Climate change: a summary for policy-makers

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Climate change: a summary for policymakers

- How rising atmospheric CO_2 causes global warming
- How global temperatures and sea level respond
- Quantifying human influence on climate and weather
- The fate of CO_2 and other anthropogenic emissions
- Global impact functions and the social cost of carbon
- Mitigation costs and pathways
- Policy options from carbon pricing to geo-engineering
- Capstone activity: design a robust climate policy

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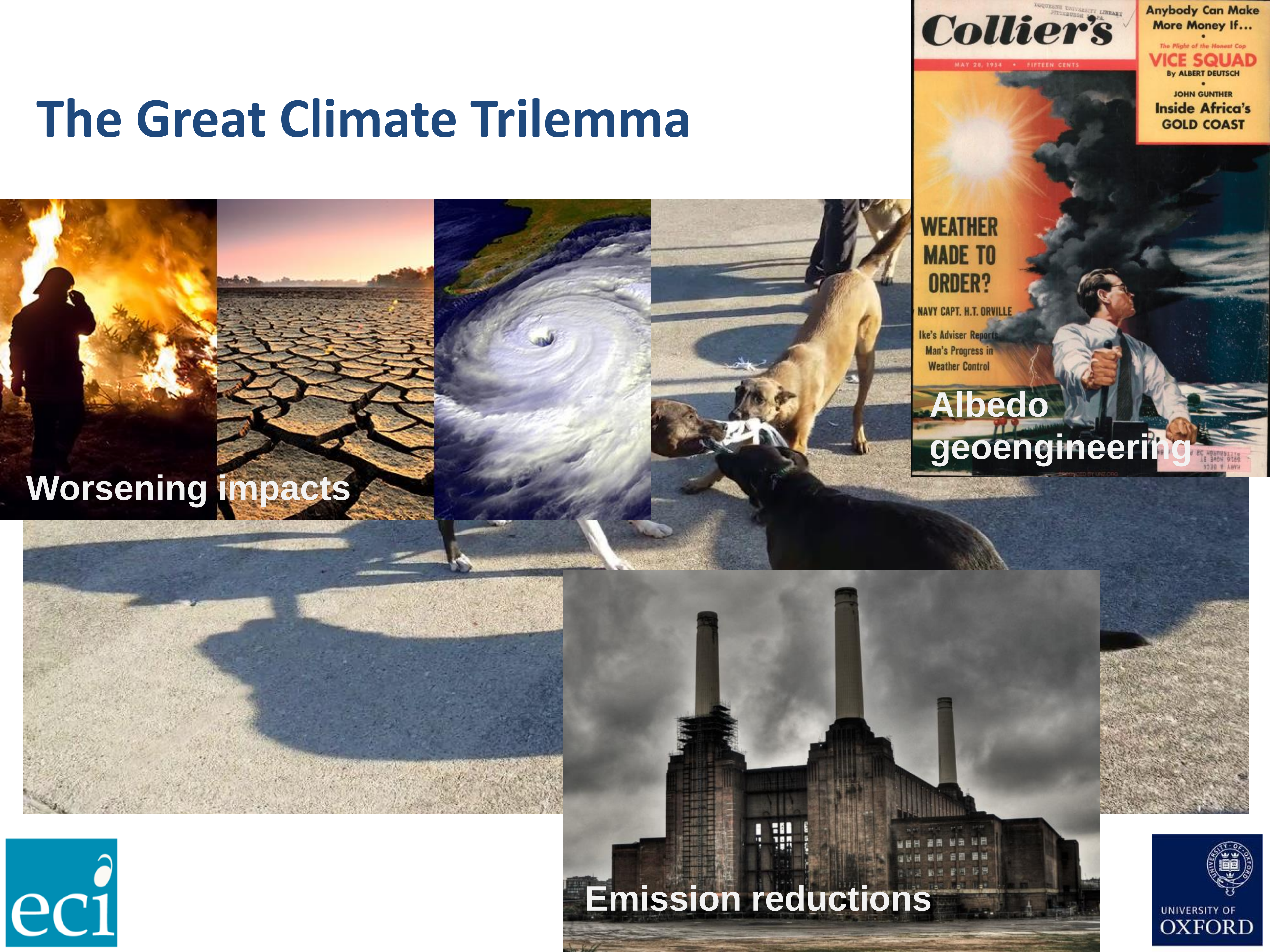
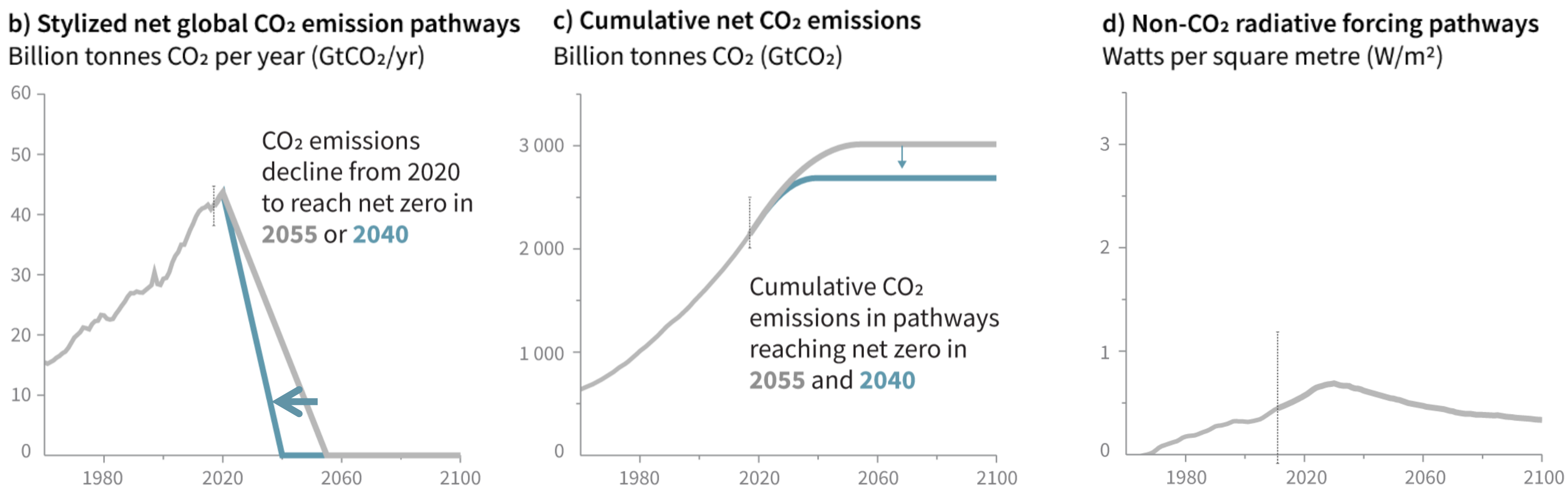
The Great Climate Trilemma



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



Faster CO_2 reductions reduce cumulative CO_2 emissions and increase the probability of limiting warming to 1.5° C

INTERGOVERNMENTAL PANEL ON climate change
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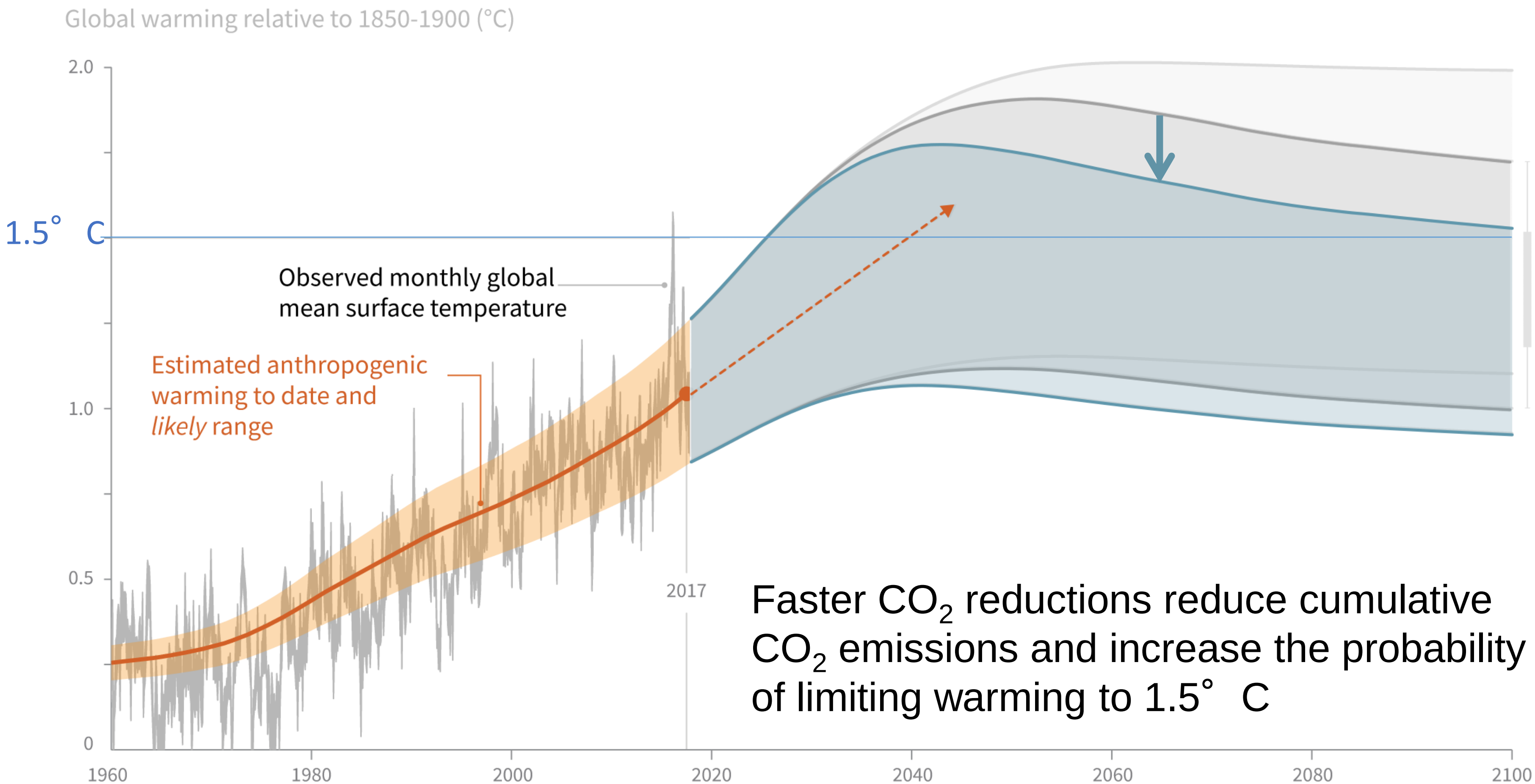

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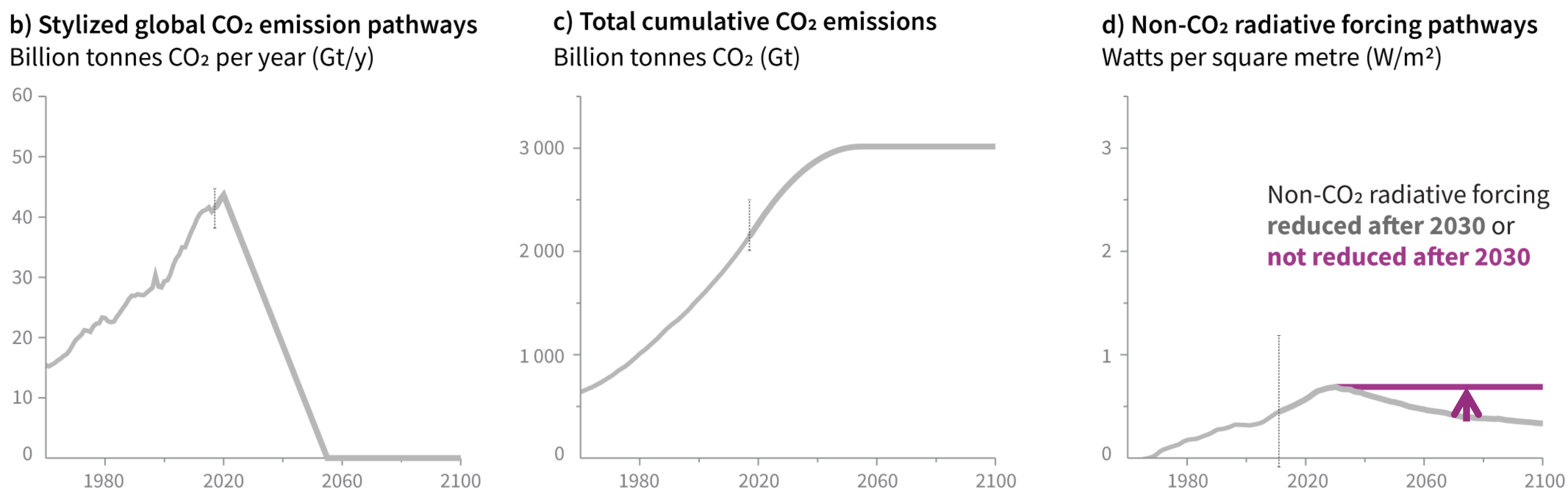

Future temperatures are also affected by radiative forcing due to methane, aerosols, nitrous oxide and other forcing agents

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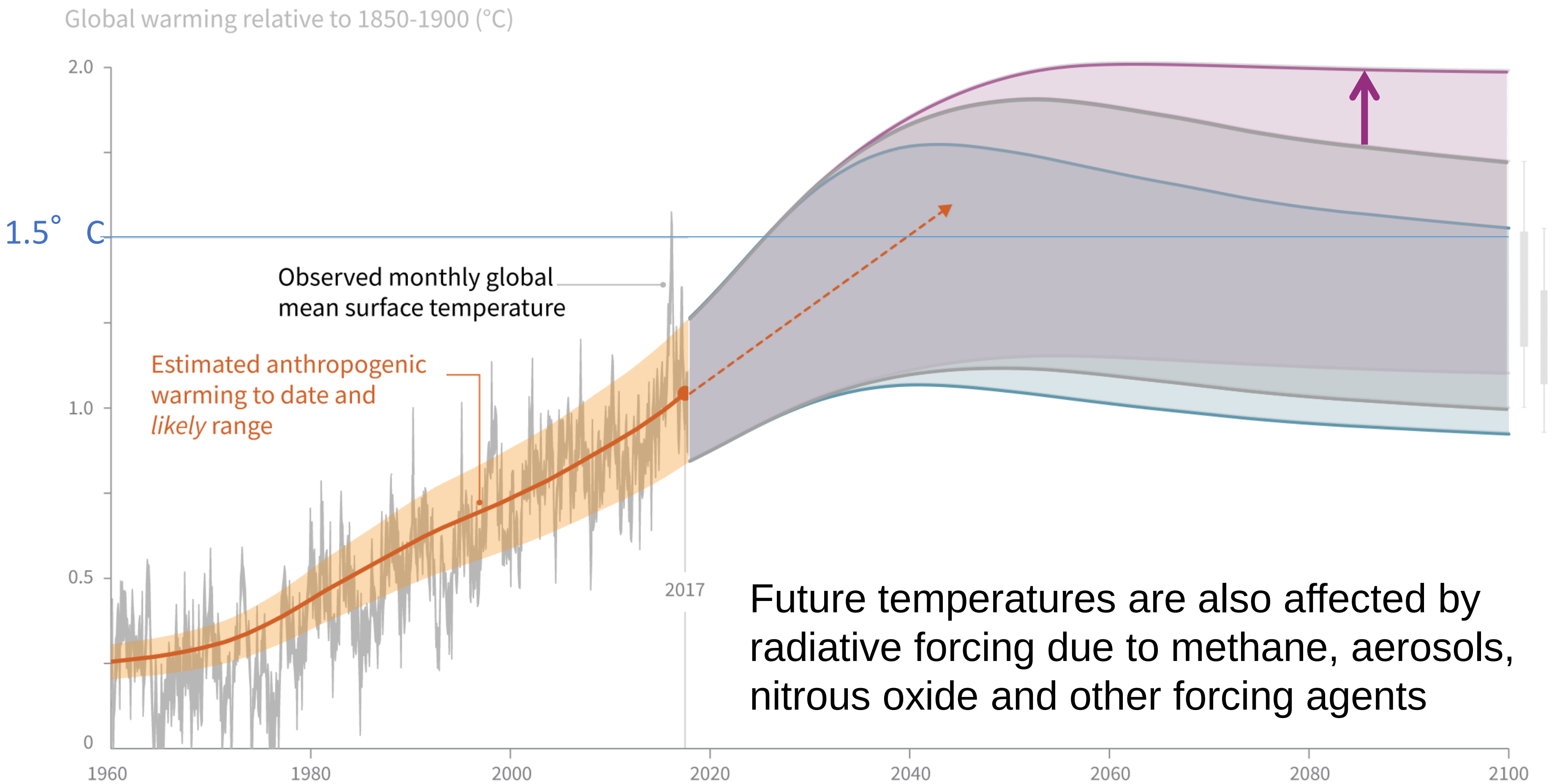
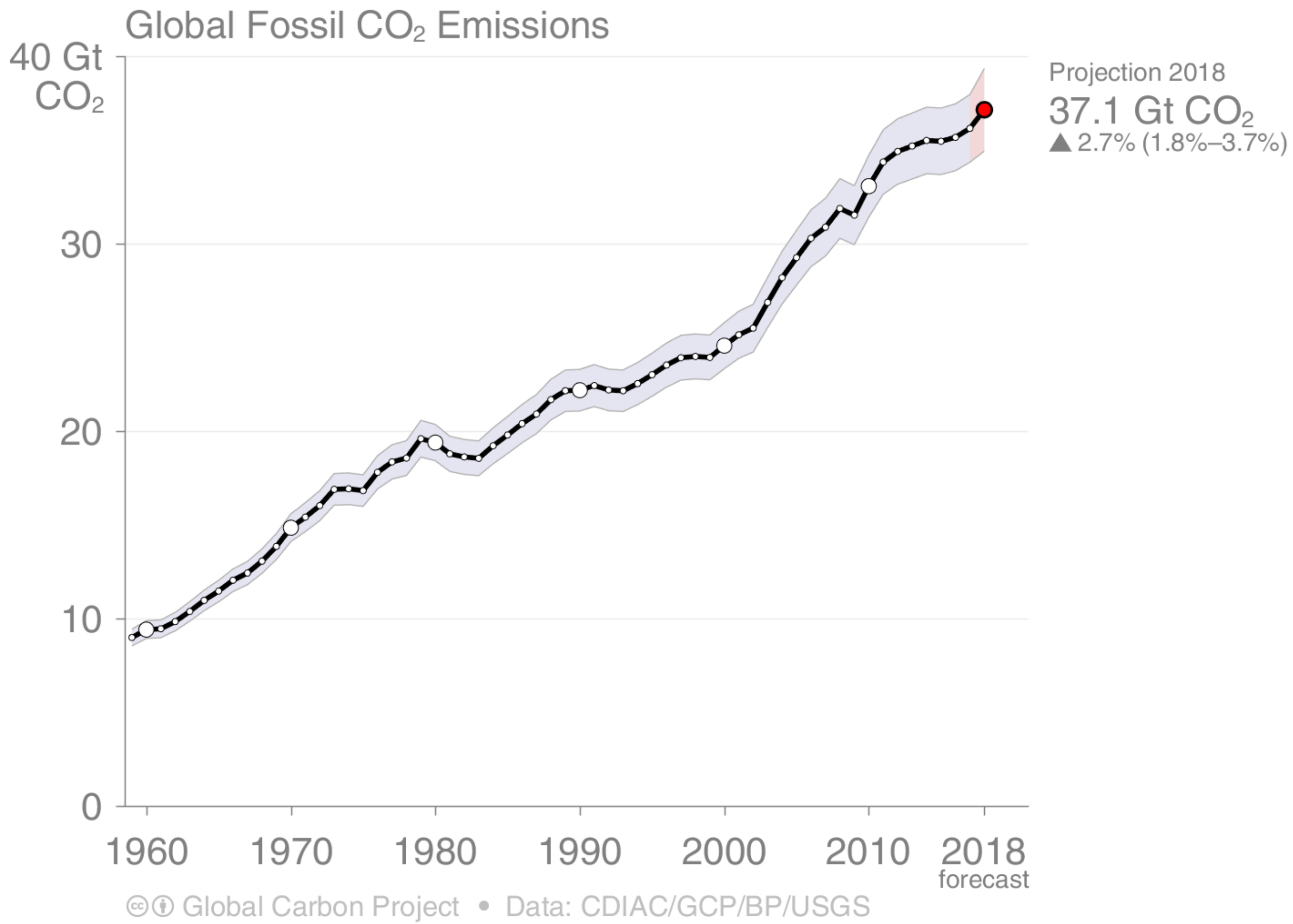


Future temperatures are also affected by radiative forcing due to methane, aerosols, nitrous oxide and other forcing agents

INTERGOVERNMENTAL PANEL ON climate change

Global Fossil CO_2 Emissions

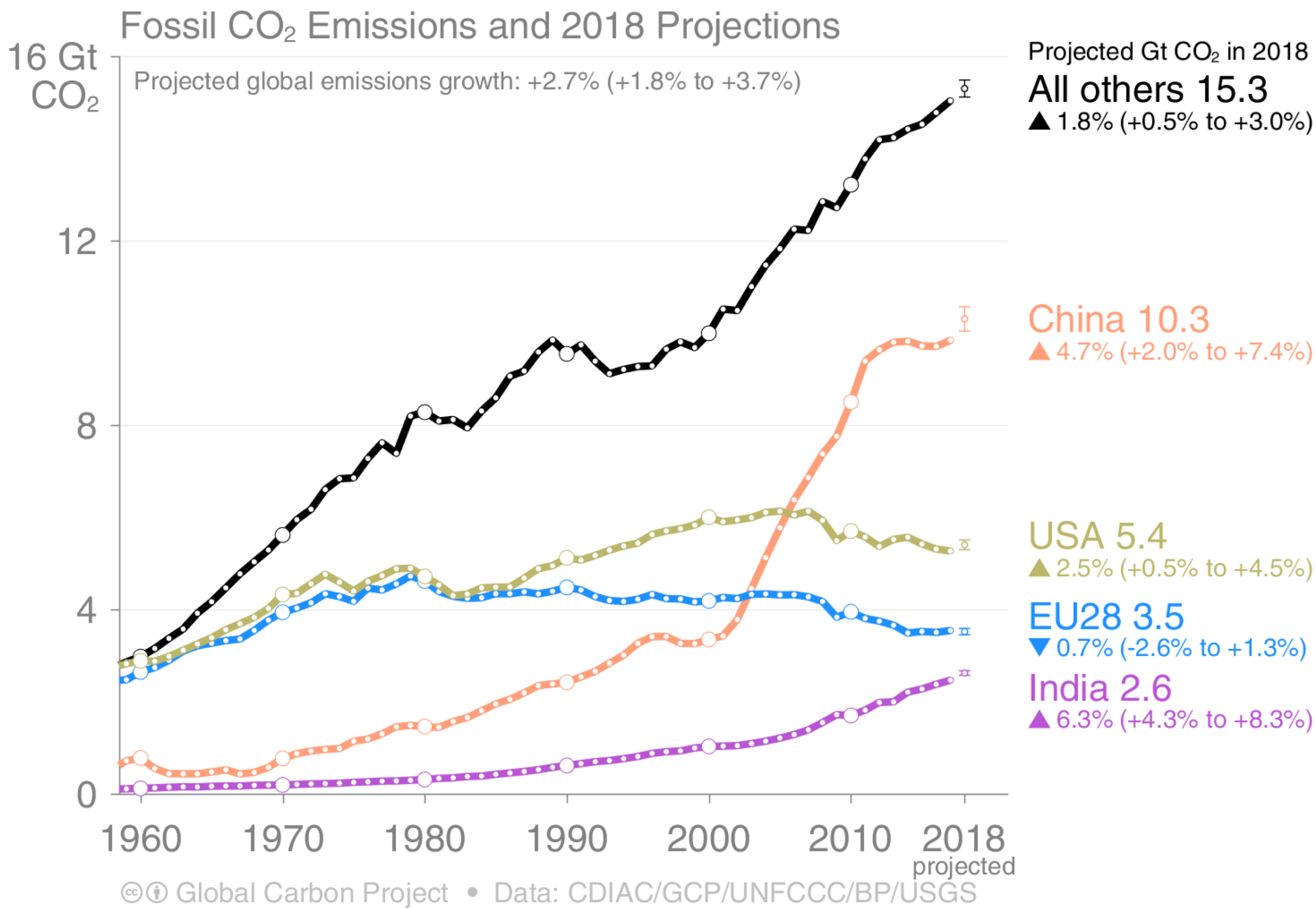
Global fossil CO_2 emissions have risen steadily over the last decades.
The peak in global emissions is not yet in sight.



Estimates for 2015, 2016 and 2017 are preliminary ; 2018 is a projection based on partial data.
Source: CDIAC; Le Quéré et al 2018; Global Carbon Budget 2018

Emissions Projections for 2018

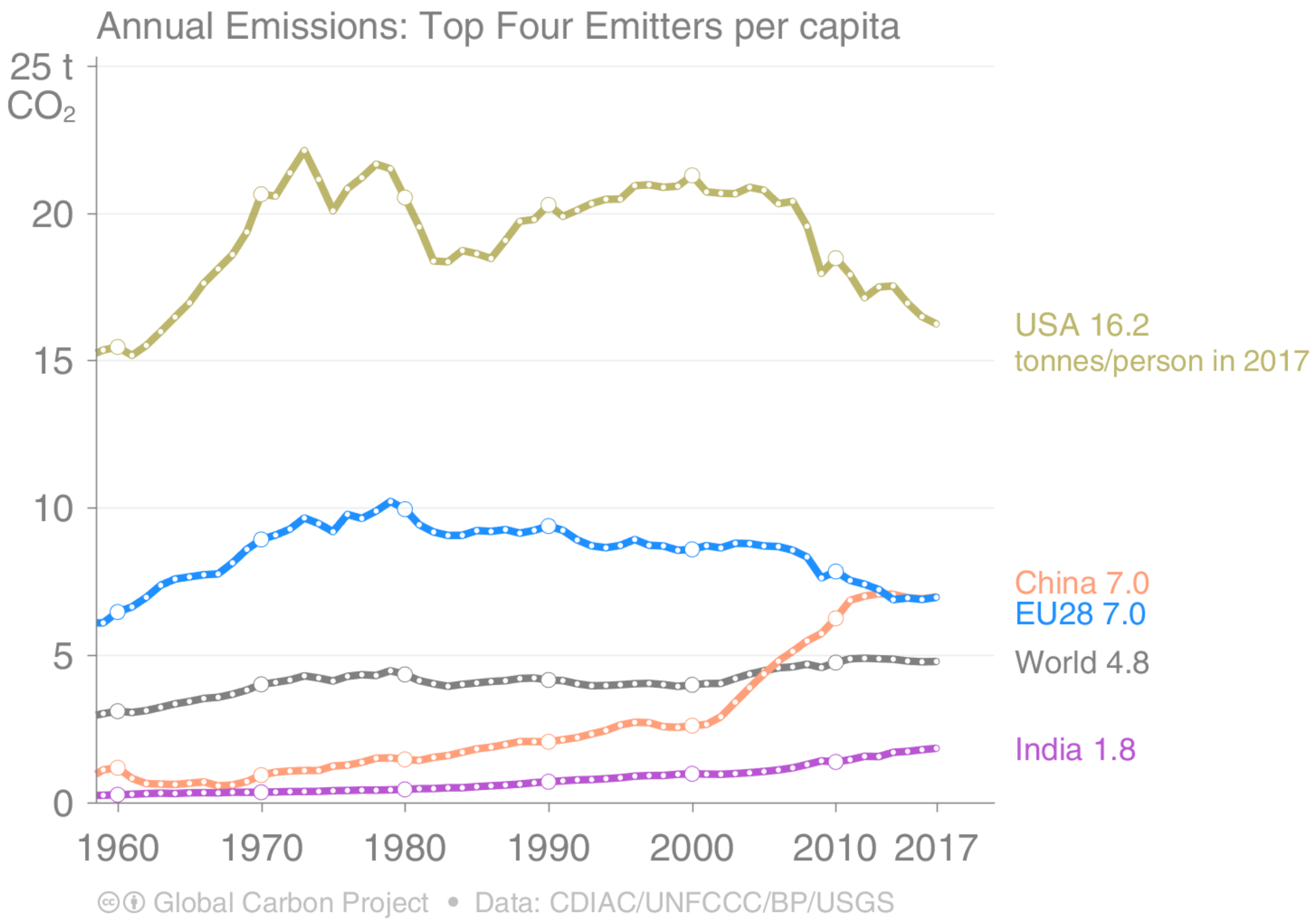
Global fossil CO_2 emissions are projected to rise by 2.7% in 2018 [range: +1.8% to +3.7%]
The global growth is driven by the underlying changes at the country level.



Source: CDIAC; Jackson et al 2018; Le Quéré et al 2018; Global Carbon Budget 2018

Top emitters: Fossil CO_2 Emissions per capita

Countries have a broad range of per capita emissions reflecting their national circumstances



Source: [CDIAC](); [Le Quéré et al 2018](); [Global Carbon Budget 2018]()

Framing the mitigation problem

- The Kaya Identity:

$$\text{Emissions} = \frac{\text{Emissions}}{\text{Energy}} \times \frac{\text{Energy}}{\text{Consumption}} \times \frac{\text{Consumption}}{\text{Population}} \times \text{Population}$$

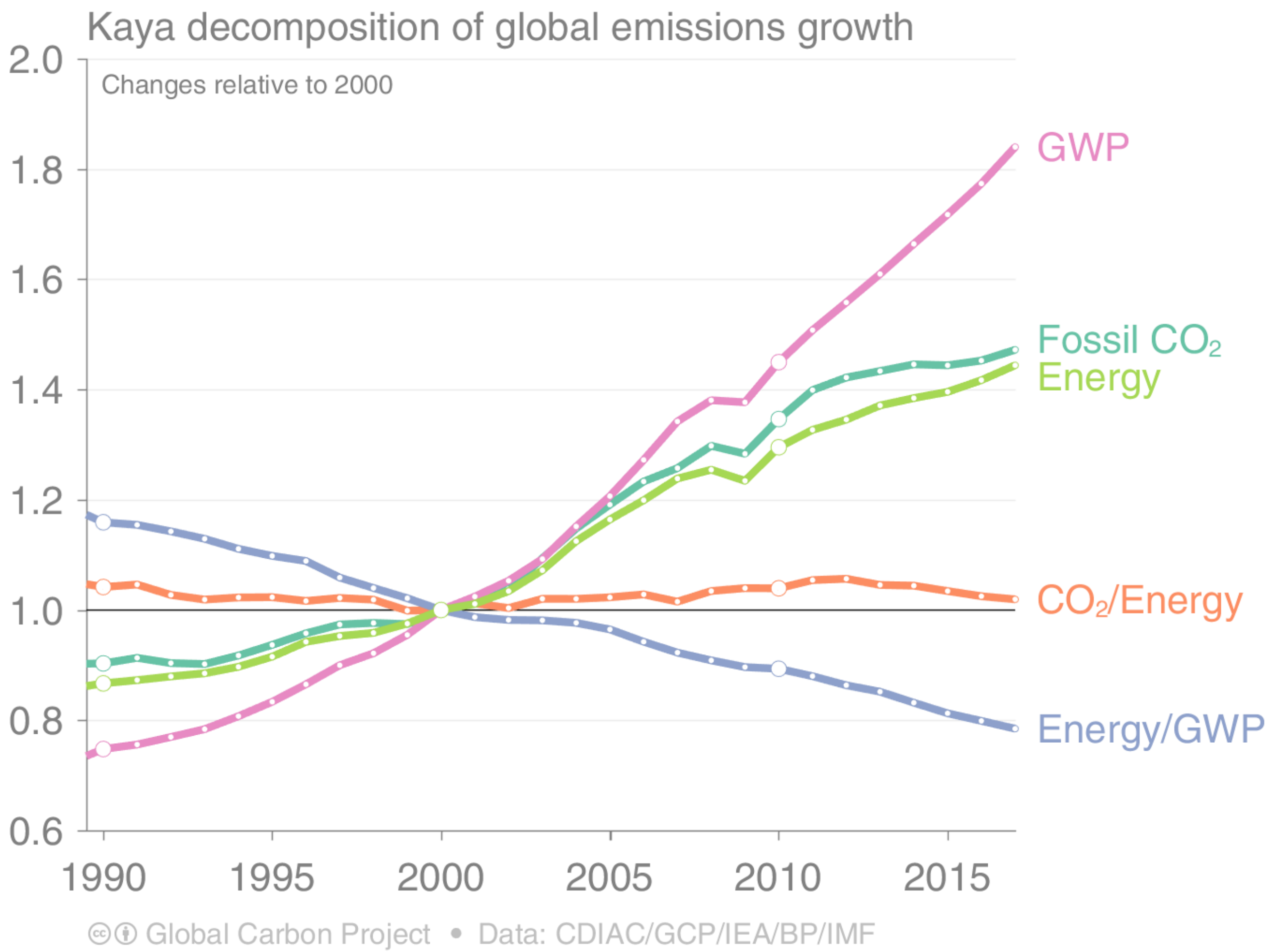
Framing the mitigation problem

- The Kaya Identity: **what is actually happening**

$$\text{Emissions} = \frac{\text{Emissions}}{\text{Energy}} \times \frac{\text{Energy}}{\text{Consumption}} \times \frac{\text{Consumption}}{\text{Population}} \times \text{Population}$$

Kaya decomposition

The Kaya decomposition illustrates that relative decoupling of economic growth from CO_2 emissions is driven by improved energy intensity (Energy/Gross World Product)



GWP: Gross World Product (economic activity)

Energy is Primary Energy from BP statistics using the substitution accounting method

Source: [Jackson et al 2018]; [Global Carbon Budget 2018]

Framing the mitigation problem

- The Kaya Identity:

$$\text{Emissions} = \frac{\text{Emissions}}{\text{Energy}} \times \frac{\text{Energy}}{\text{Consumption}} \times \frac{\text{Consumption}}{\text{Population}} \times \text{Population}$$

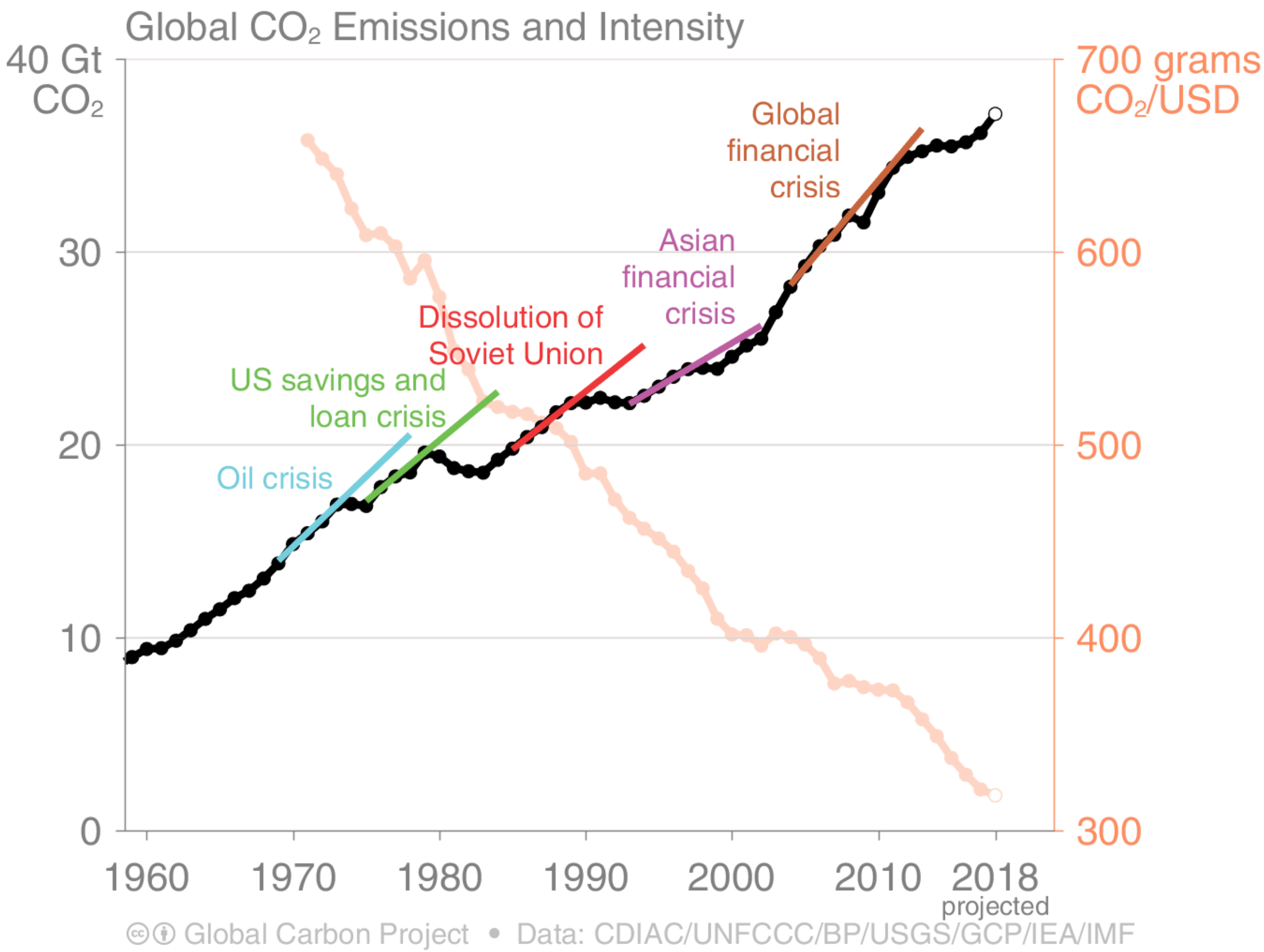
- A more progressive Kaya Identity:

$$\text{Emissions} = \frac{\text{Emissions}}{\text{Energy}} \times \frac{\text{Energy}}{\text{Consumption}} \times \frac{\text{Consumption}}{\text{Welfare}} \times \frac{\text{Welfare}}{\text{Population}} \times \text{Population}$$

- Welfare economics: recognizing that the impact of a £1 increase in consumption depends on your starting point.

Fossil CO_2 emission intensity

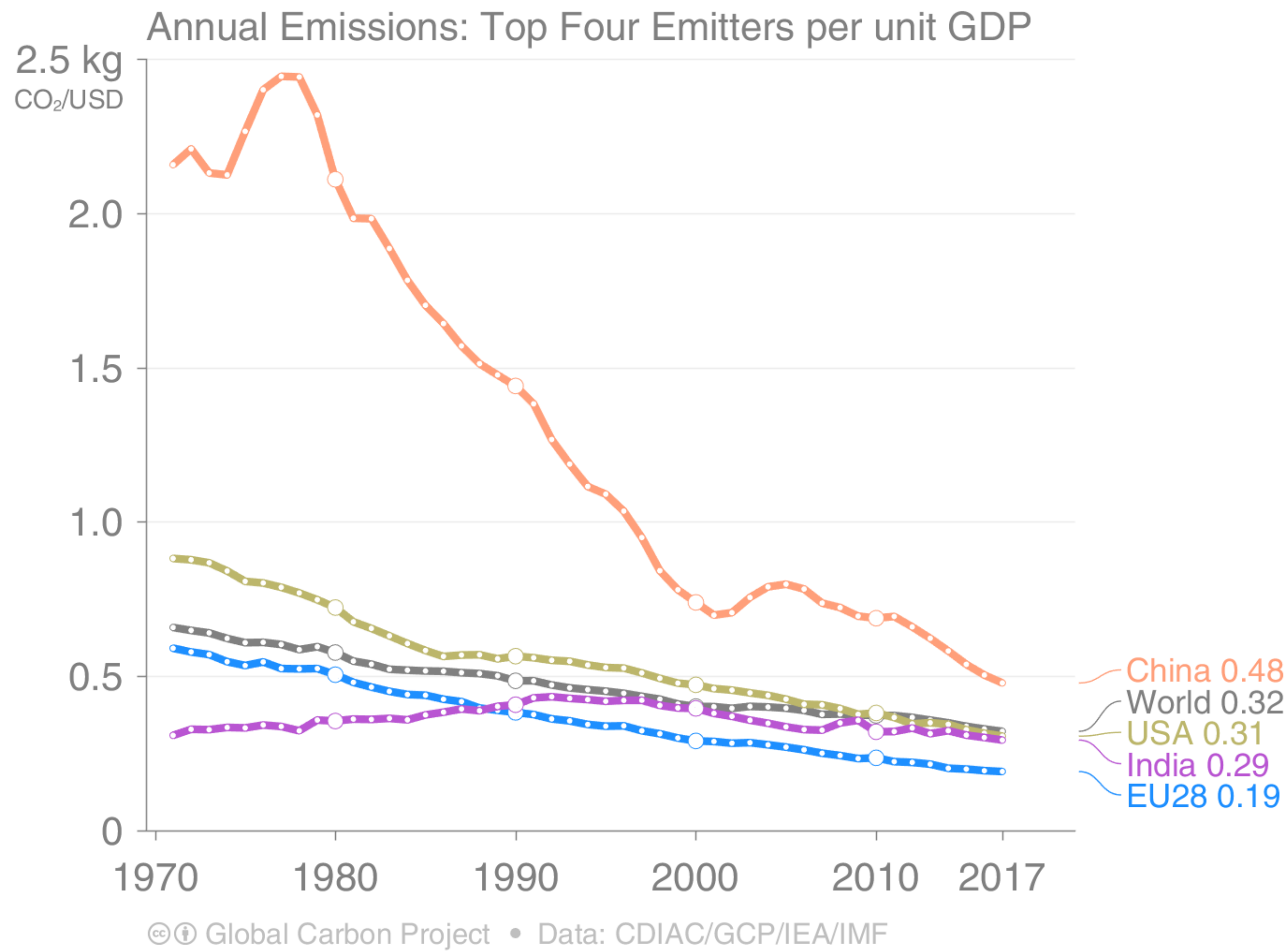
Global CO_2 emissions growth has generally resumed quickly from financial crises.
Emission intensity has steadily declined but not sufficiently to offset economic growth.



Economic activity is measured in purchasing power parity (PPP) terms in 2010 US dollars.
Source: CDIAC; Peters et al 2012; Le Quéré et al 2018; Global Carbon Budget 2018

Top emitters: Fossil CO_2 Emission Intensity

Emission intensity (emission per unit economic output) generally declines over time.
In many countries, these declines are insufficient to overcome economic growth.

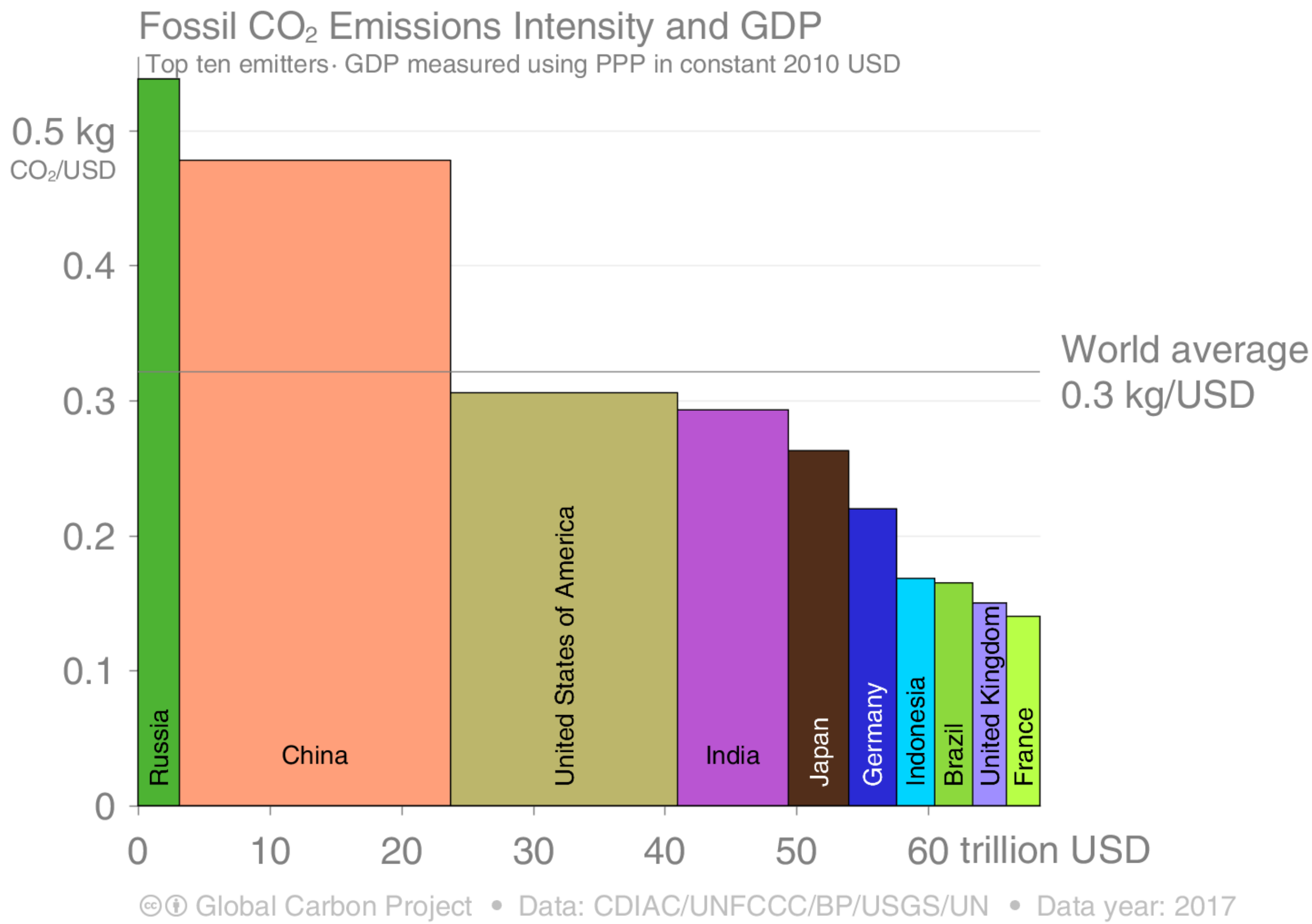


GDP is measured in purchasing power parity (PPP) terms in 2010 US dollars.

Source: CDIAC; IEA 2017 GDP to 2015, IMF 2018 growth rates to 2017; Le Quéré et al 2018; Global Carbon Budget 2018

Fossil CO_2 emission intensity

The 10 largest economies have a wide range of emission intensity of economic activity

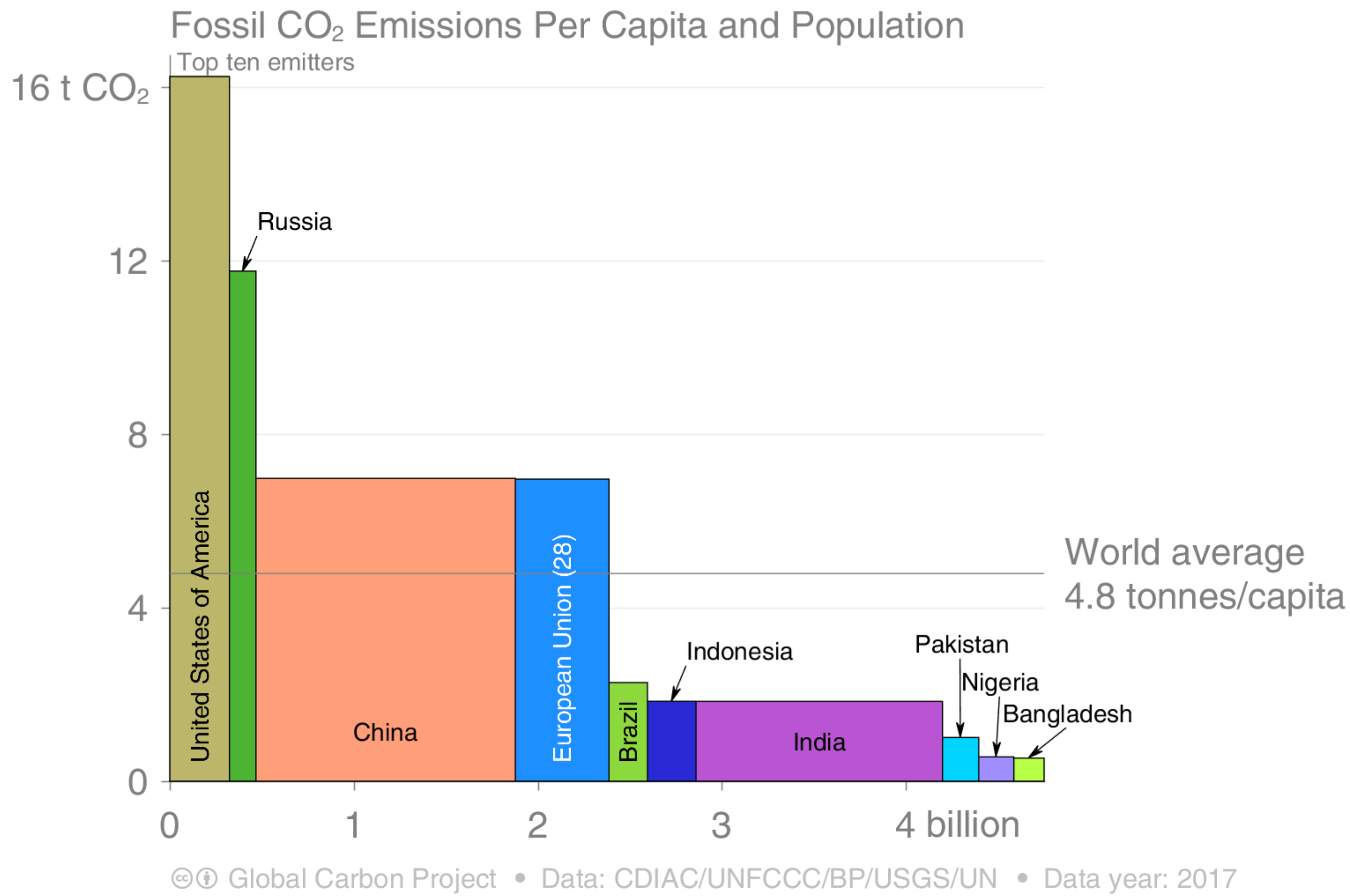


Emission intensity: Fossil CO_2 emissions divided by Gross Domestic Product (GDP)

Source: [Global Carbon Budget 2018]

Fossil CO_2 Emissions per capita

The 10 most populous countries span a wide range of development and emissions per capita

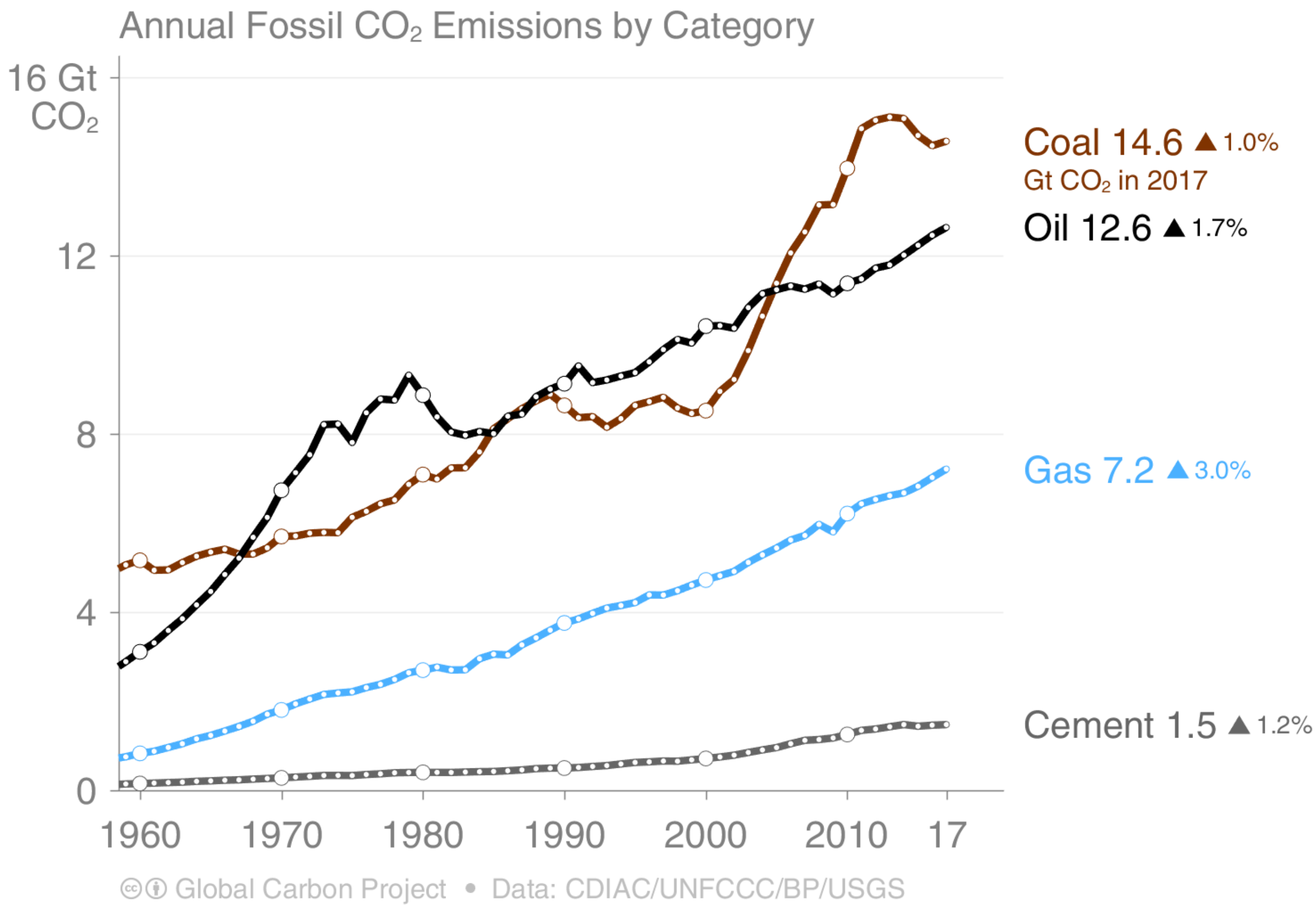


Emission per capita: Fossil CO_2 emissions divided by population

Source: [Global Carbon Budget 2018]

Fossil CO_2 Emissions by source

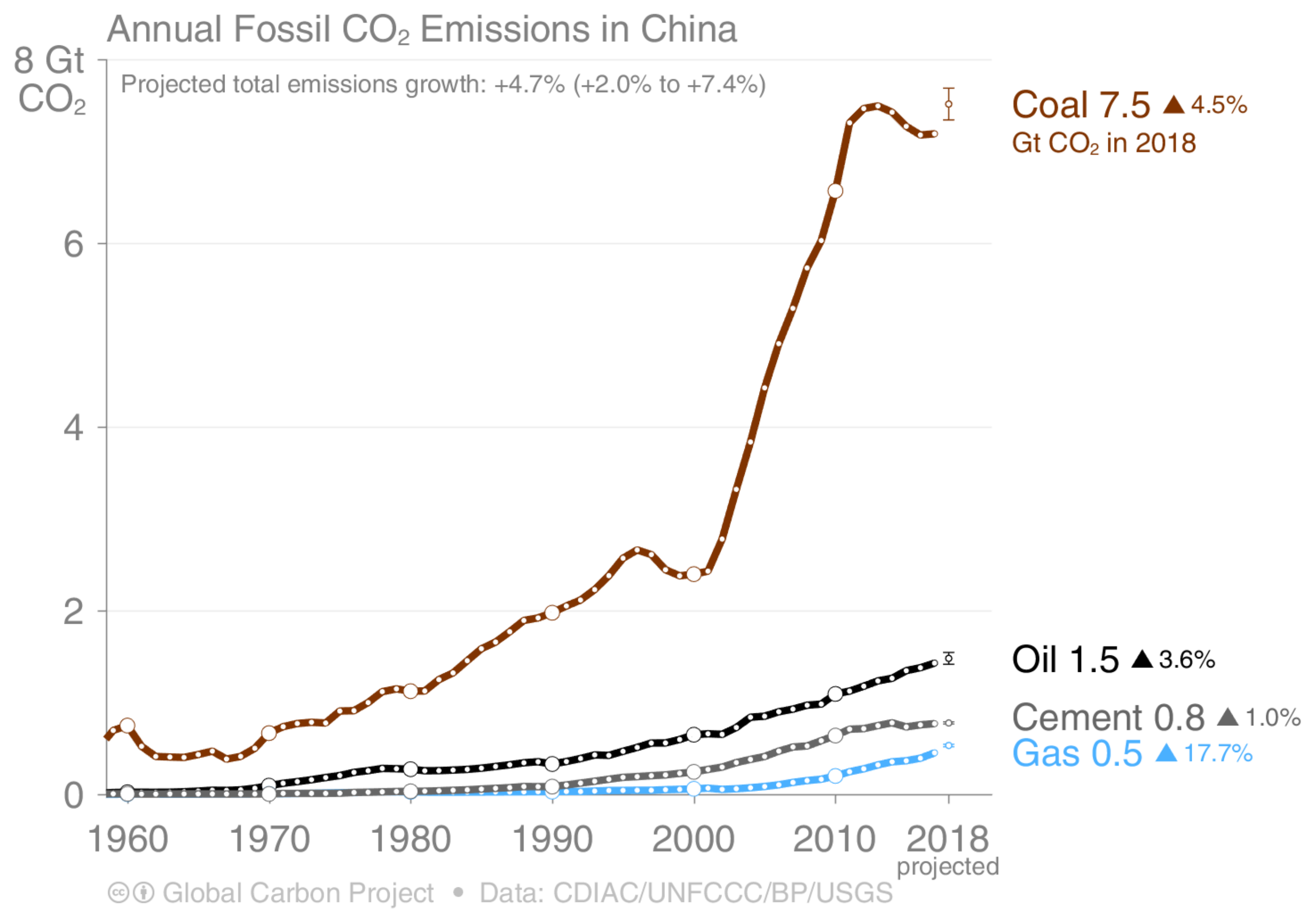
Share of global fossil CO_2 emissions in 2017:
coal (40%), oil (35%), gas (20%), cement (4%), flaring (1%, not shown)



Source: [CDIAC](); [Le Quéré et al 2018](); [Global Carbon Budget 2018]()

Fossil CO_2 Emissions in China

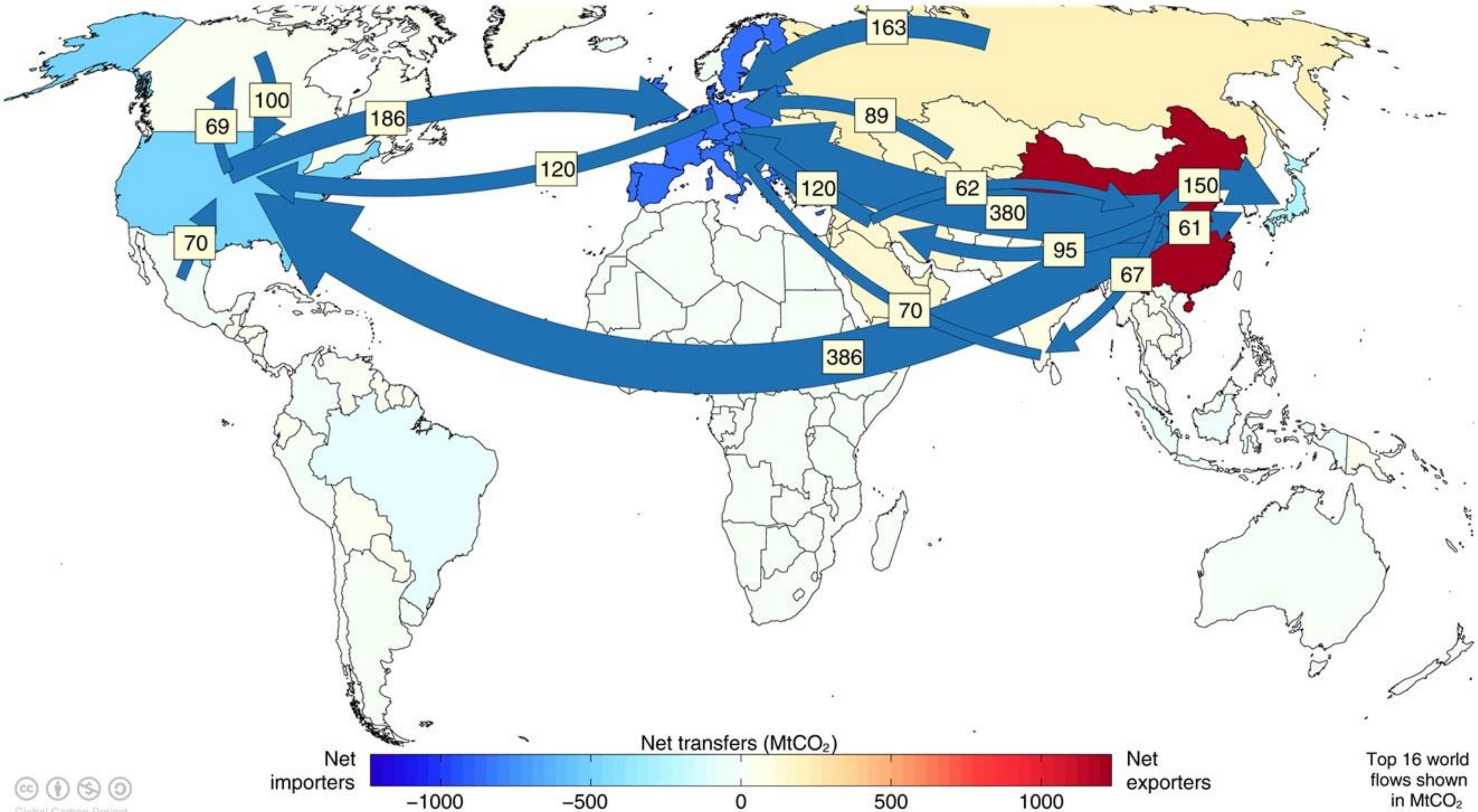
China's emissions are dominated by coal use, with strong and sustained growth in oil & gas
The recent declines in coal emissions may soon be undone if the return growth persists



Source: CDIAC; Le Quéré et al 2018; Global Carbon Budget 2018

Major flows from production to consumption

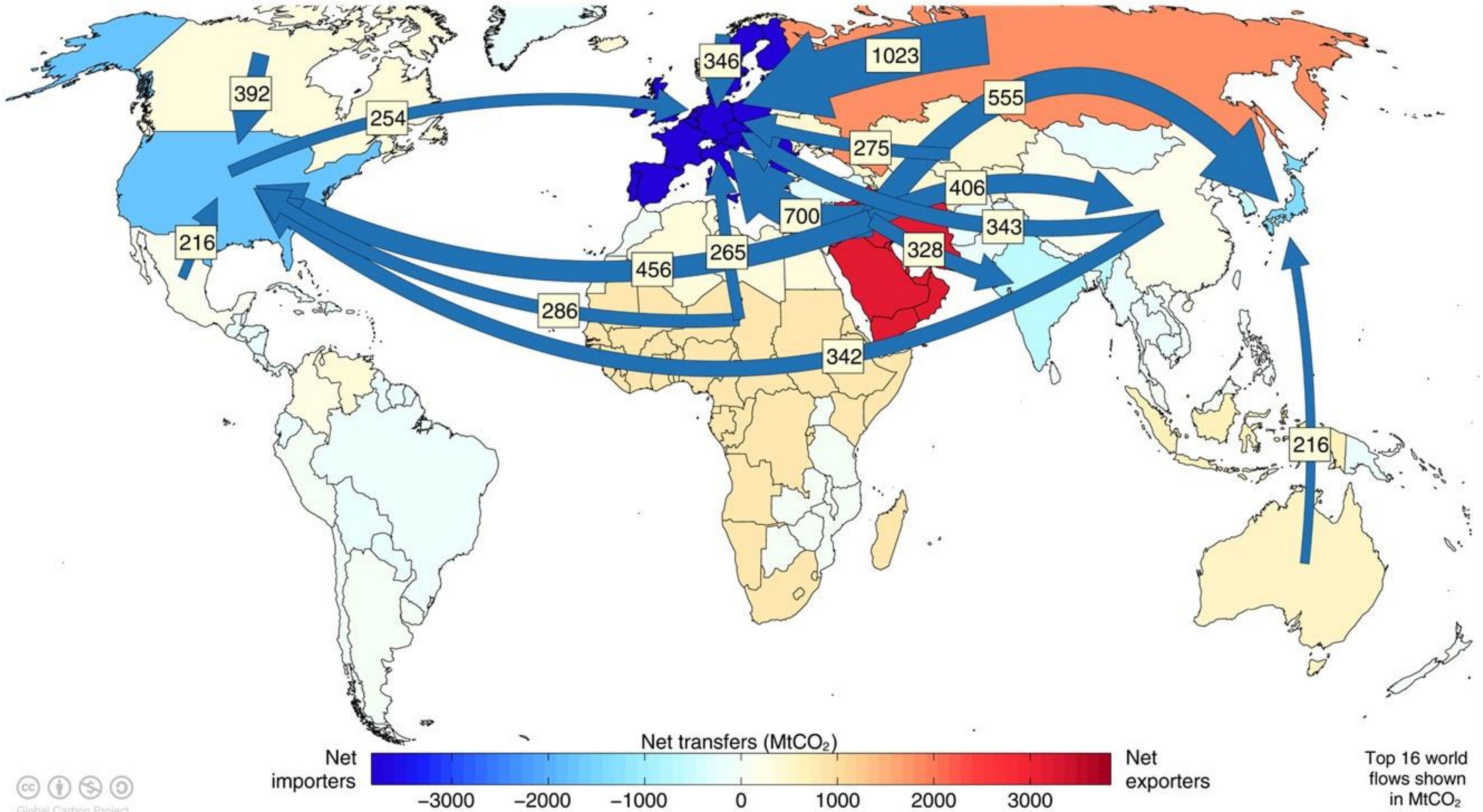
Flows from location of generation of emissions to location of consumption of goods and services



Values for 2011. EU is treated as one region. Units: $MtCO_2$
Source: Peters et al 2012

Major flows from extraction to consumption

Flows from location of fossil fuel extraction to location of consumption of goods and services

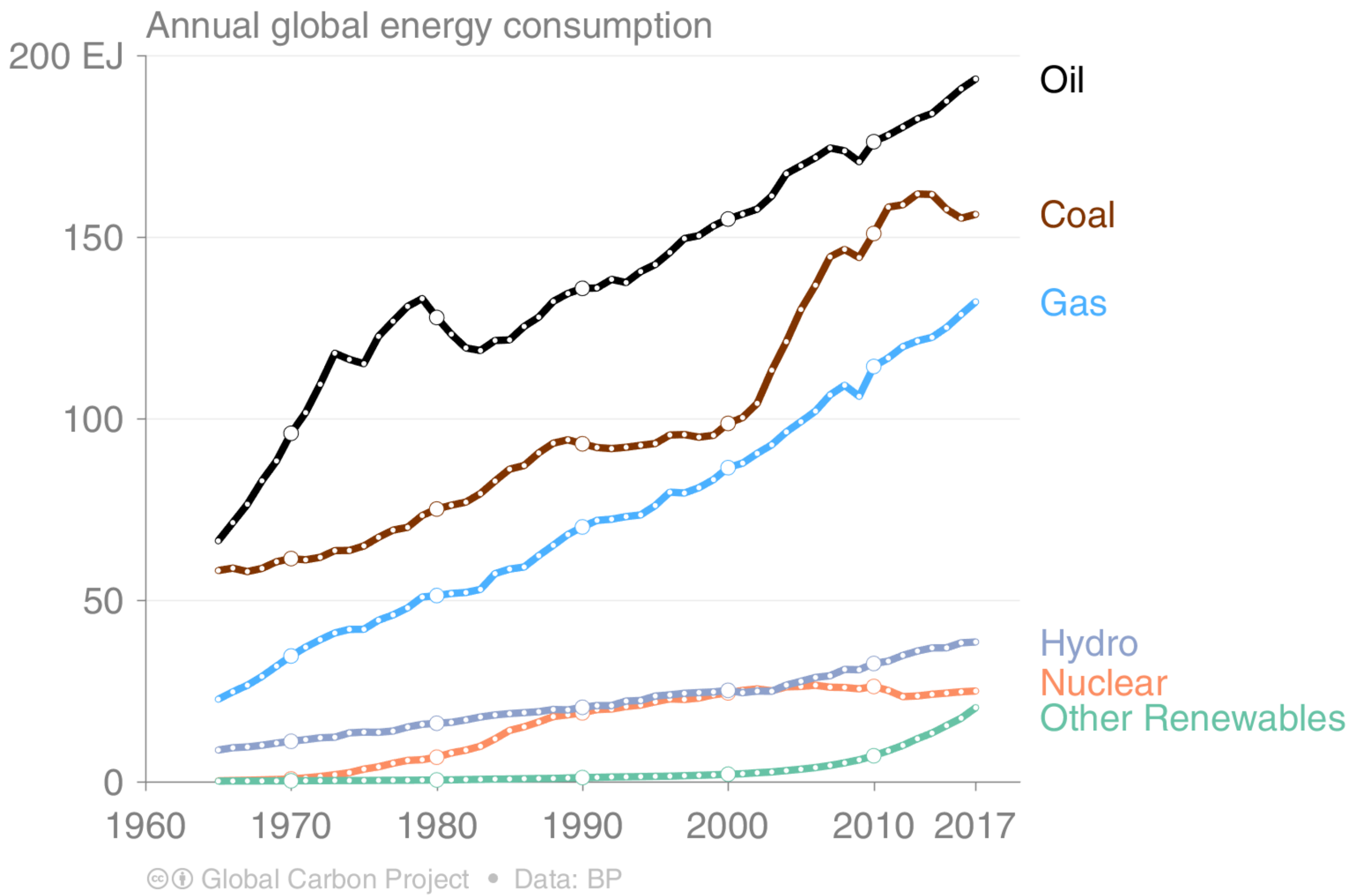


Values for 2011. EU is treated as one region. Units: $MtCO_2$

Source: Andrew et al 2013

Energy use by source

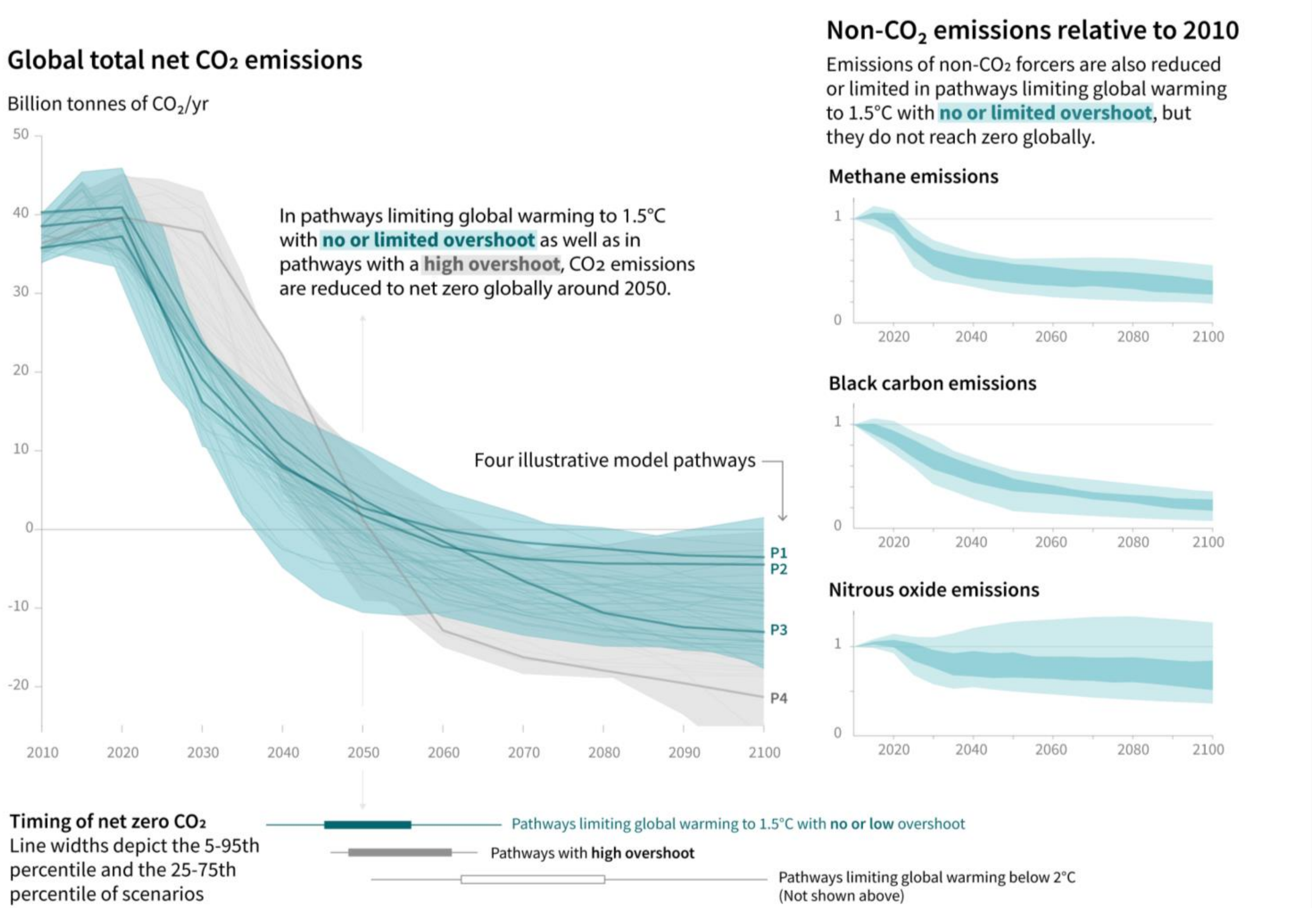
Renewable energy is growing exponentially, but this growth has so far been too low to offset the growth in fossil energy consumption.



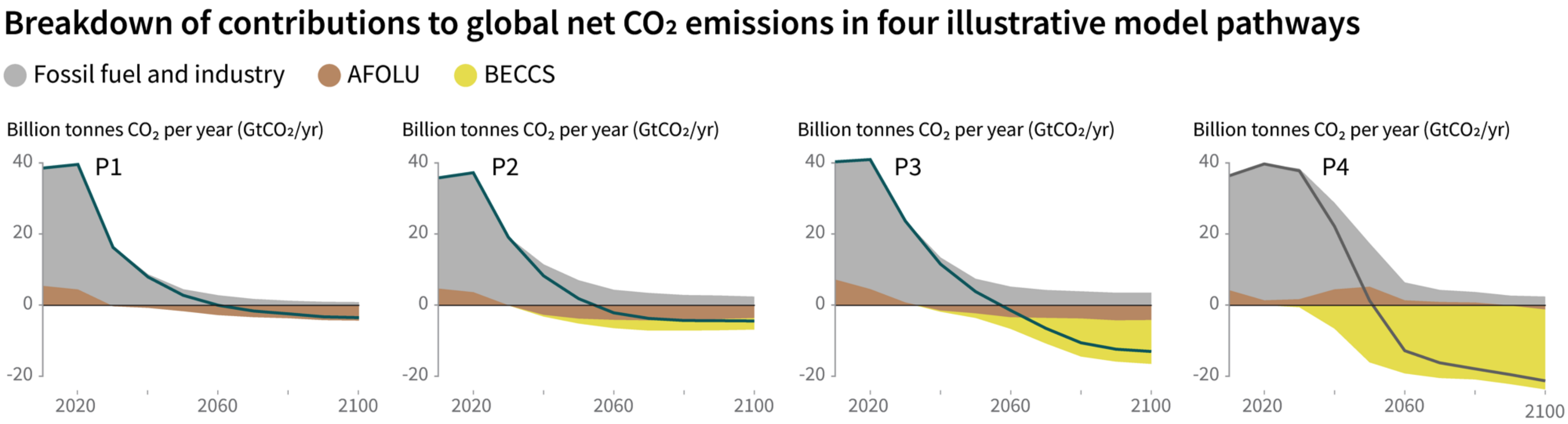
This figure shows "primary energy" using the BP substitution method (non-fossil sources are scaled up by an assumed fossil efficiency of 0.38)

Source: BP 2018; Figueres et al 2018; Global Carbon Budget 2018

Global 1.5°C emissions pathways:
Limiting warming to 1.5°C with no or limited overshoot
Limiting warming to 1.5°C with high overshoot



Characteristics of four illustrative model pathways



CO_2 emission reductions are mainly achieved by …

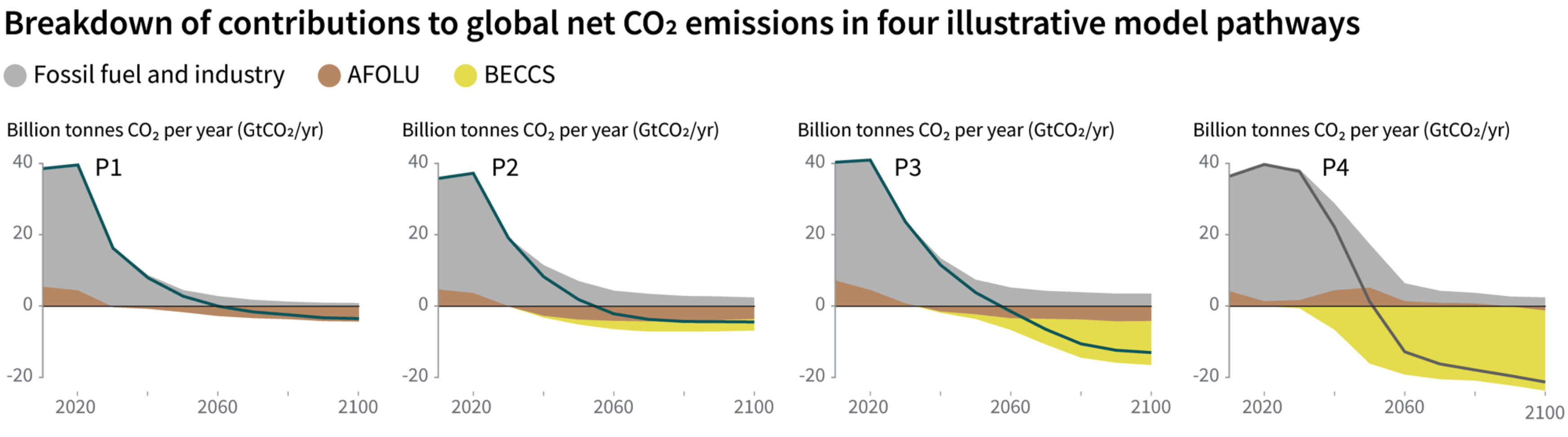
P1: … social, business and technological innovations result in lower energy demand up to 2050 …

P2: … a broad focus on sustainability … with limited societal acceptability for BECCS.

P3: … changing the way in which energy and products are produced, and [some] reductions in demand.

P4: … technological means, making strong use of CDR through the deployment of BECCS.

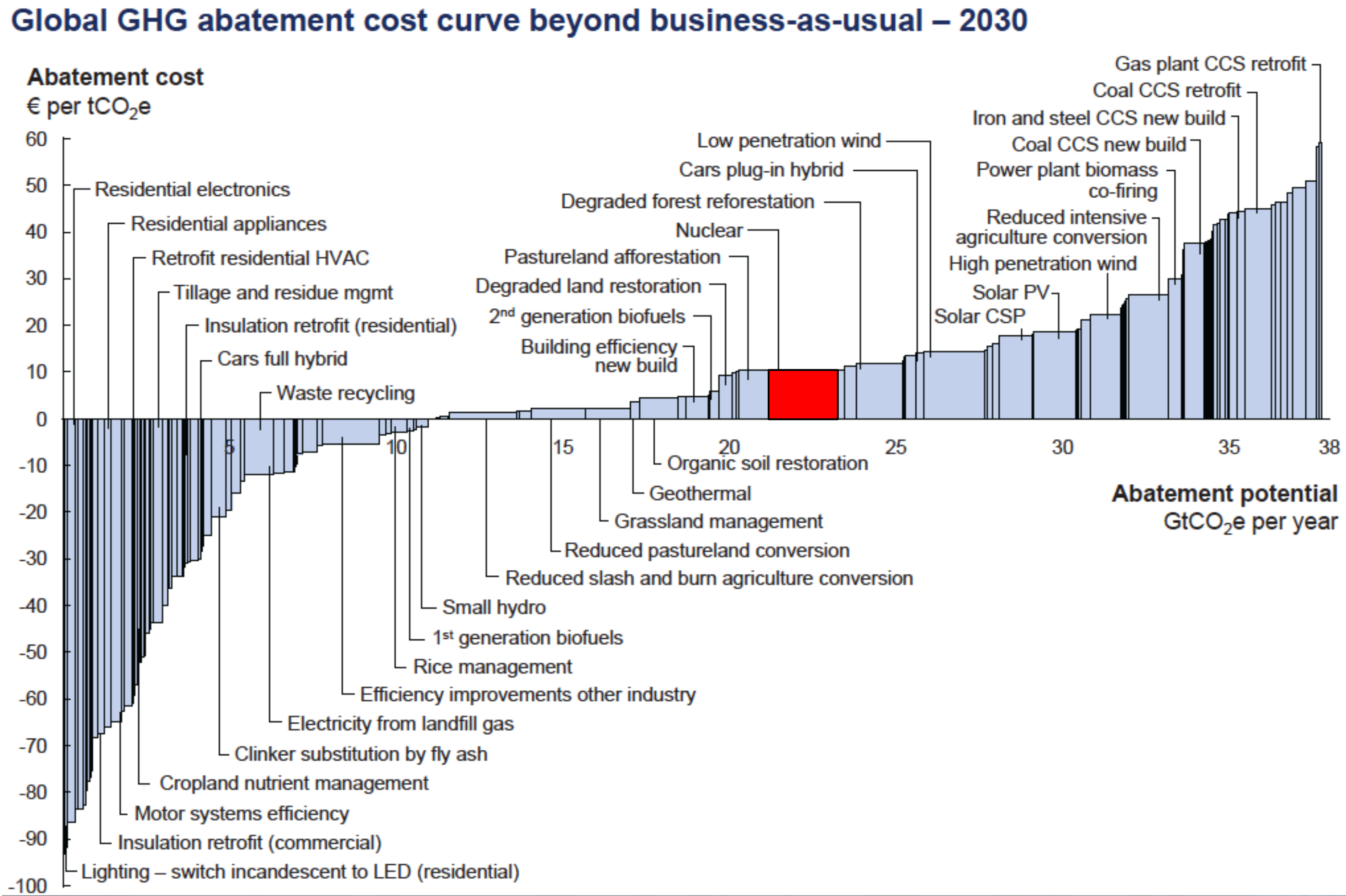
Characteristics of four illustrative model pathways



All 1.5° C pathways involve rapid reductions in emissions either before (P1-3) or after (P4) 2030.

Note rapid means RAPID: emissions approximately halving over 10 years
How can this be done, and what will it cost?

Counting the cost of reducing emissions: the Marginal Abatement Cost Curve (MACC)



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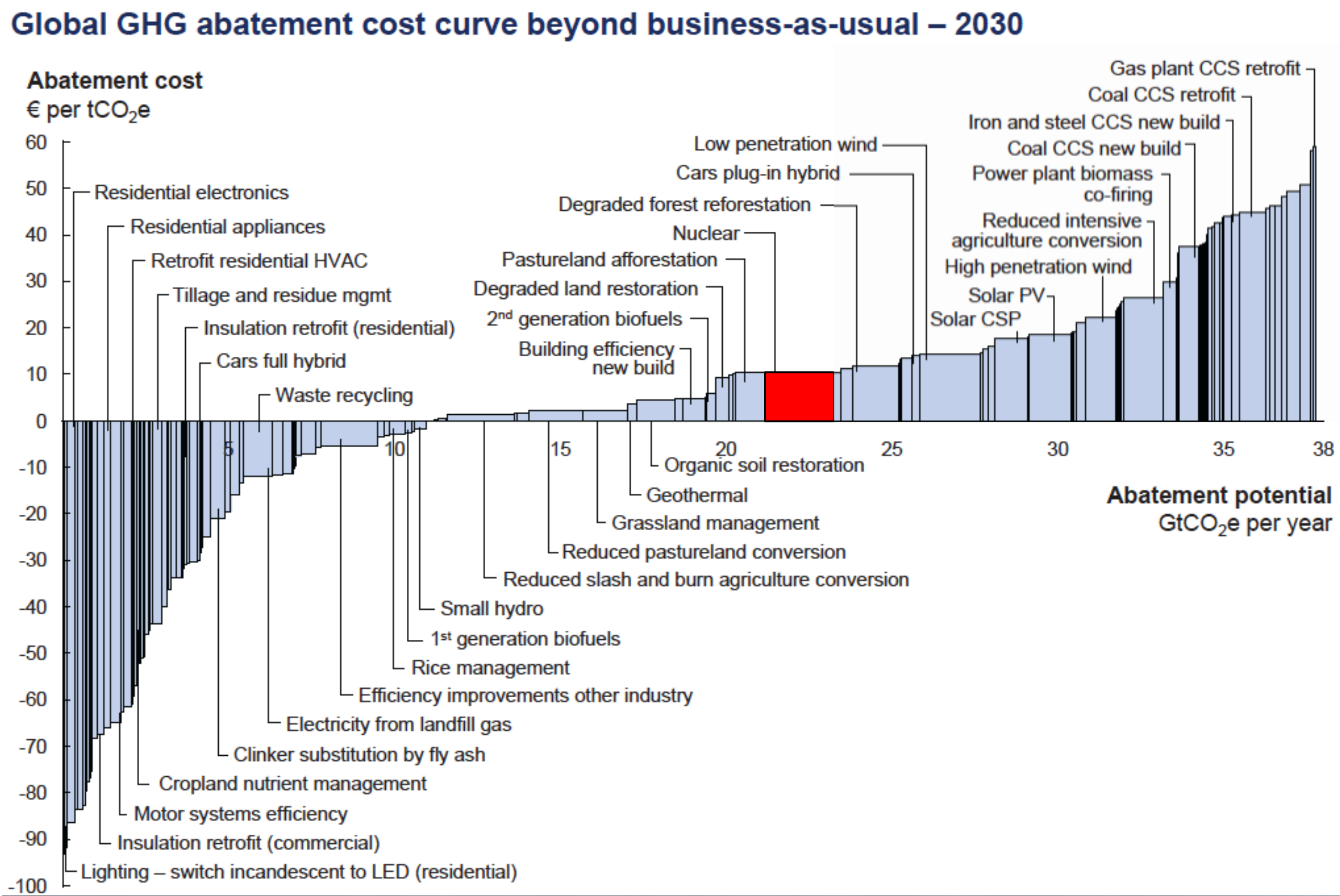
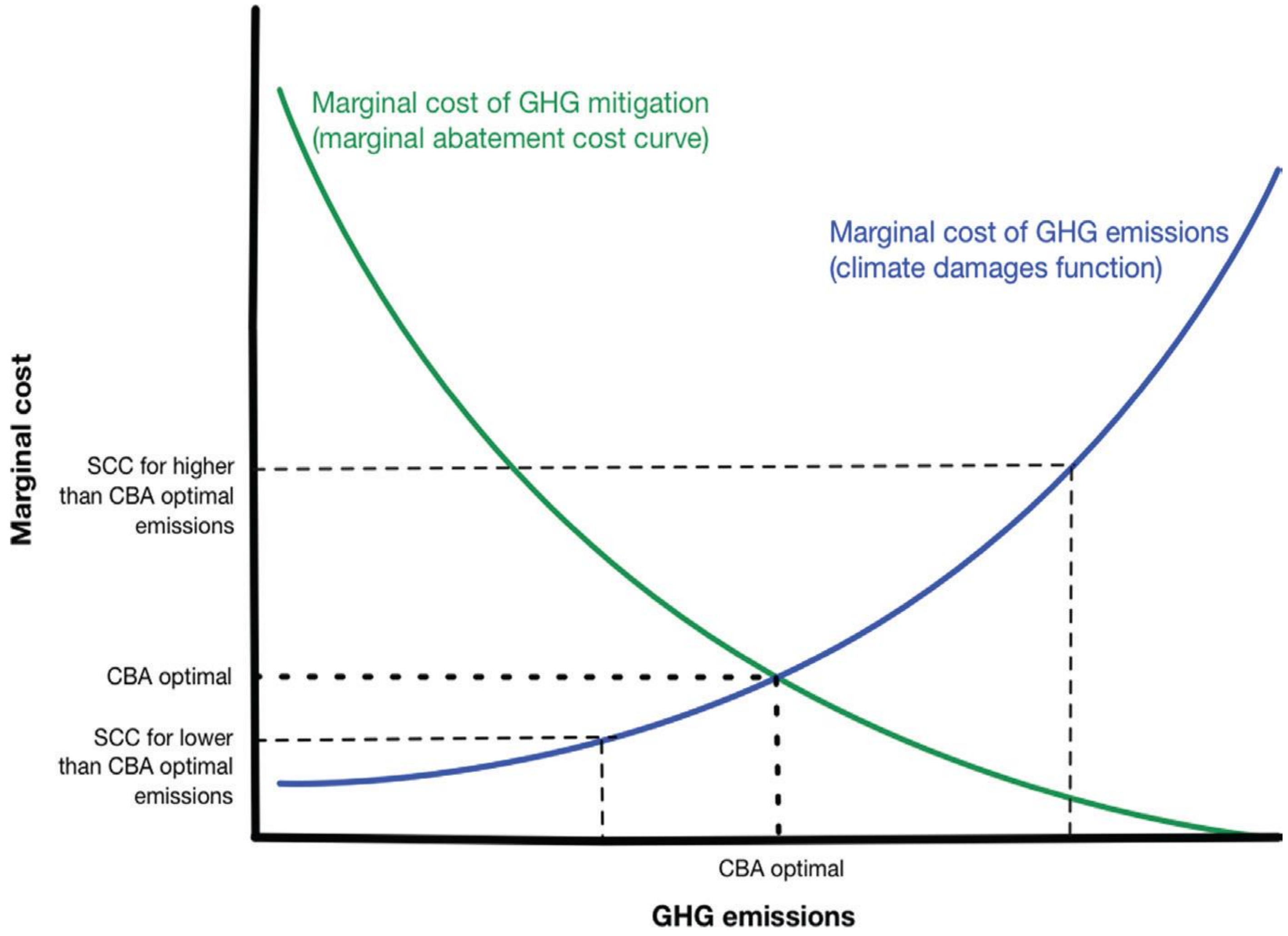
Total cost of reducing emissions = the area under the MACC



Problems with MACC-onomics

- MACCs frame mitigation as a succession of marginal decisions, each making a small difference.
- Interactions (positive and negative) between mitigation measures at any given time are not represented.
- Impact on mitigation costs of actions taken at an earlier time are also not represented. These may include:
  - Positive feedbacks (learning effects)
  - Negative feedbacks (exhaustion of political capital)

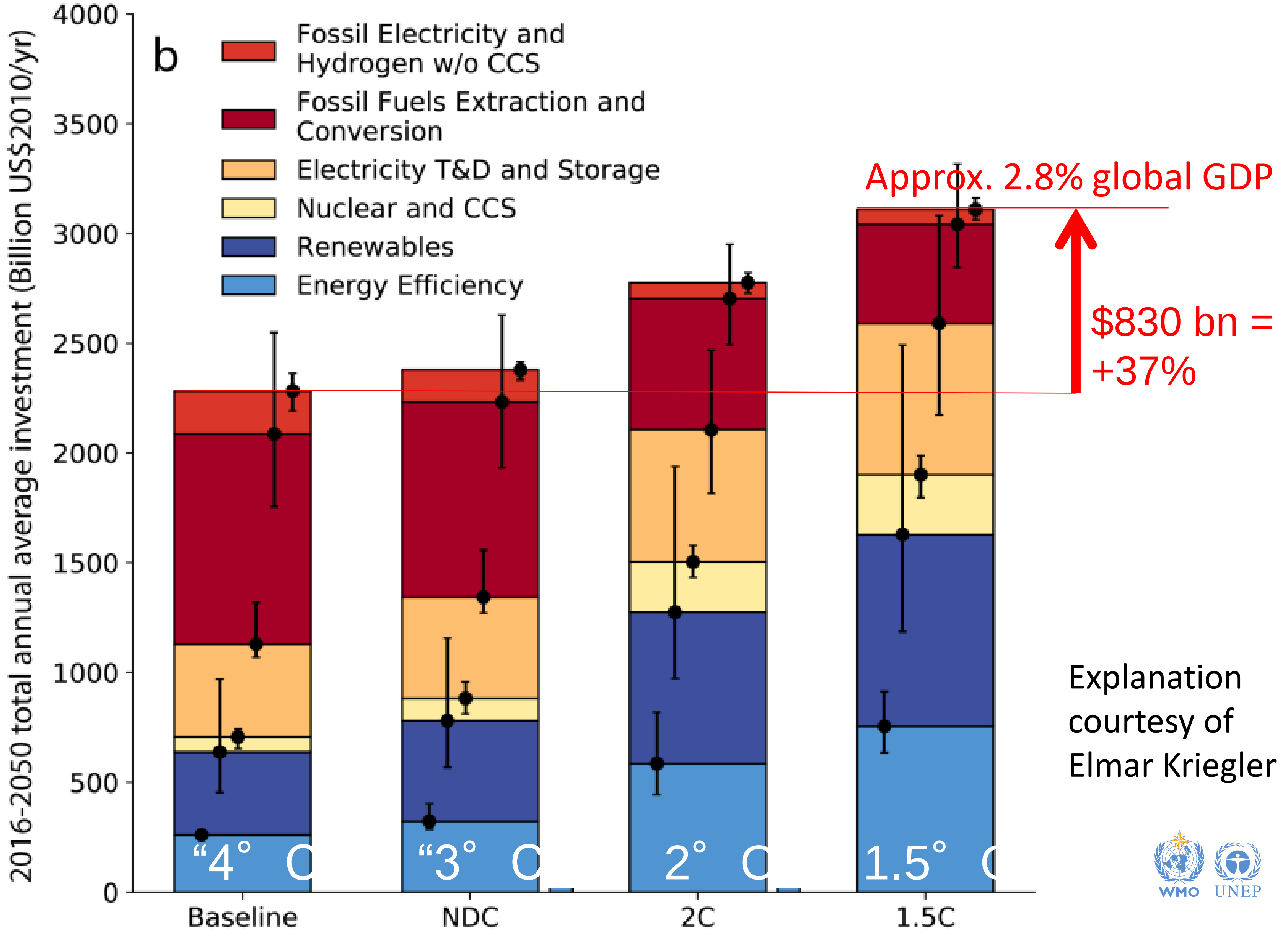
Conventional Benefit-Cost-Maximisation: reduce emissions until MACC = SC-CO_2



Your turn

- Open OxfordSimpleIAM_2019_1.xlsx, Policy sheet
- “Consumption weighted participation in mitigation”
  - When 0, no-one participates, and we follow baseline (RCP8.5)
  - Set to 1, immediate global participation
  - Look at MACC: starts above zero, assuming current MACC = current SC-CO_2 (we are already rational agents)
  - Try varying slope (rate of increase in MACC)
  - Can you explain the response?

Annual average energy-related investments over the period 2016-2050 in 4 scenario categories (Fig 2.27 underlying report)



Explanation courtesy of Elmar Kriegler

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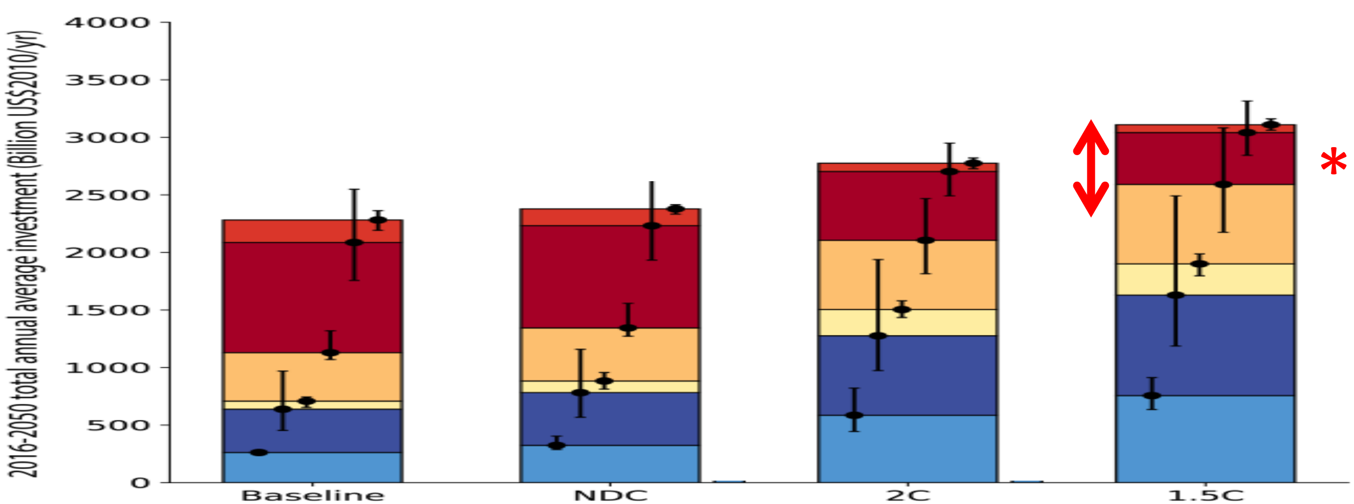
Context: annual average energy-related investments relative to energy-related expenditure (assuming this follows GDP)

"1.5° C to cost 2.5% of GDP"

Additional energy-related investment for 1.5°C is <1% of global GDP, or <10% of projected spending on energy if that remains at ~10% of global GDP



Spending on energy