Bending the curve: how to start reducing emissions?

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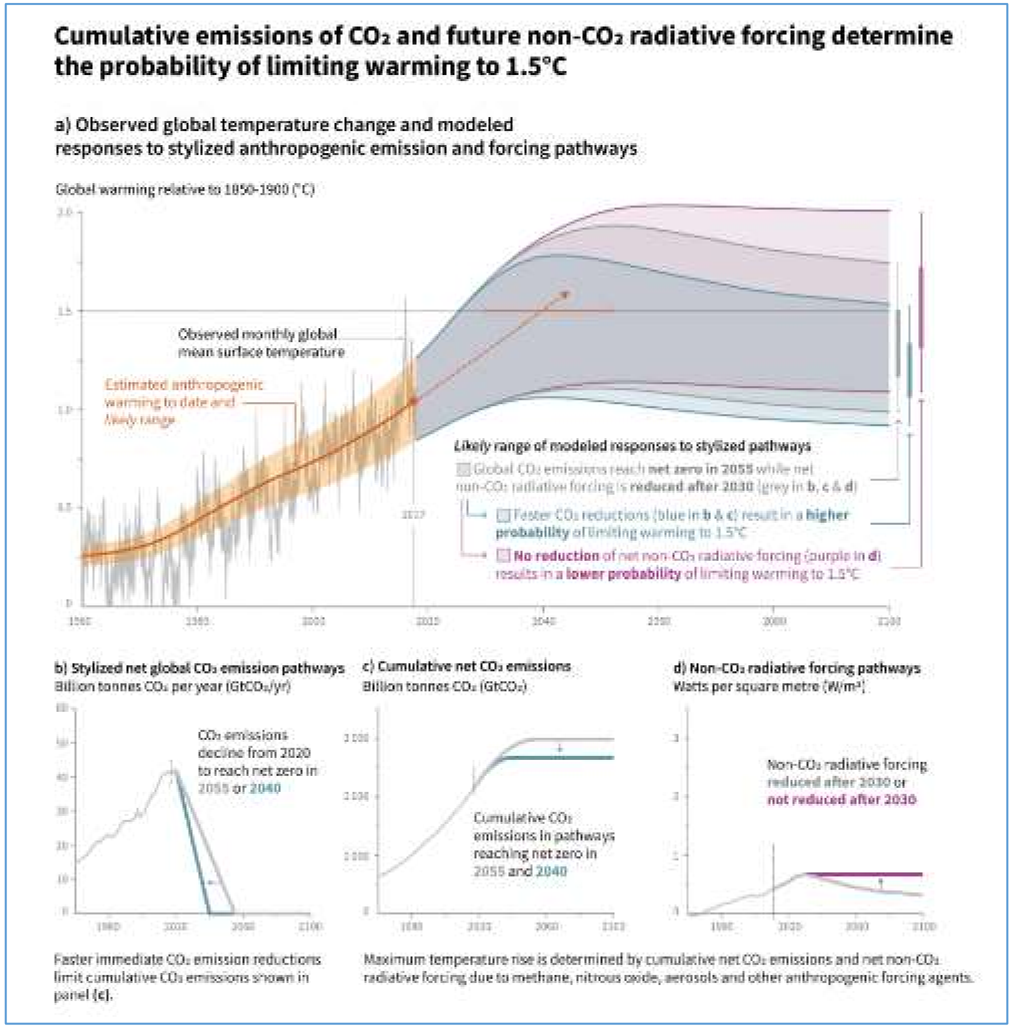
The Great Climate Trilemma

The Great Climate Trilemma

Find out what it will take to limit global warming to 1.5°C

Interactive version of figure SPM.1 of the IPCC Special Report



This is the first approved figure of the IPCC 6th Assessment Report Cycle. Interactive by Stuart Jenkins and Myles Allen, University of Oxford, available for download and sharing:

https://apps.ipcc.ch/report/sr15/fig1/index.html

Environmental Change Institute

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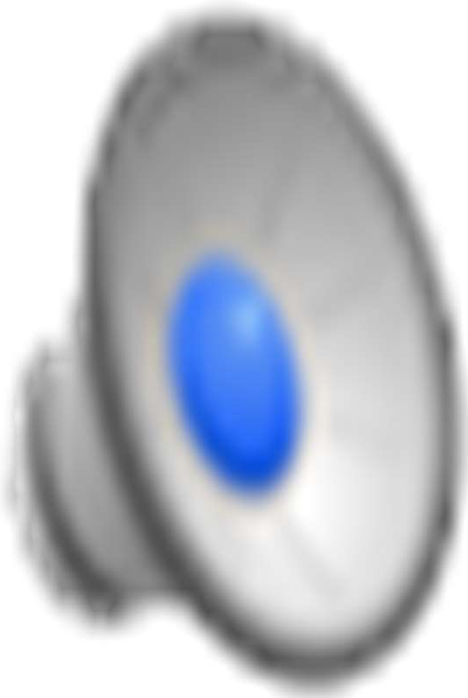
INTERGOVERNMENTAL PANEL ON climate change

Reaching and sustaining **net-zero** global anthropogenic **CO_2 emissions** and **declining net non-CO_2 radiative forcing** would **halt** anthropogenic global warming



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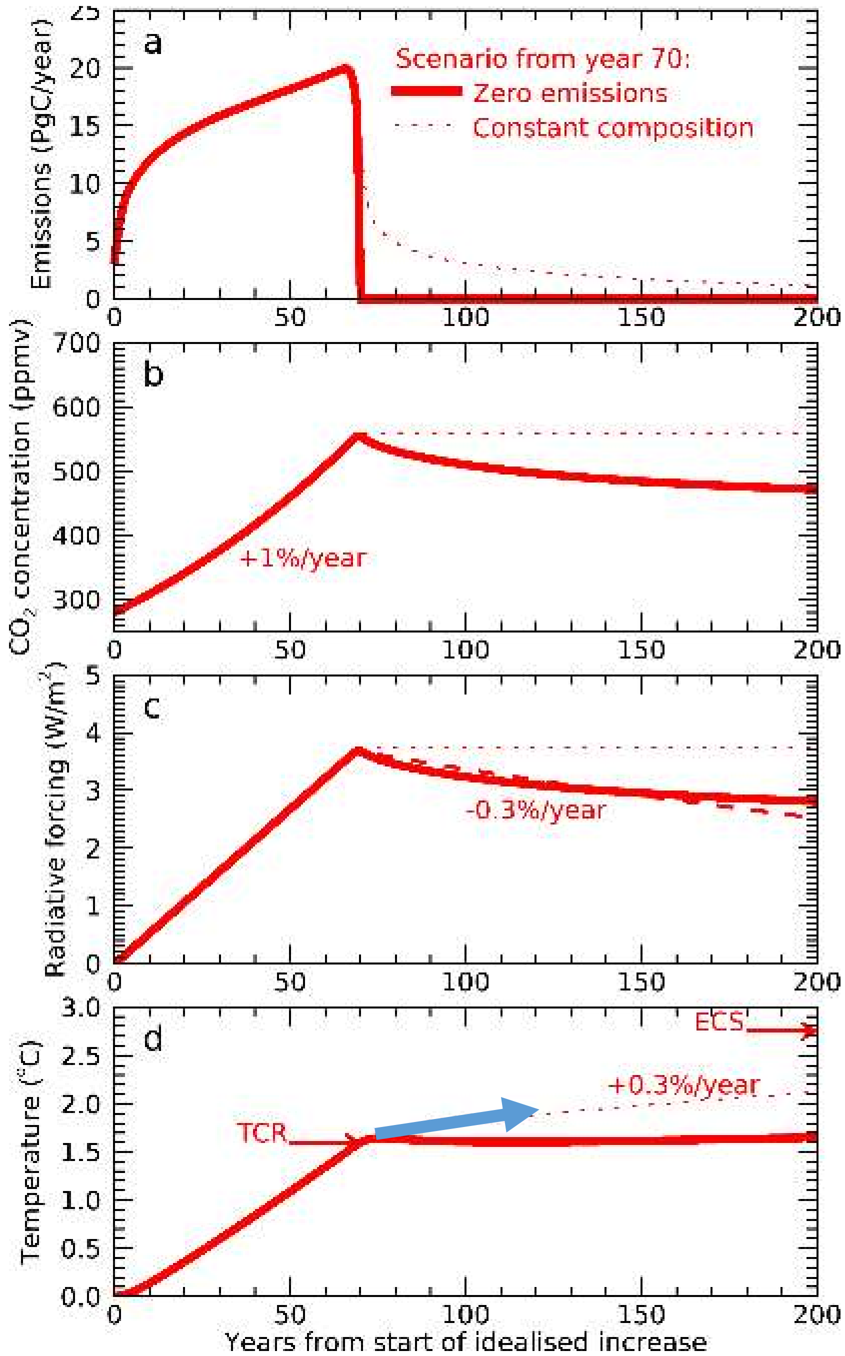
Why does achieving net zero CO_2 emissions halt CO_2's contribution to global warming?

- Constant CO_2 emissions from year 70 = rising temperatures.

- Constant CO_2 concentrations implies constant radiative forcing (externally-driven global energy imbalance).

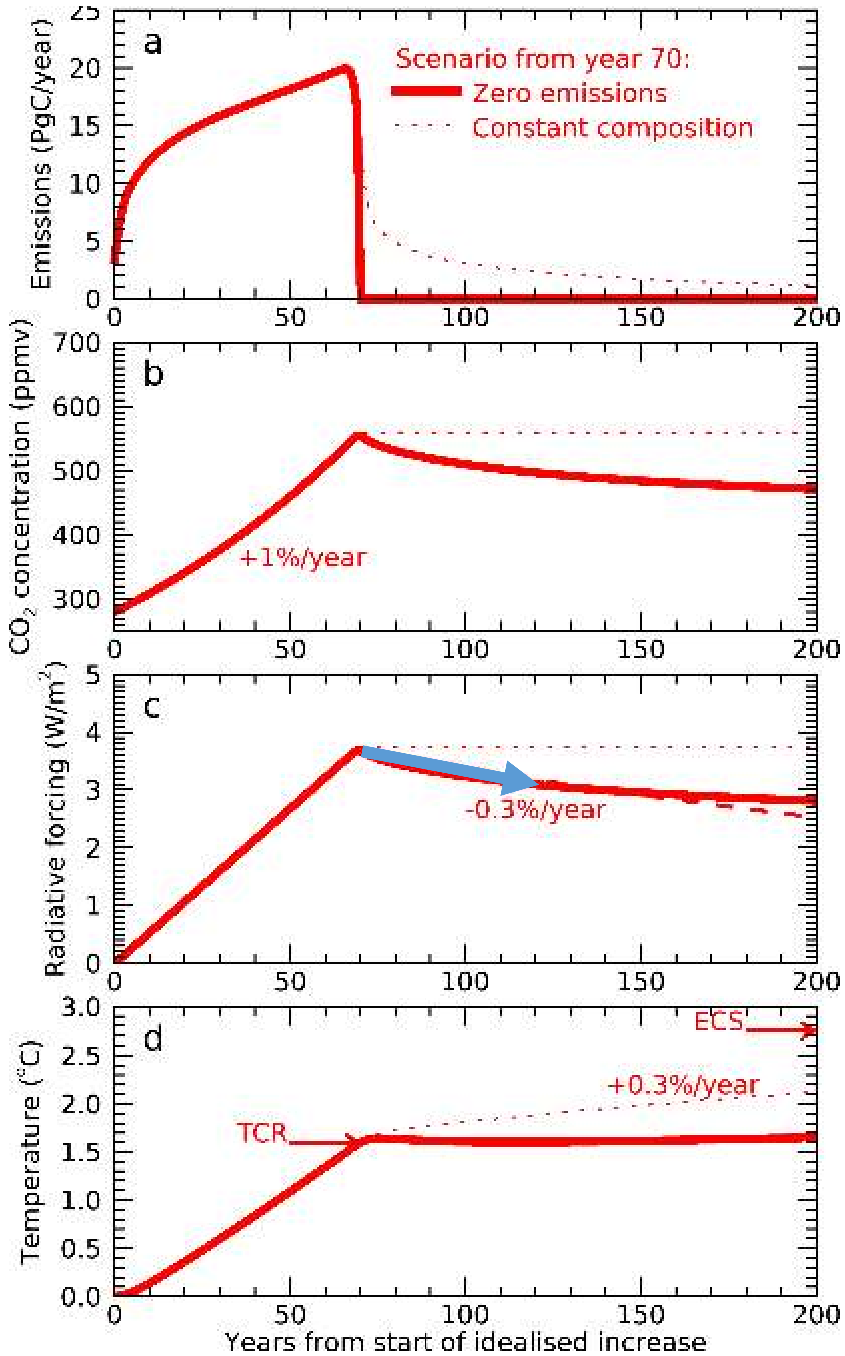
- Initial adjustment to equilibrium under constant composition depends on "warming commitment" (ECS-TCR), divided by response to date (TCR) & adjustment timescale:

$$\frac{\mathrm{ECS}-\mathrm{TCR}}{\mathrm{TCR}\times d_2} \approx 0.3\% \text{ per year}$$



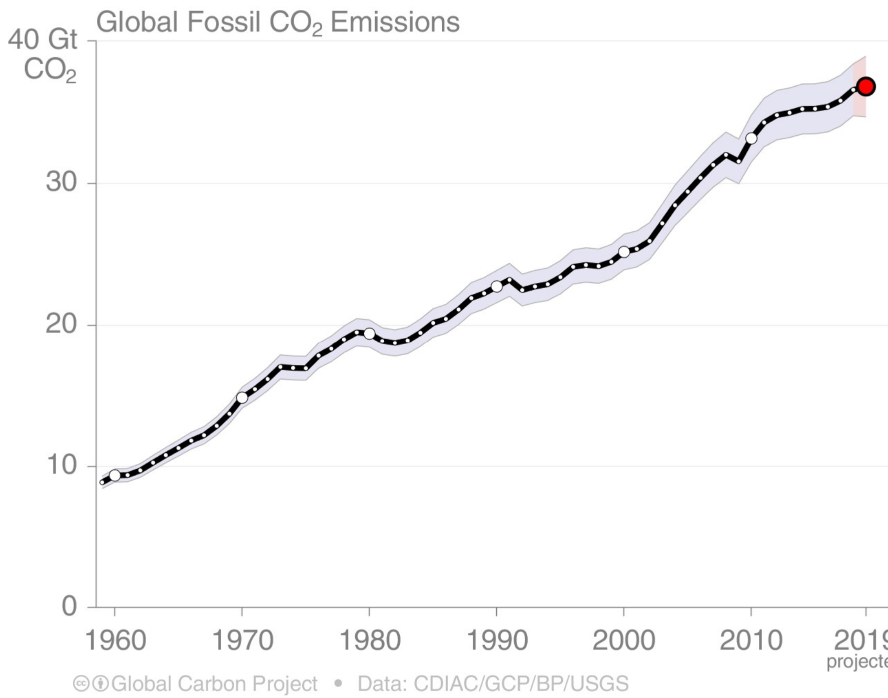
Why does achieving net zero CO_2 emissions halt CO_2's contribution to global warming?

- Zero CO_2 emissions from year 70 = stable temperatures.
- Zero CO_2 emissions implies about -0.3% per year decline in radiative forcing.
- This happens to be the required to compensate for slow adjustment to equilibrium under constant composition.



Global Fossil CO_2 Emissions

Global fossil CO_2 emissions have risen steadily over the last decades & show no sign of peaking
Fossil CO_2 emissions will likely be 62% higher in 2019 than the year of the 1st IPCC report in 1990

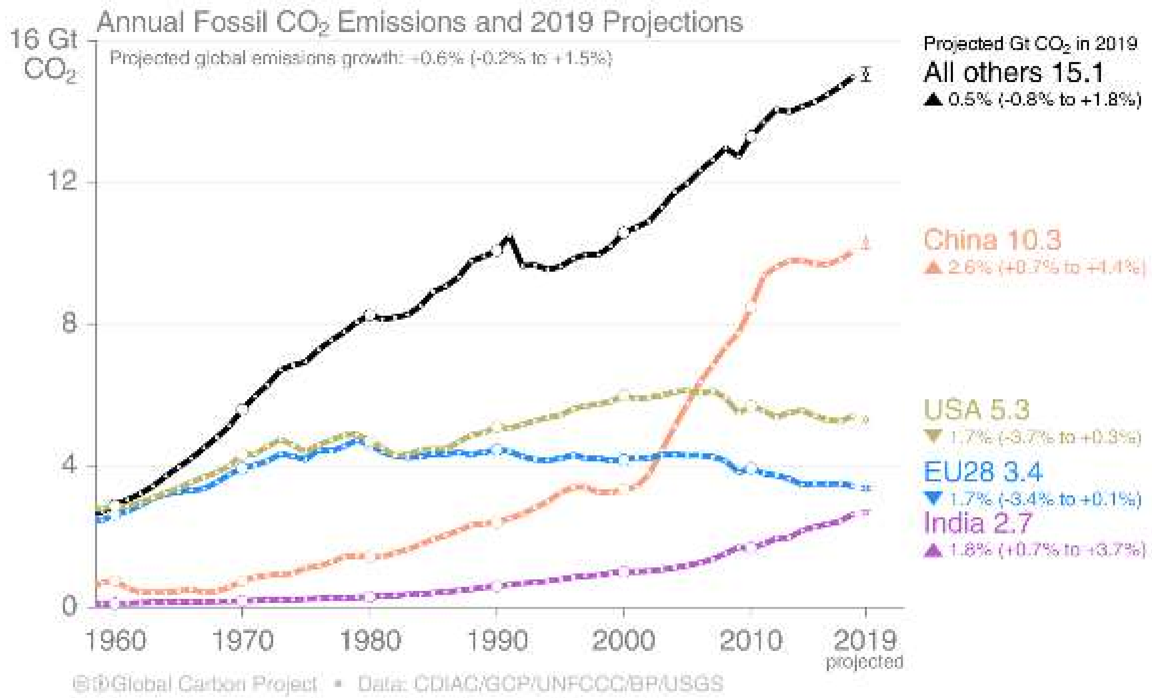


Uncertainty is ±5% for one standard deviation (IPCC "likely" range)

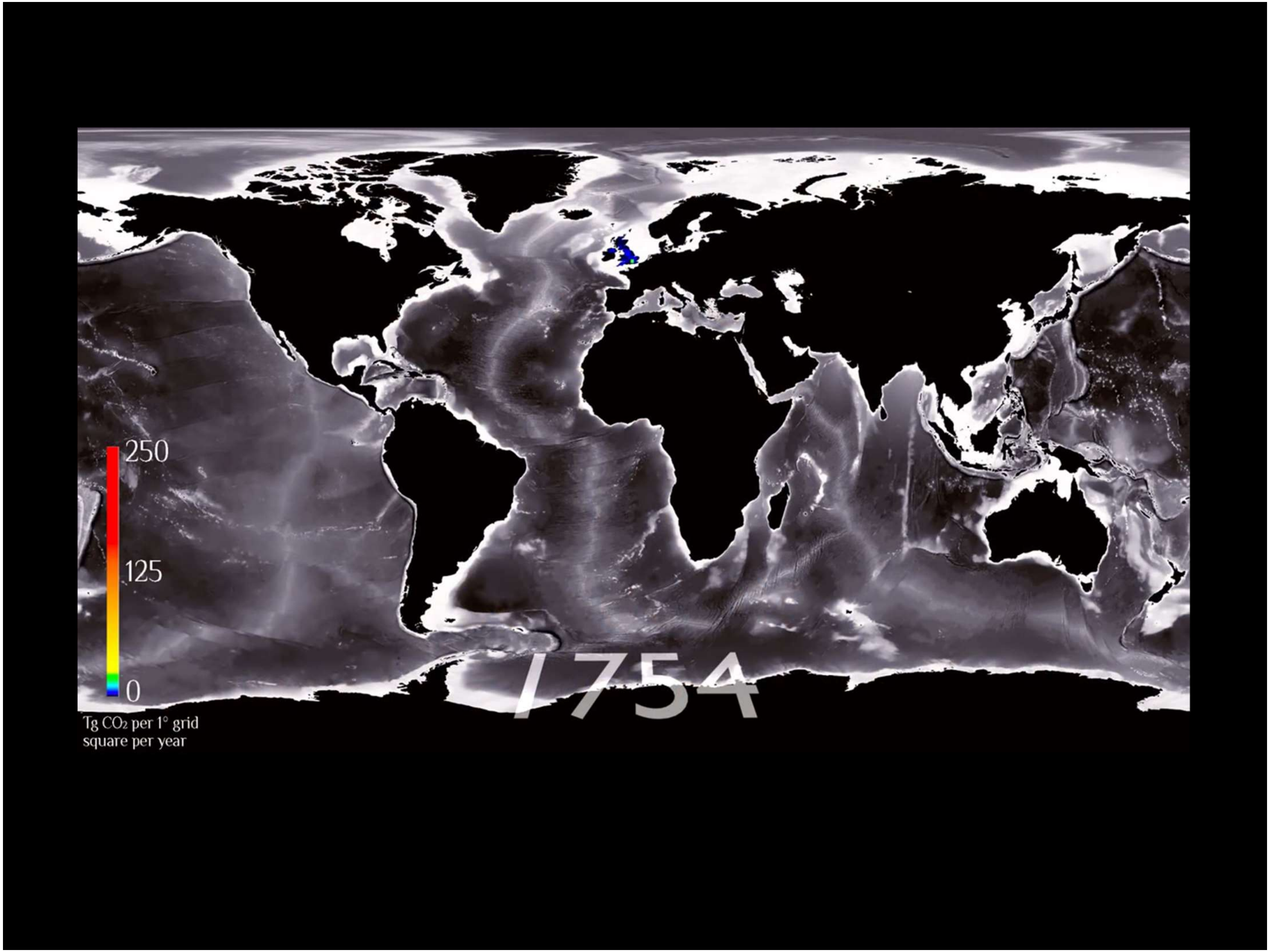
The 2019 projection is based on preliminary data and modelling.
Source: CDIAC; Friedlingstein et al 2019; Global Carbon Budget 2019

Emissions Projections for 2019

Global fossil CO_2 emissions are projected to rise by 0.6% in 2019 [range: -0.2% to +1.5%]
The global growth is driven by the underlying changes at the country level.

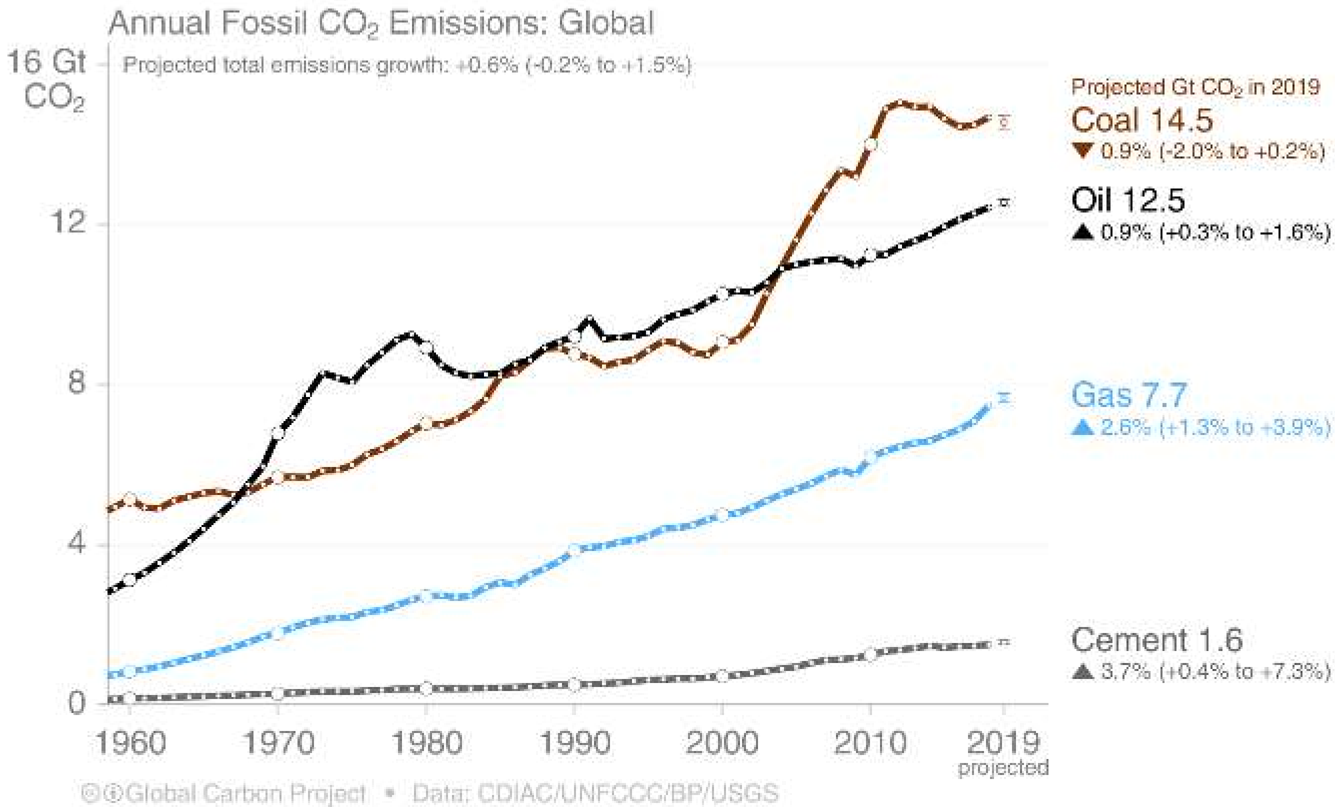


Source: CDIAC; Peters et al 2019; Friedlingstein et al 2019; Global Carbon Budget 2019


250
125
0
Tg CO_2 per 1° grid
square per year
1754

Fossil CO_2 Emissions by source

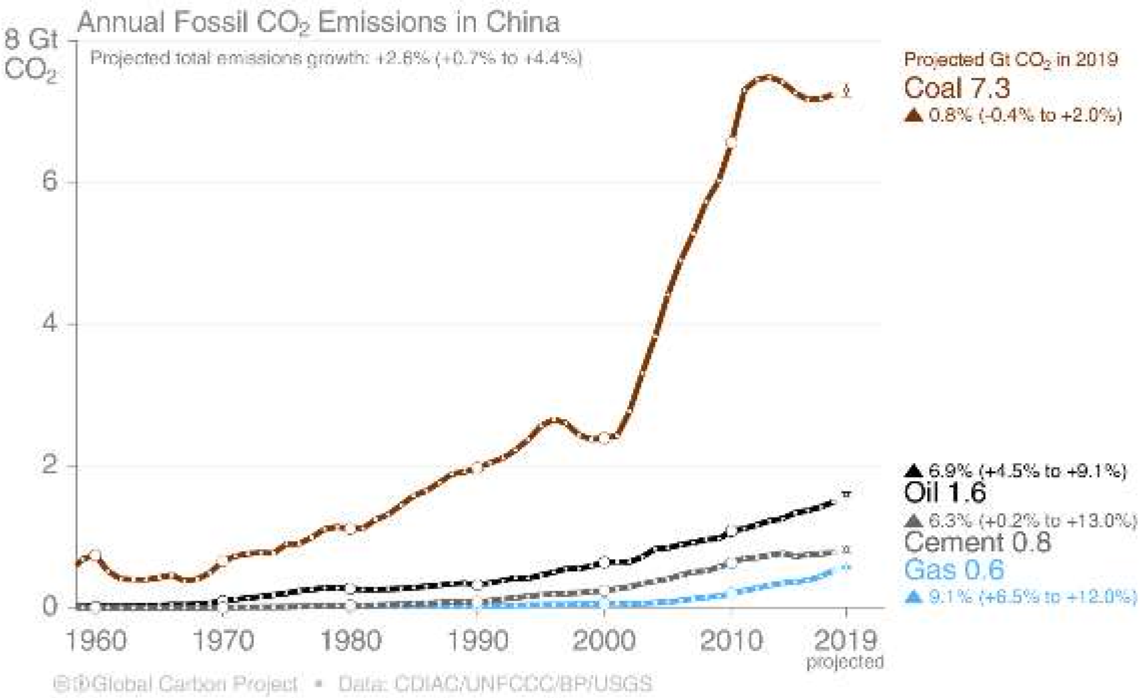
Share of global fossil CO_2 emissions in 2018:
coal (40%), oil (34%), gas (20%), cement (4%), flaring (1%, not shown)



Source: CDIAC; Peters et al 2019; Friedlingstein et al 2019; Global Carbon Budget 2019

Fossil CO_2 Emissions in China

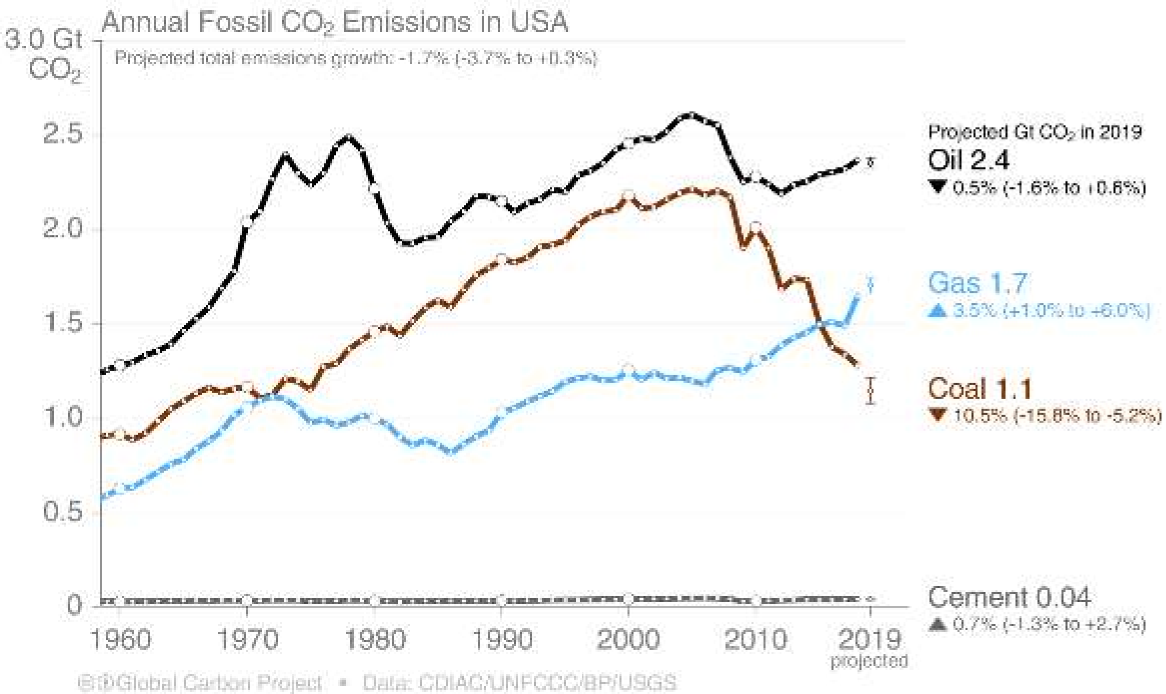
China's emissions are dominated by coal use, with strong and sustained growth in oil & gas
The recent declines in coal emissions may soon be undone if the return to growth persists



Source: [CDIAC]; [Friedlingstein et al 2019]; [Global Carbon Budget 2019]

Fossil CO_2 Emissions in USA

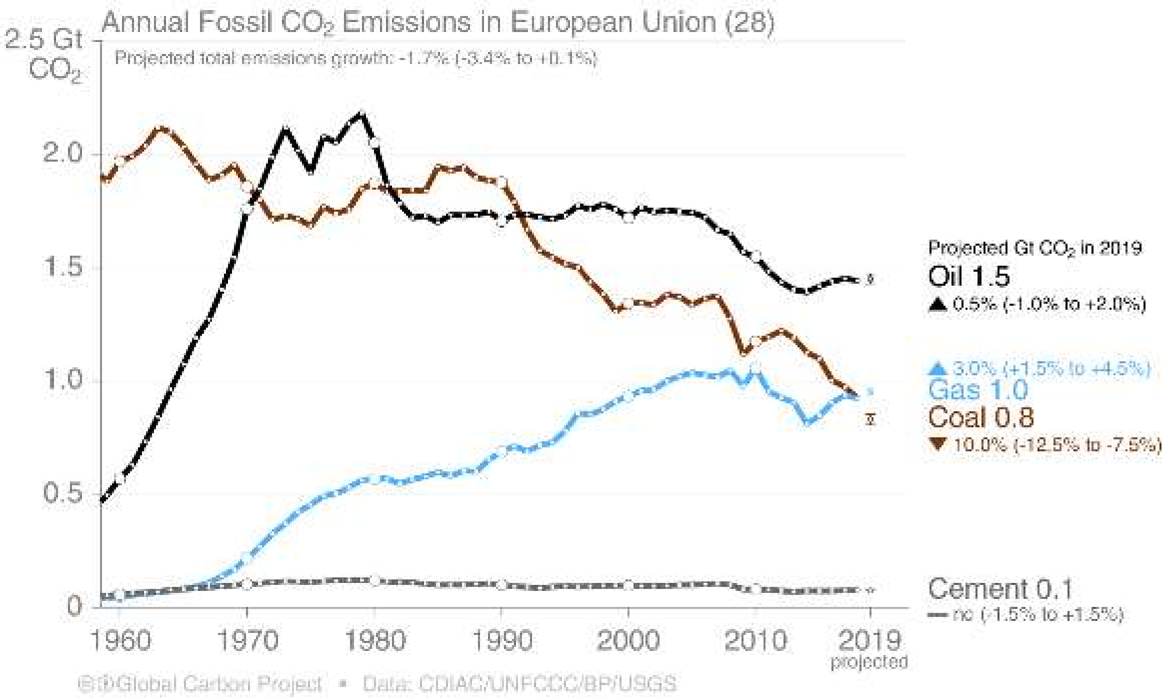
USA's CO_2 emissions have declined since 2007, driven by coal displaced by gas, solar, & wind. Oil use has returned to growth. Emissions growth in 2018 was driven partly by weather.



Source: CDIAC; Friedlingstein et al 2019; Global Carbon Budget 2019

Fossil CO_2 Emissions in the European Union (EU28)

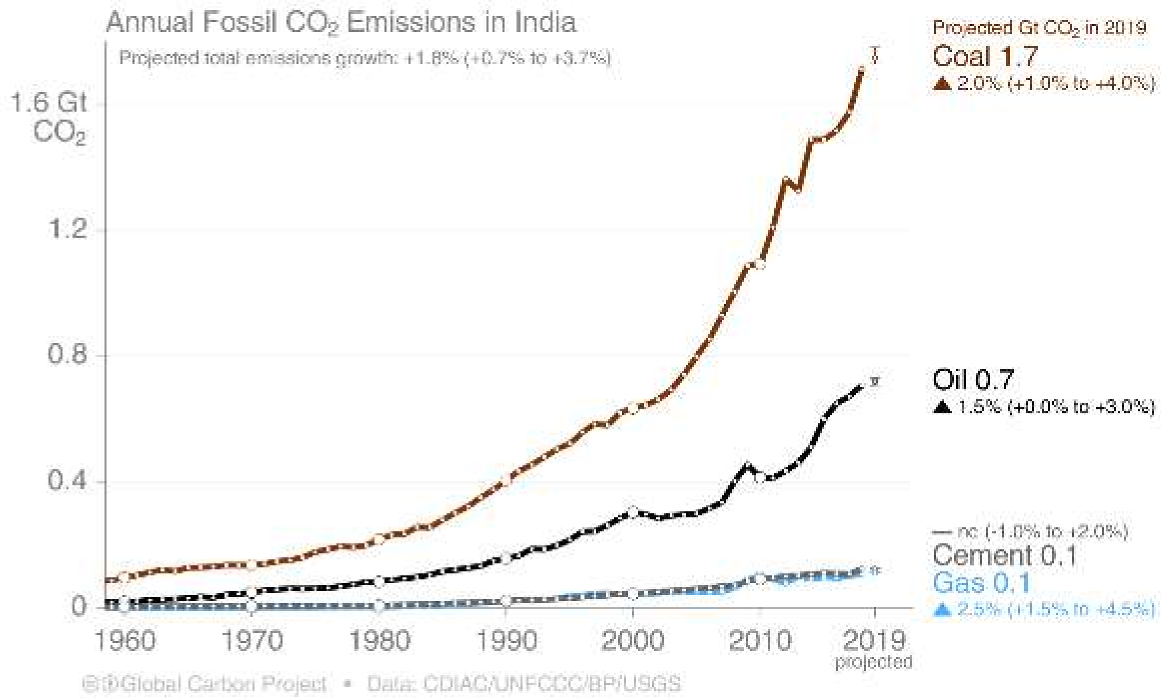
Emissions in the EU28 declined steadily from 2008 (the Global Financial Crisis) to 2014, but oil and gas emissions are growing again. A small decline is expected in 2019.



Source: [CDIAC](); [Friedlingstein et al 2019](); [Global Carbon Budget 2019]()

Fossil CO_2 Emissions in India

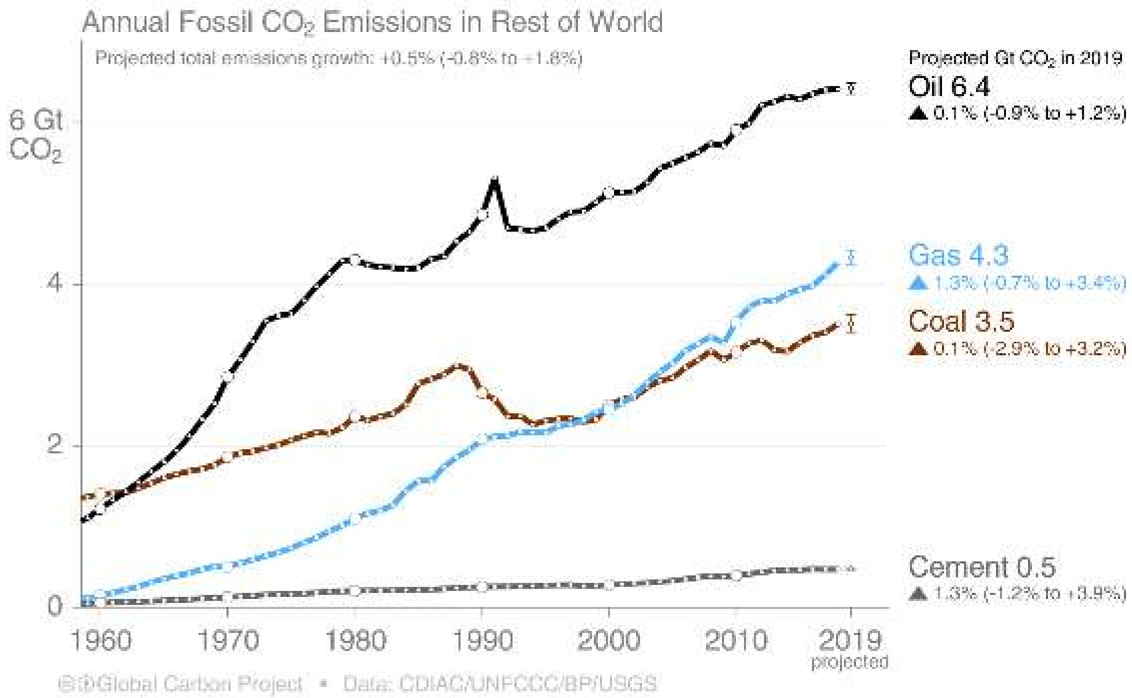
India's emissions are growing strongly along with rapid growth in economic activity.
Although India is rapidly deploying solar & wind power, coal continues to grow.



Source: CDIAC; Friedlingstein et al 2019; Global Carbon Budget 2019

Fossil CO_2 Emissions in Rest of World

Emissions in the Rest of the World are expected to grow weakly in 2019, on the back of weaker economic growth.

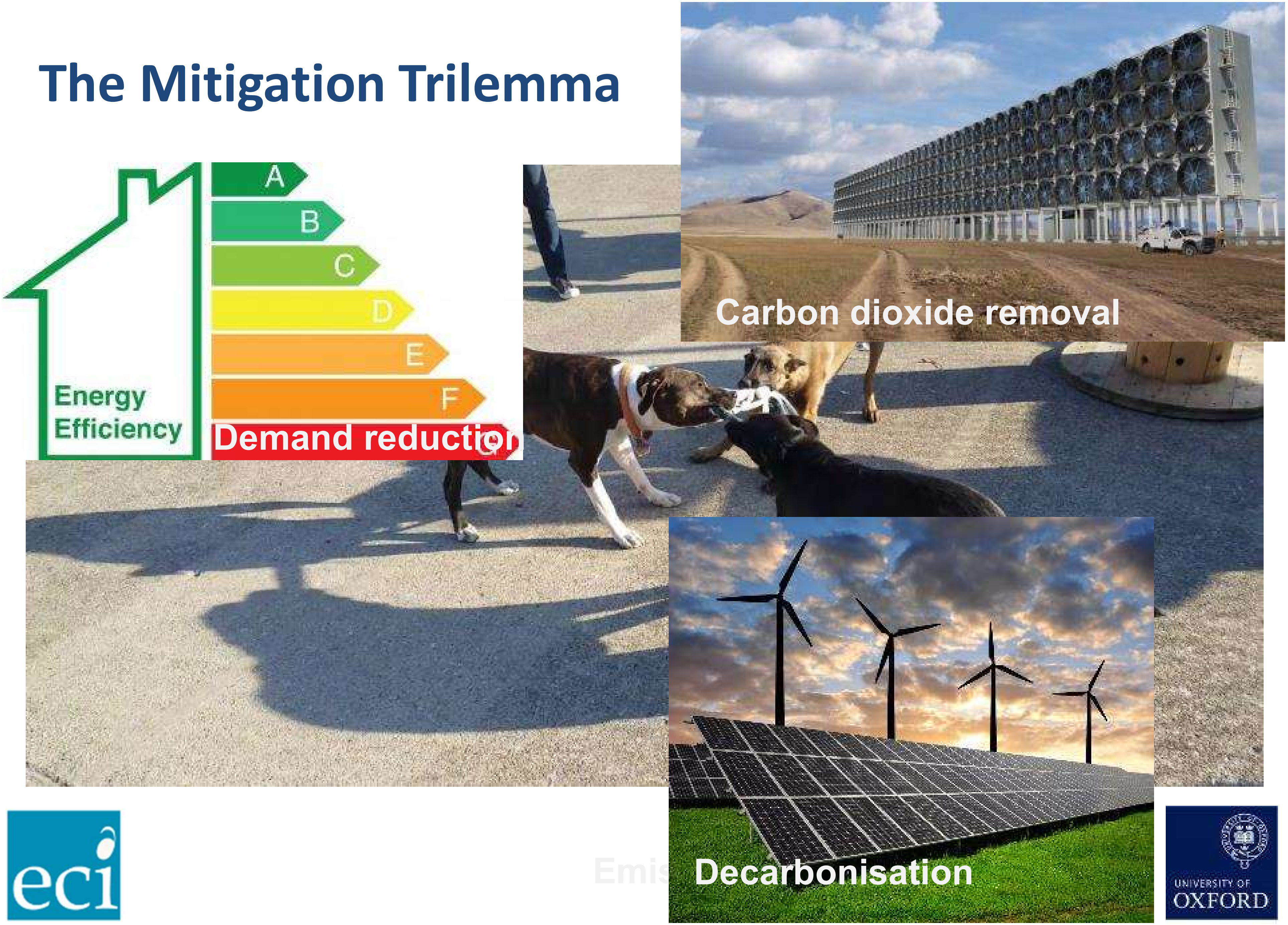


The Rest of the World is the global total less China, US, EU, and India. It also includes international aviation and marine bunkers.

Source: CDIAC; Friedlingstein et al 2019; Global Carbon Budget 2019

The Mitigation Trilemma

The Mitigation Trilemma



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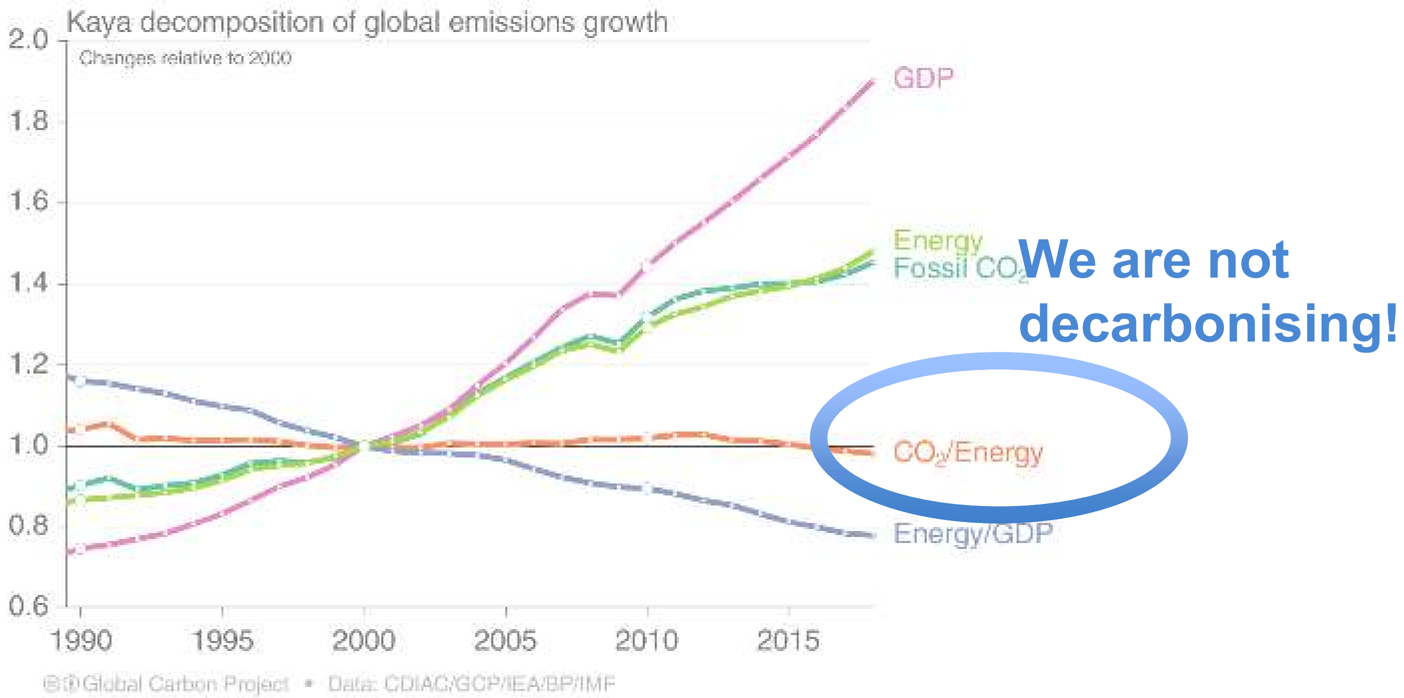
Framing the mitigation problem

- The Kaya Identity:

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

Kaya decomposition

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



GDP: Gross Domestic Product (economic activity)
Energy is Primary Energy from BP statistics using the substitution accounting method
Source: Jackson et al 2019; Global Carbon Budget 2019

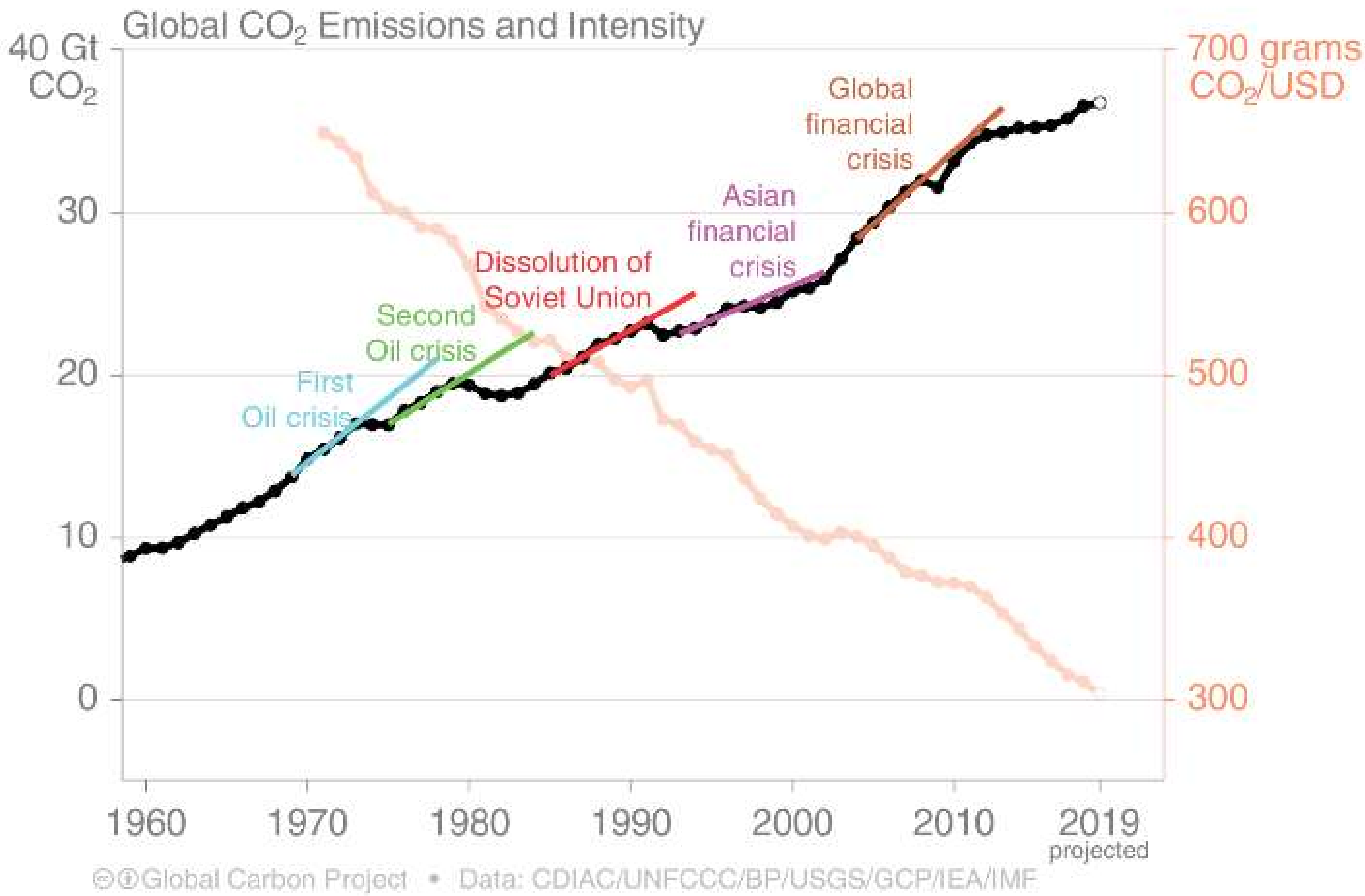
Framing the mitigation problem

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

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

Fossil CO_2 emission intensity

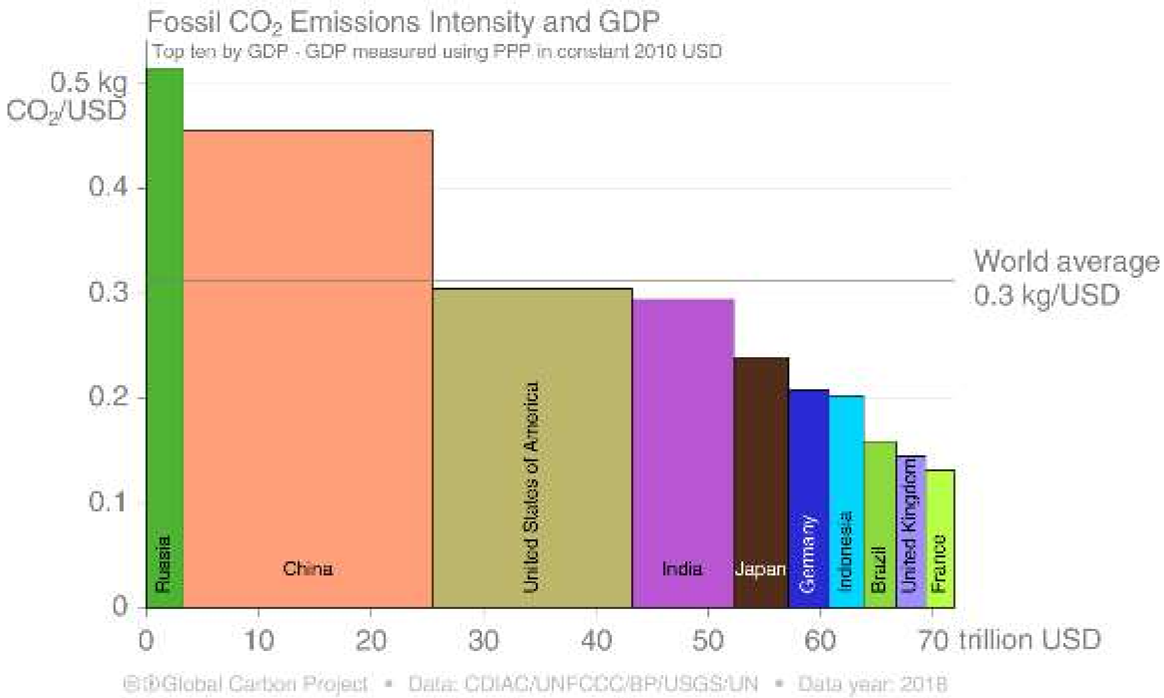
Global CO_2 emissions growth has generally resumed quickly from financial crises.
Emission intensity has steadily declined but not sufficiently to offset economic growth.



Economic activity is measured in purchasing power parity (PPP) terms in 2010 US dollars.
Source: CDIAC; Peters et al 2012; Friedlingstein et al 2019; Global Carbon Budget 2019

Fossil CO_2 emission intensity

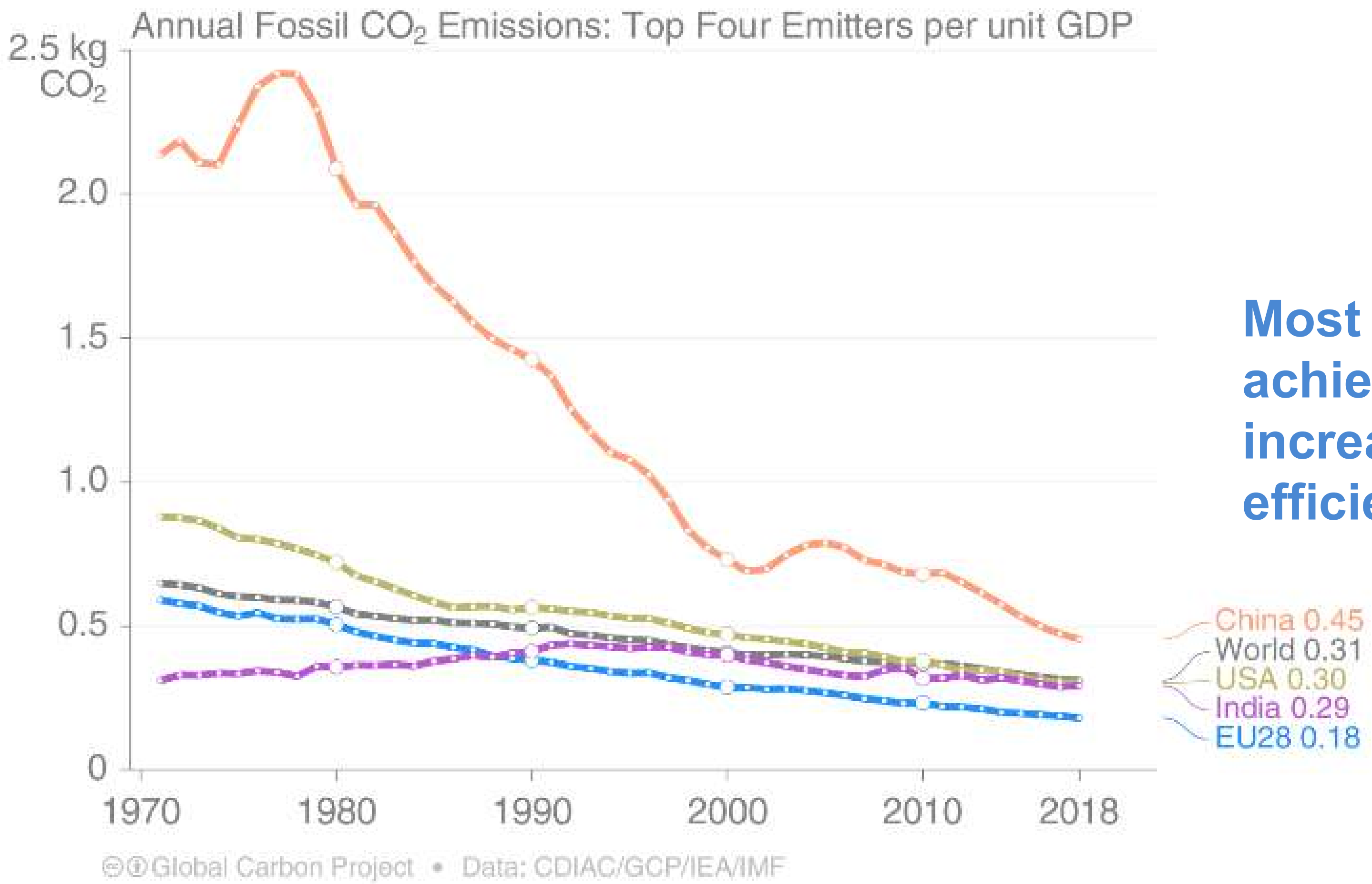
The 10 largest economies have a wide range of emission intensity of economic activity



Emission intensity: Fossil CO_2 emissions divided by Gross Domestic Product (GDP)
Source: Global Carbon Budget 2019

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.



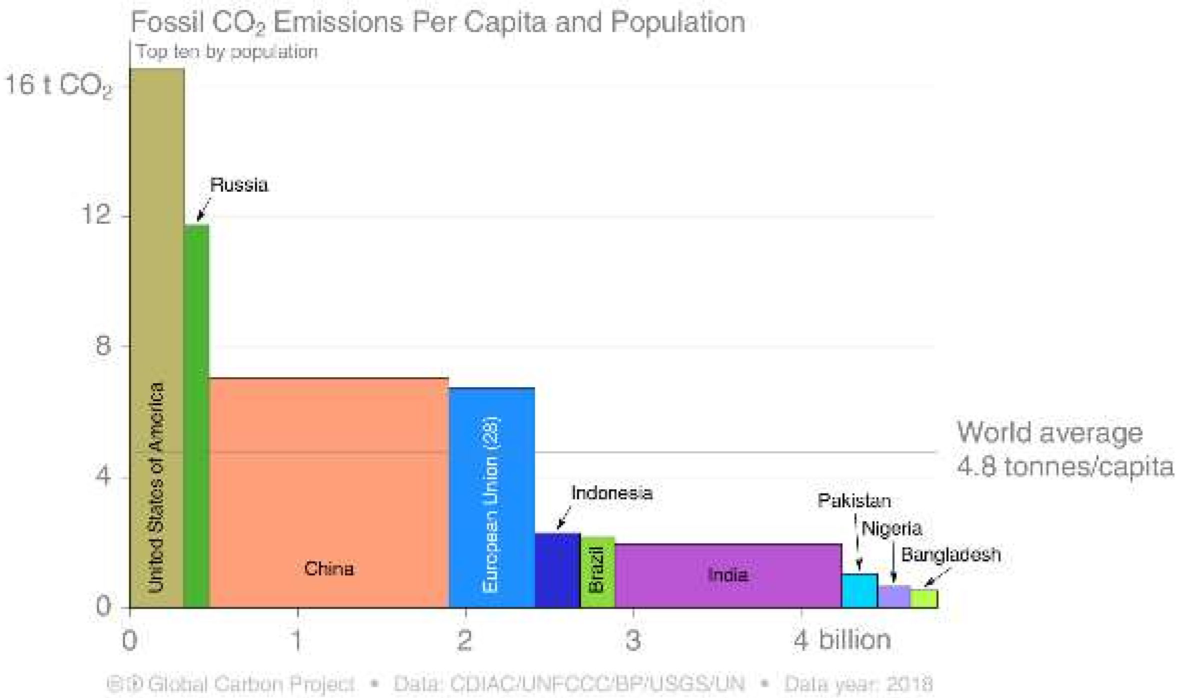
Most of this is achieved by increased efficiency

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

Source: CDIAC; IEA 2018 GDP to 2016, IMF 2019 growth rates to 2018; Friedlingstein et al 2019; Global Carbon Budget 2019

Fossil CO_2 Emissions per capita

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

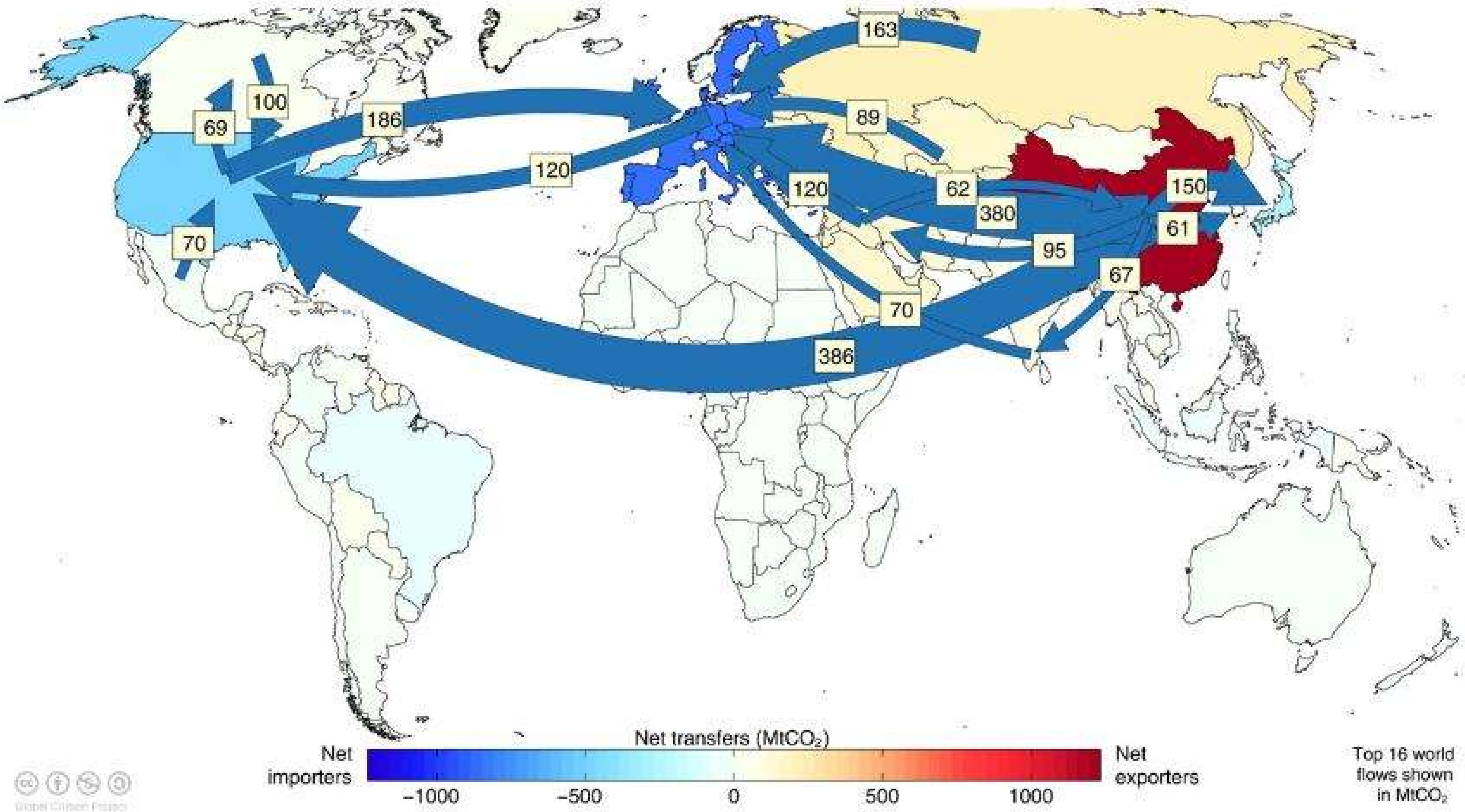


Emission per capita: Fossil CO_2 emissions divided by population

Source: Global Carbon Budget 2019

Major flows from production to consumption

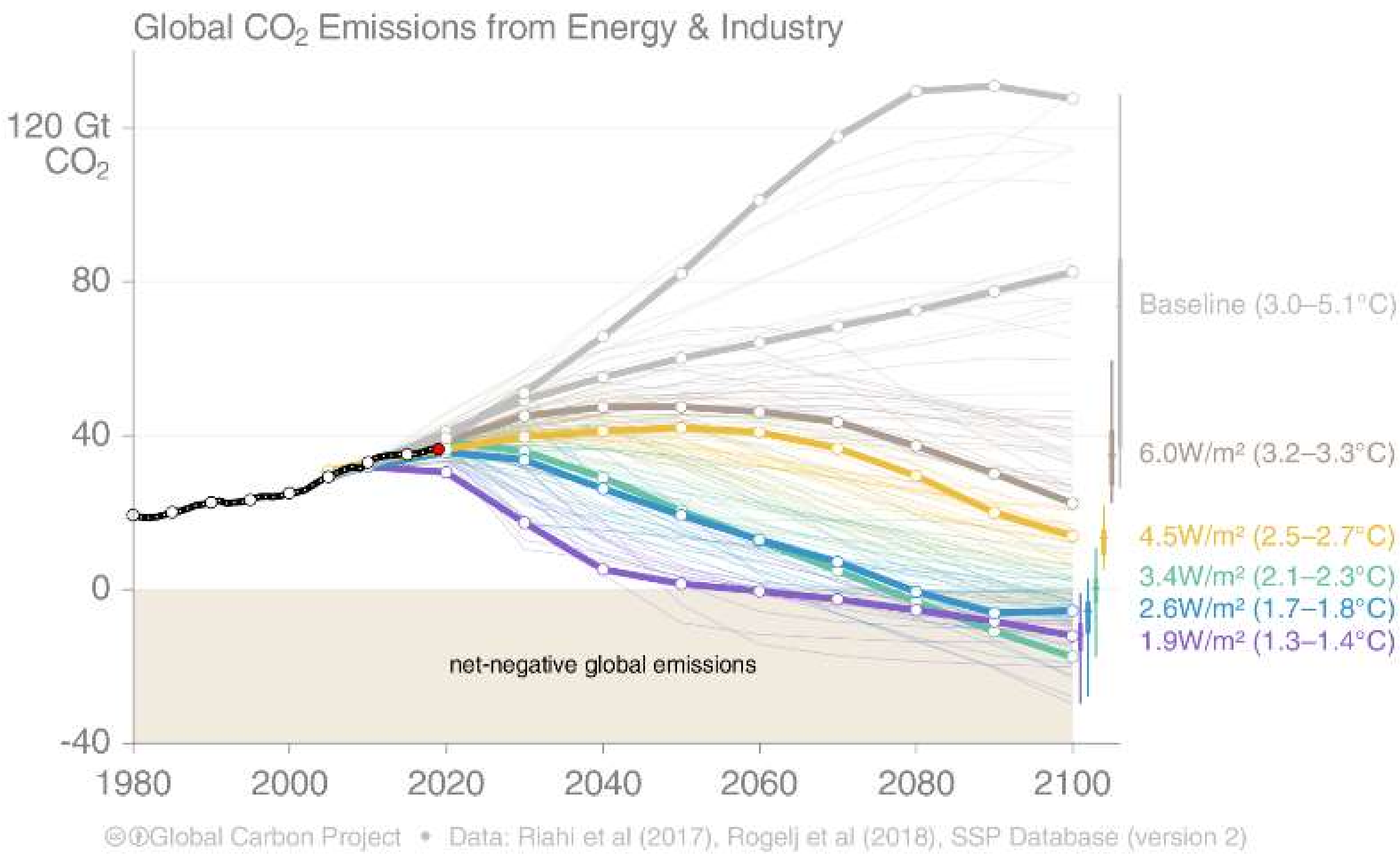
Flows from location of generation of emissions to location of consumption of goods and services



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

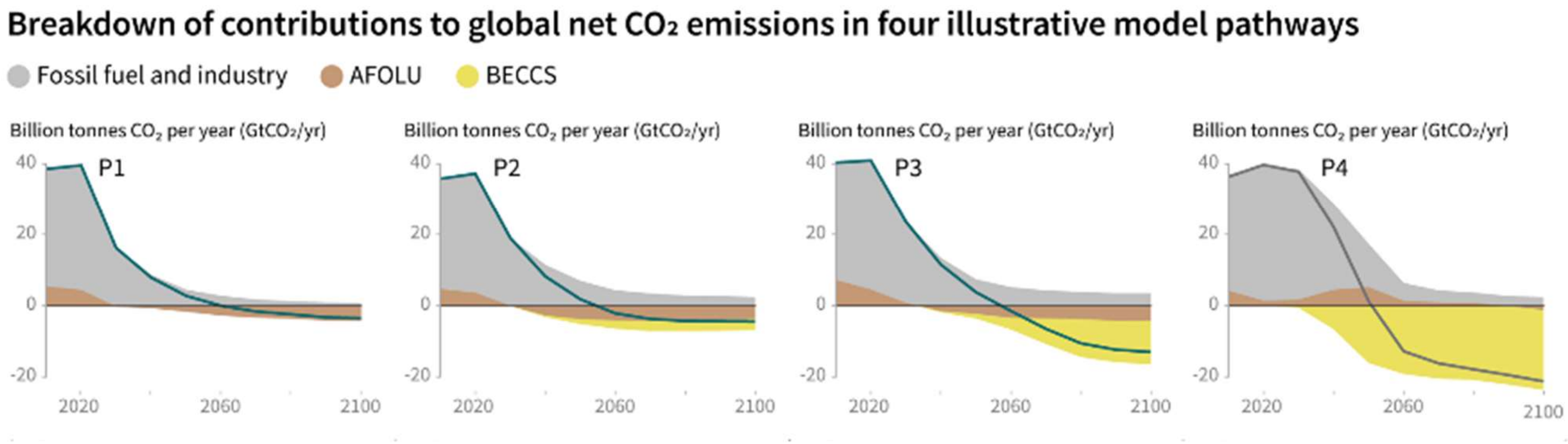
Shared Socioeconomic Pathways (SSPs)

The SSPs lead to a broad range in baselines (grey); more aggressive mitigation leading to lower temperatures.
The bold lines are scenarios that will be analysed in CMIP6 and the results assessed in the IPCC AR6 process.



This set of quantified SSPs are based on the output of six Integrated Assessment Models (AIM/CGE, GCAM, IMAGE, MESSAGE, REMIND, WITCH). Net emissions include those from land-use change and bioenergy with CCS.
Source: [Riahi et al. 2016](); [Rogelj et al. 2018](); [IIASA SSP Database](); [IAMC](); [Global Carbon Budget 2019]()

Characteristics of four illustrative 1.5°C pathways



CO_2 emission reductions are mainly achieved by …

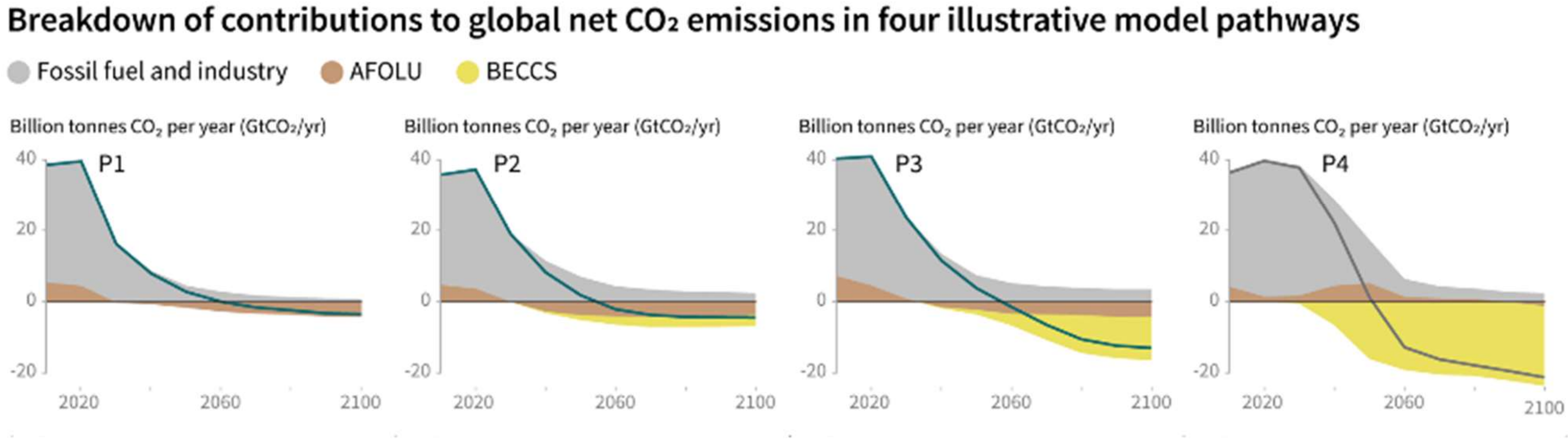
P1: … social, business and technological innovations result in lower energy demand up to 2050 …

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 1.5°C 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?

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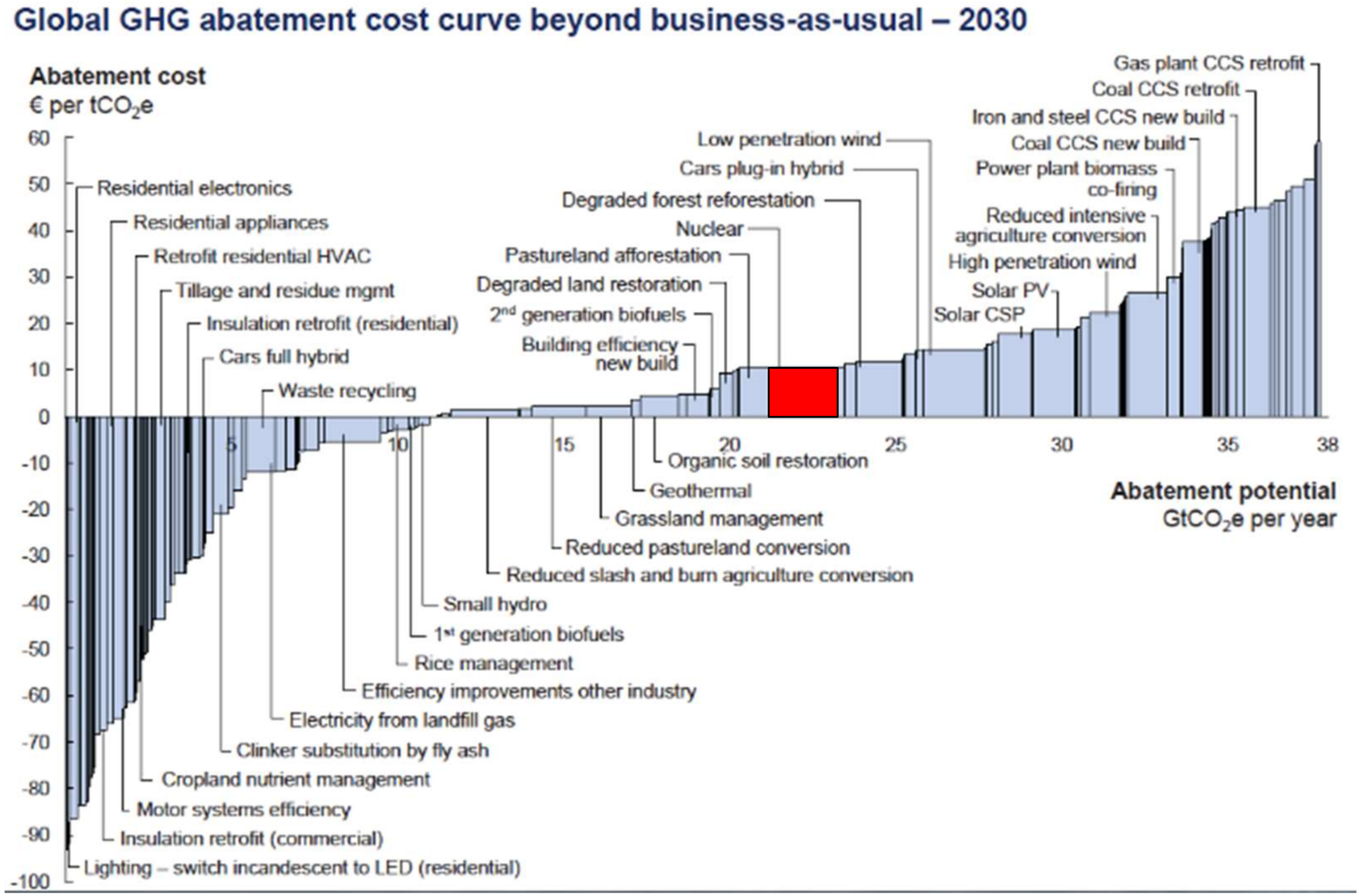
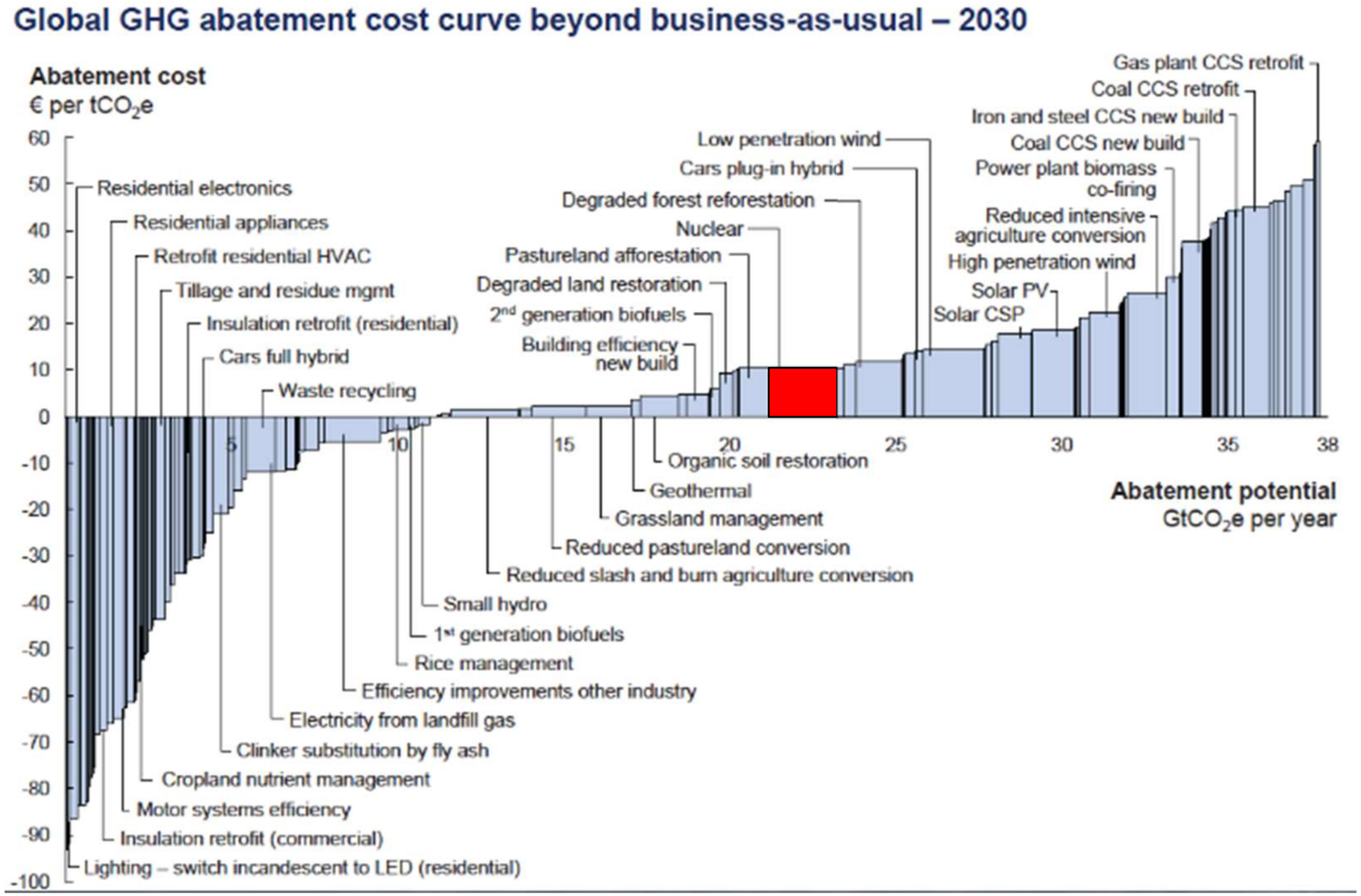
Counting the cost of reducing emissions: the Marginal Abatement Cost Curve (MACC)

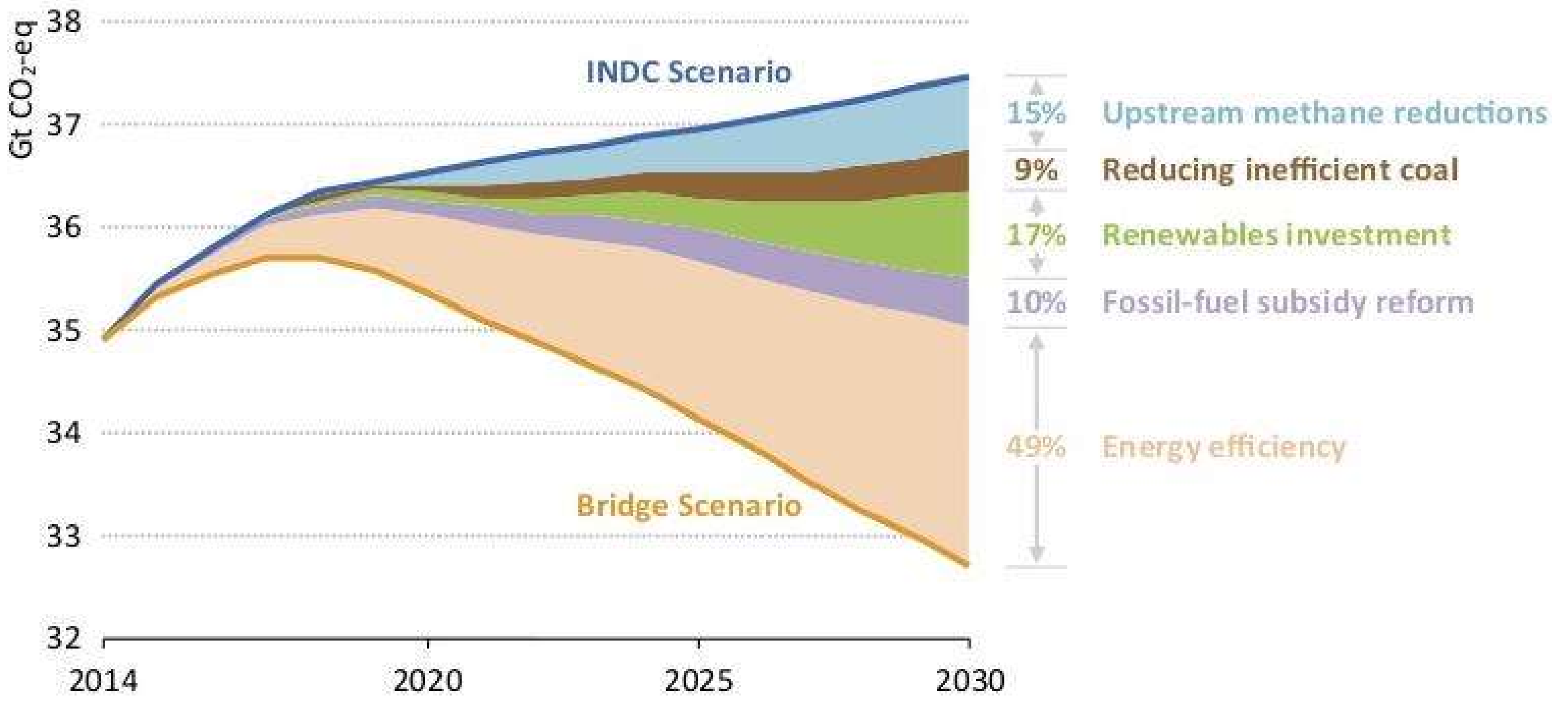


Total cost of reducing emissions = the area under the MACC



So efficiency is the big contributor in the short term

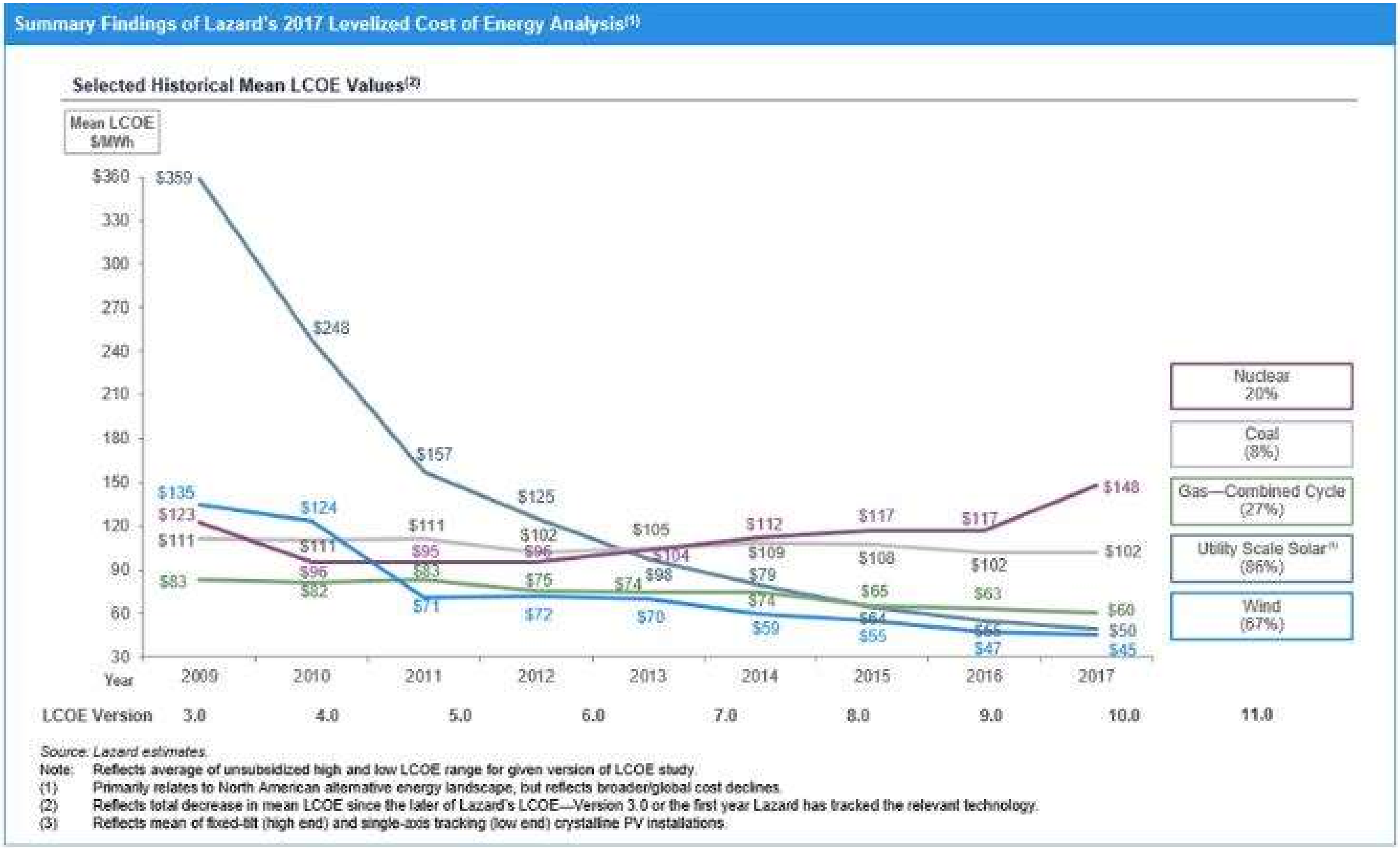
Figure 3.2 ▷ Global energy-related GHG emissions reduction by policy measure in the Bridge Scenario relative to the INDC Scenario



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)
- Non-economic drivers and blockages.

Evidence of non-economic blockages: Estimates of the levelized cost of energy



Your turn

- Open the Excel spreadsheet, Oxford_Simple_IAM_0.xlsx
- Under Clim Model Dash, select CUSTOM scenario (A3)
- Under Clim Policy Dash, vary Participation rate.
  - When 0, no-one participates, emissions remain at current level. Note this is NOT BaU – more like "current policies"
  - Set to 1, immediate global participation. Check impact on total damage cost and total mitigation costs (n.b. no discounting).
  - Try varying carbon price in 2030, 2050 and 2100.
  - Try varying abatement costs at 50% and 100% mitigation.