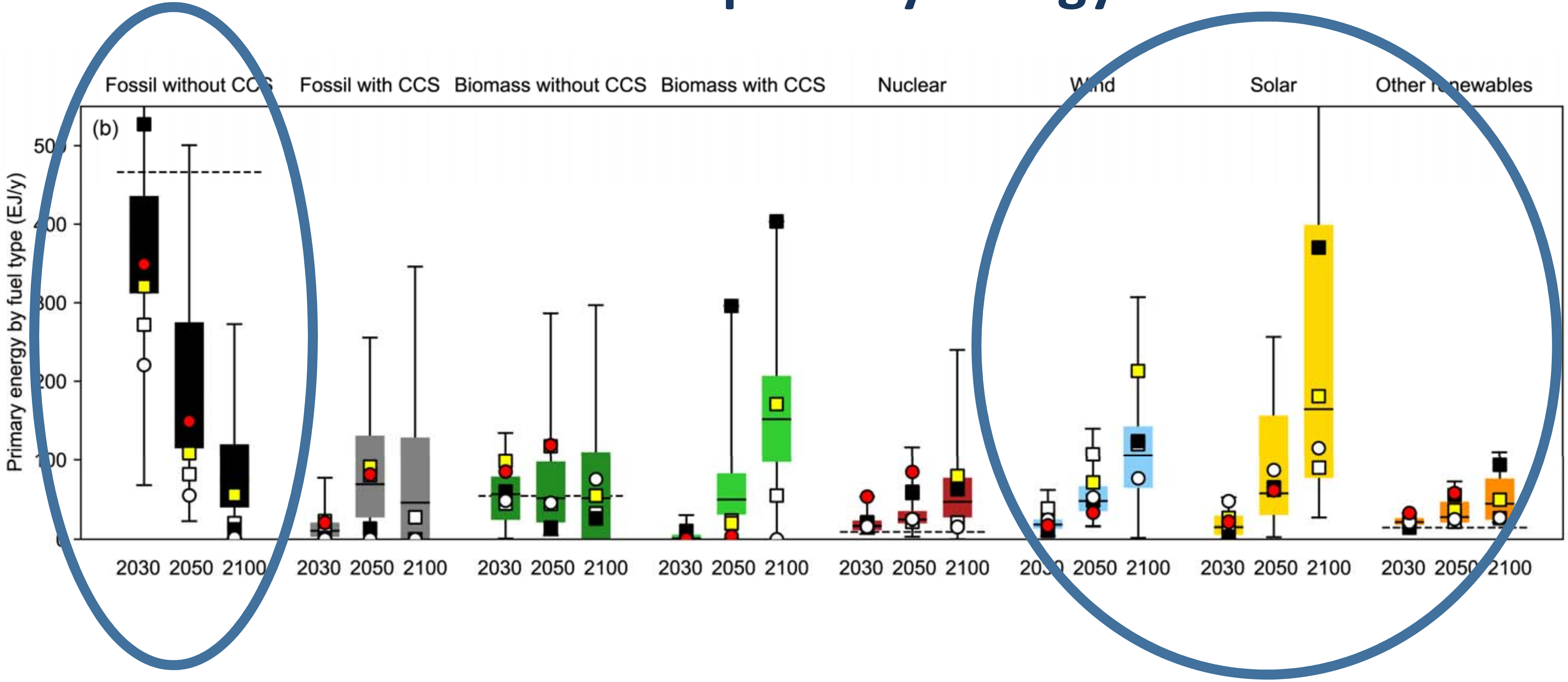
Energy system transitions
Global primary energy



Energy system transitions

Global primary energy

In pathways limiting warming to 1.5°C:

- Fossil fuels as a groups show a clear decline, but with important variations

- Coal sees a robust strong decline in all 1.5°C pathways
- Oil also declines by mid-century but to a lesser degree
- Projected gas use varies from strong reductions to increases from today's levels

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Energy system transitions

Global primary energy

In pathways limiting warming to 1.5°C
with no or limited overshoot

By 2030:

- Fossil fuels still supply 2/3rd of global primary energy
  (range: 30-80%) from about 85% in 2020
- Coal reduced to about 10% of global primary energy
  from about 25% in 2020
- Oil supplies about 30% of global primary energy
  similar to the 2020 share
- Gas supplies about 25% of global primary energy
  similar to the 2020 share

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Energy system transitions

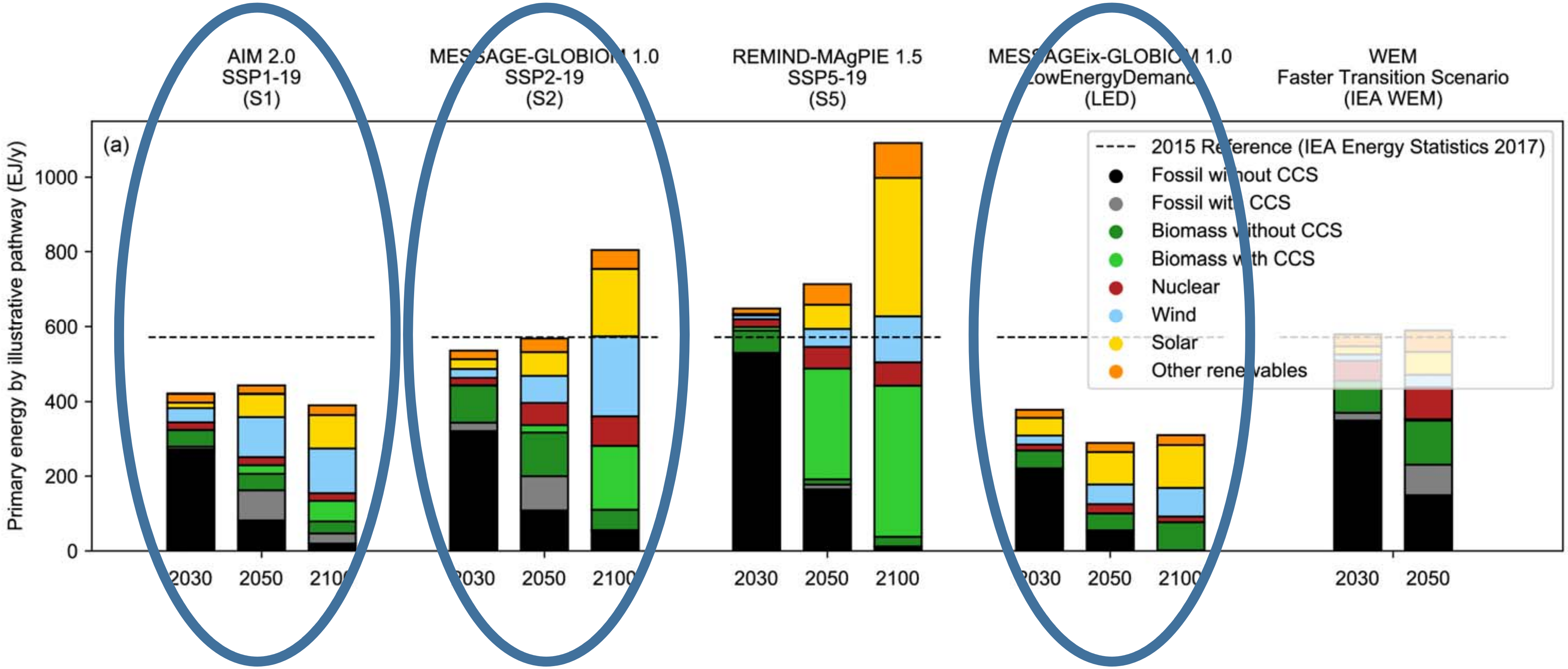
Global primary energy

In pathways limiting warming to 1.5°C
with no or limited overshoot

By 2050:

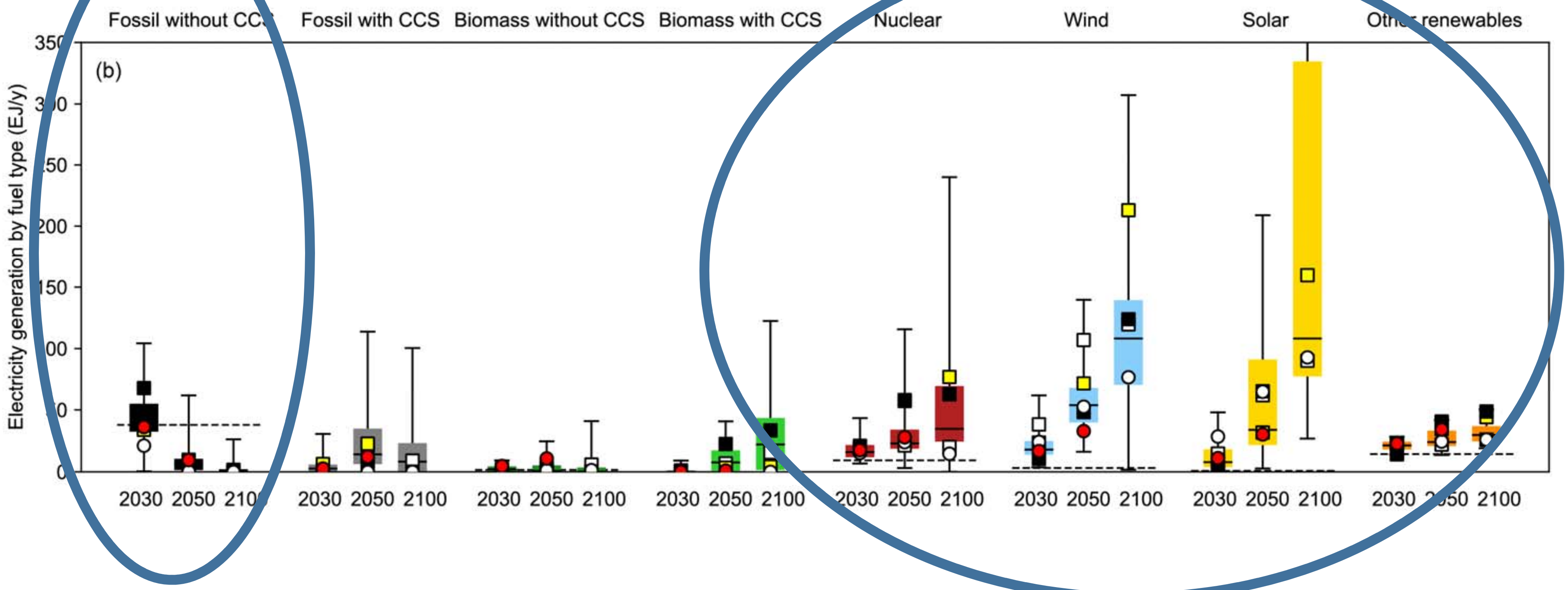
- Fossil fuels supply 1/3rd of global primary energy
  (range: 10-60%)
- Coal is reduced to 5% of global primary energy
  (range: 0-10%)
- Oil supplies about 15% of global primary energy,
  (range: 5-25%)
- Gas supplies about 15% of global primary energy,
  (range: 5-35%)

Energy system transitions



Limiting warming to 1.5°C
with no or limited overshoot

Electricity system transitions
Full decarbonisation by mid-century



Electricity system transitions

Global electricity generation
In pathways limiting warming to 1.5°C
with no or limited overshoot

By 2030:

- Fossil fuels supply 1/3rd of electricity (range: 0-55%)
  from about 60% in 2020
- Coal supplies about 5% of electricity
  from about 30% in 2020
- Oil supplies less than 5% of electricity
  similar to 2020
- Gas supplies about 20% (range: 0-35%) of electricity
  from about 25% in 2020

Electricity system transitions

Global electricity generation
In pathways limiting warming to 1.5°C
with no or limited overshoot

By 2050:

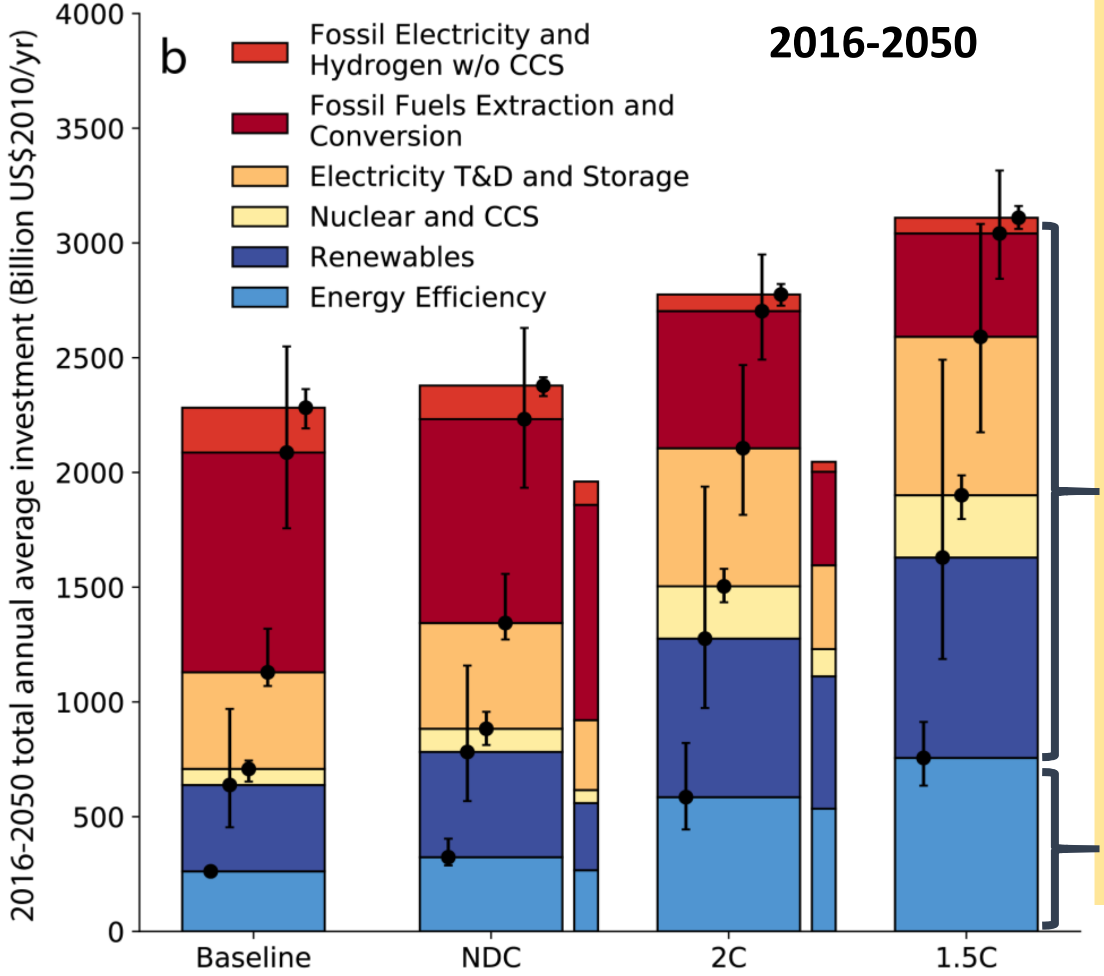
- Fossil fuels supply less than 10% of electricity (range: 0-25%)
- Coal is phased out of electricity (<1%)
- Oil is phased out of electricity (<1%)
- Gas supplies about 5% (range: 0-25%) of electricity

Energy system transitions

Reasons for variations in gas use?

- Managing of upstream gas leakage
- Successful deployment of carbon capture and storage (CCS)
- Acceptance of overshoot risk
- Success in limiting energy demand

Investments



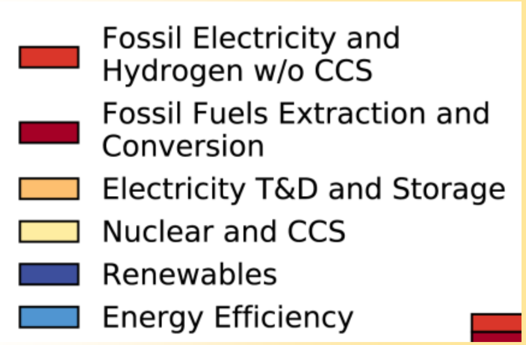
Key changes:

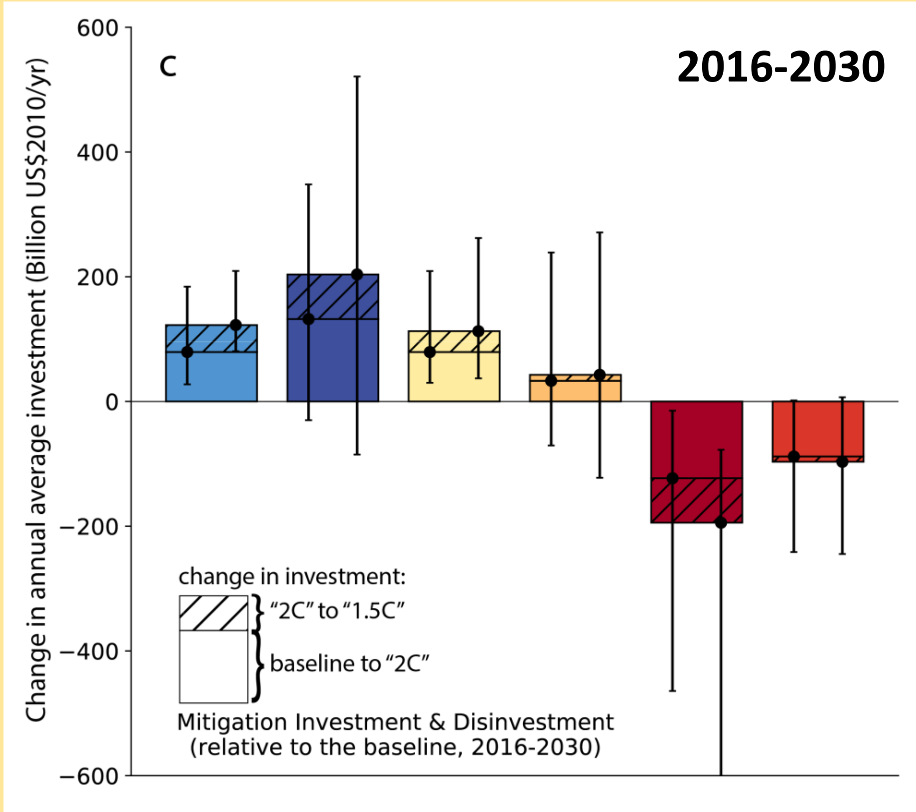
- 12% increase in total annual (2016-2050) investments between 1.5°C and 2°C
- 890 billion USD additional rel. baseline
- Average annual investment in low-carbon energy technologies and energy efficiency upscaled by a factor of six (range 4-10) by 2050 compared to 2015

1460-3510 billion USD
energy supply investments

640-910 billion USD
energy demand investments

Investments changes

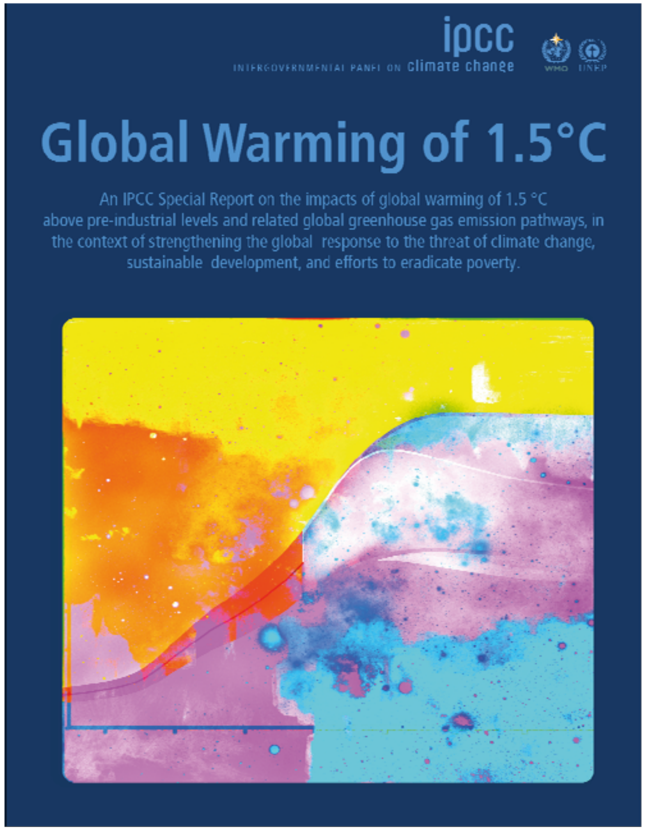




Sustainability considerations for continued gas use

- Increasing water shortages for thermal electricity generation with CCS
- Taking into account other factors (ambient water resources and demand changes in irrigation water)
- Applying CCS would increase water consumption
- Uncertainty in the future CCS given:
  - limited pace of current deployment
  - the current lack of incentives for large-scale implementation of CCS
- Near- and long-term warming impact of gas leakage

Conclusions



- Limiting global warming to 1.5°C will require rapid, far-reaching and unprecedented changes in the energy system

- By mid-century:
  - Energy efficiency key to keep flexibility in choices
  - Coal is phased out globally
  - Oil is phased out from electricity, but can still supply a smaller share of primary energy
  - Gas shows a large range in both primary energy and electricity, with the difference between a global phase-out and continued use strongly dependent on the success of CCS

- Trade-offs with sustainable development (water)
- Risk of overshoot can increase if gas infrastructure is developed without operational CCS, or insufficiently leakage control

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