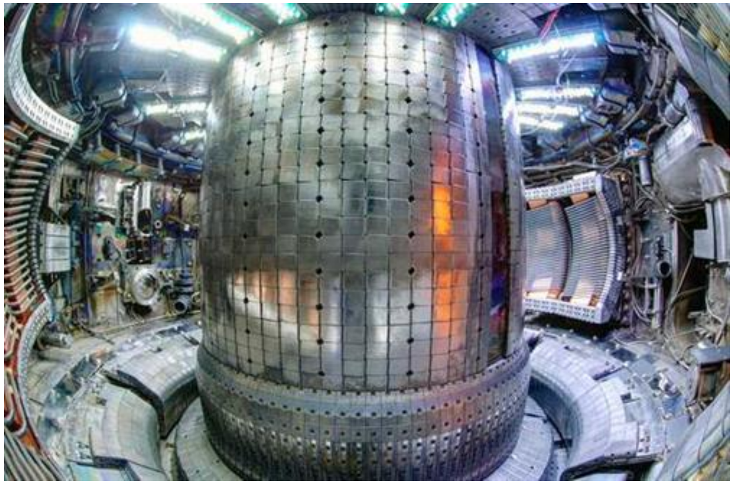
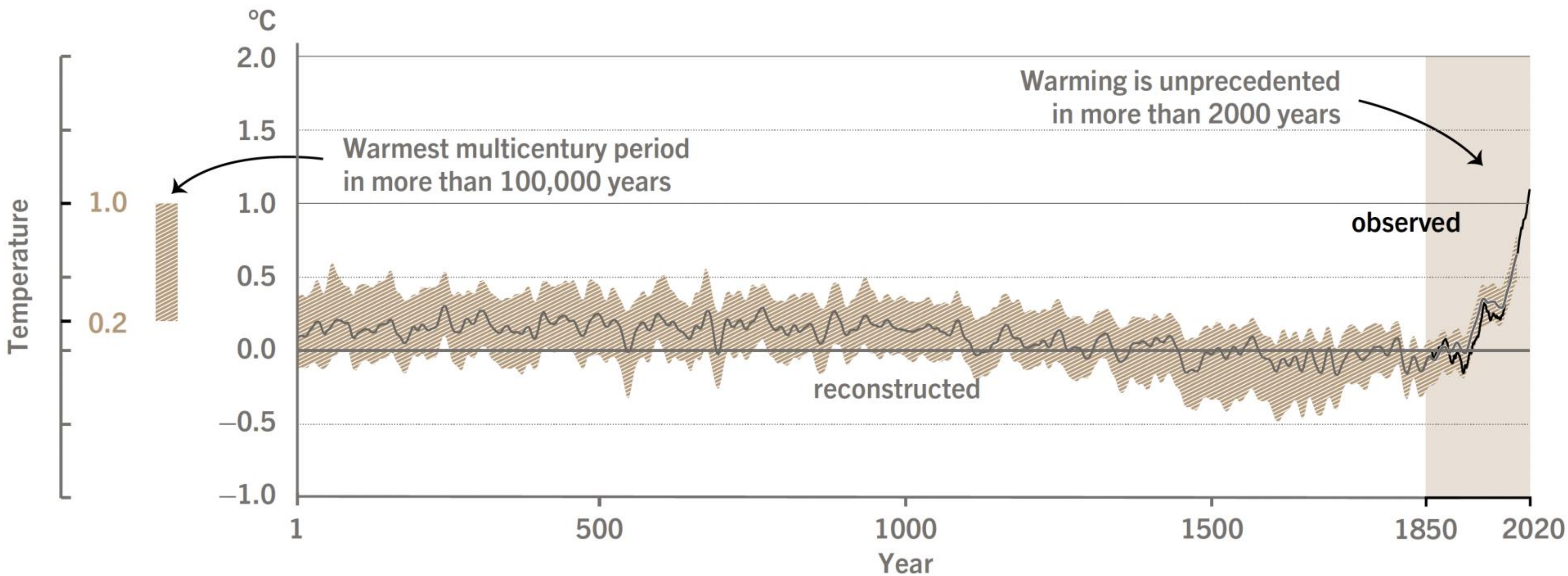
Green Innovation Policies
Economics and Climate Change



Climate Change is underway

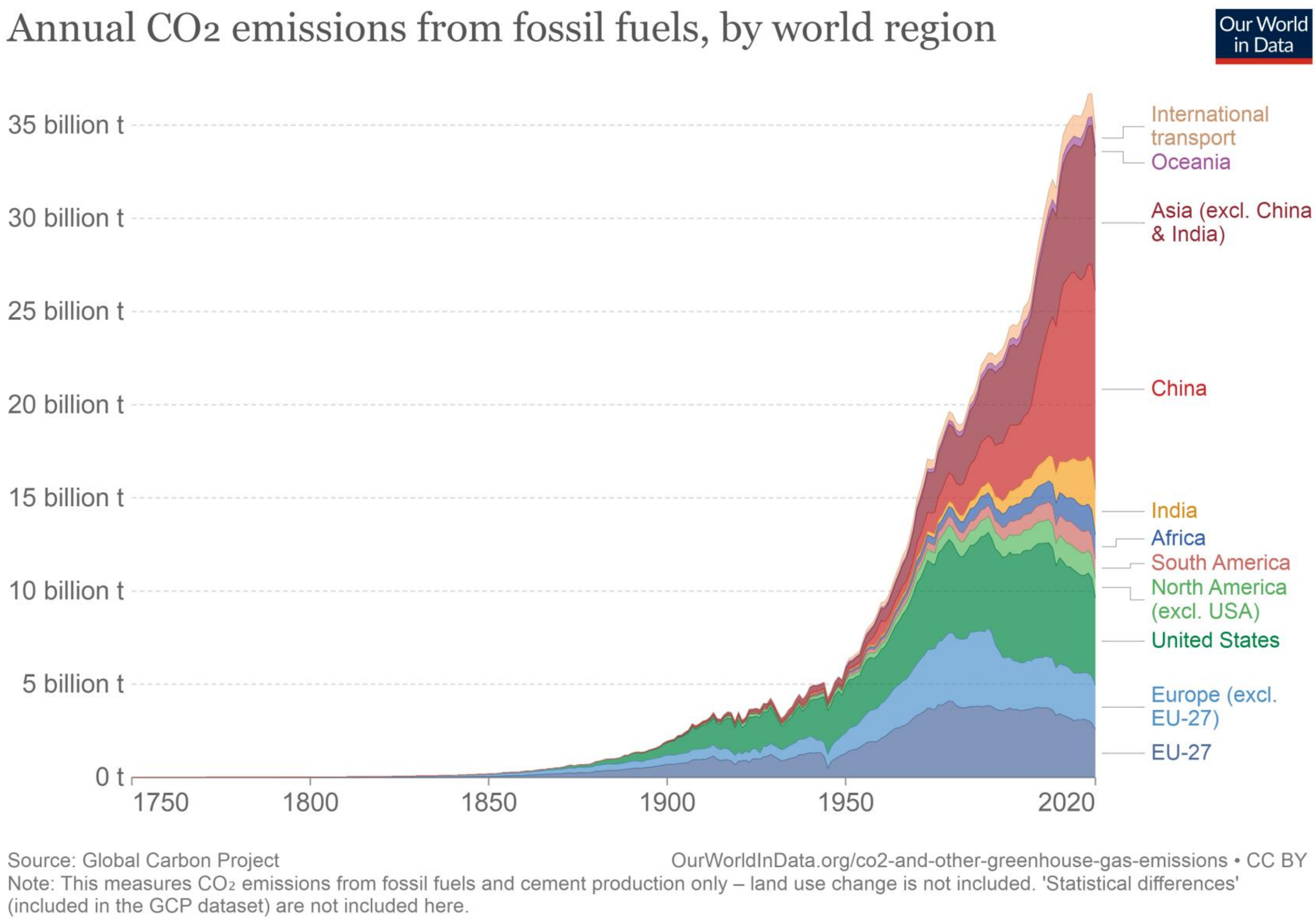
Fig. 1 Changes in global surface temperature relative to 1850–1900



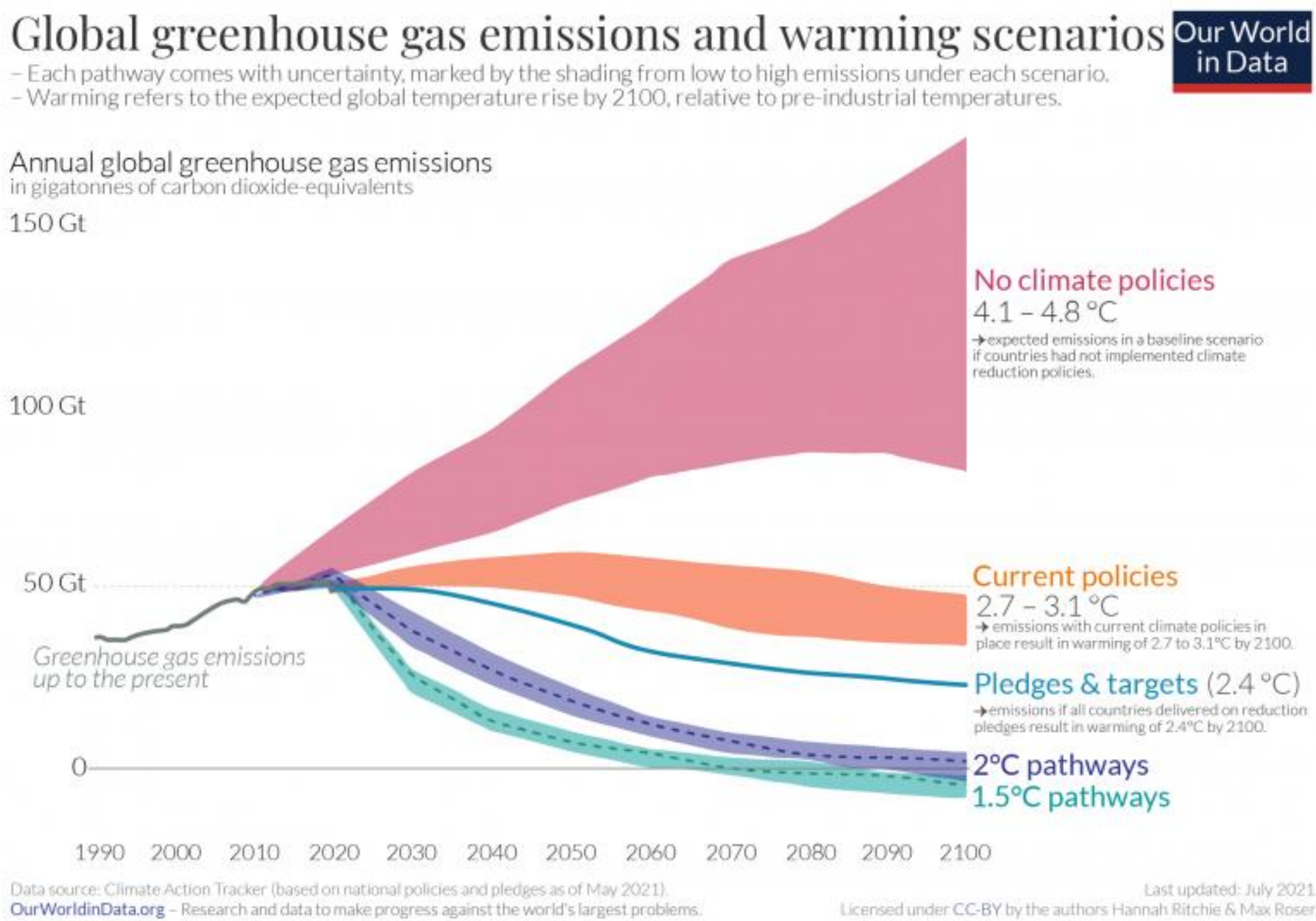
Notes: Change in global surface temperature (decadal average) as reconstructed (1–2000) and observed (1850–2020)

Source: IPCC report

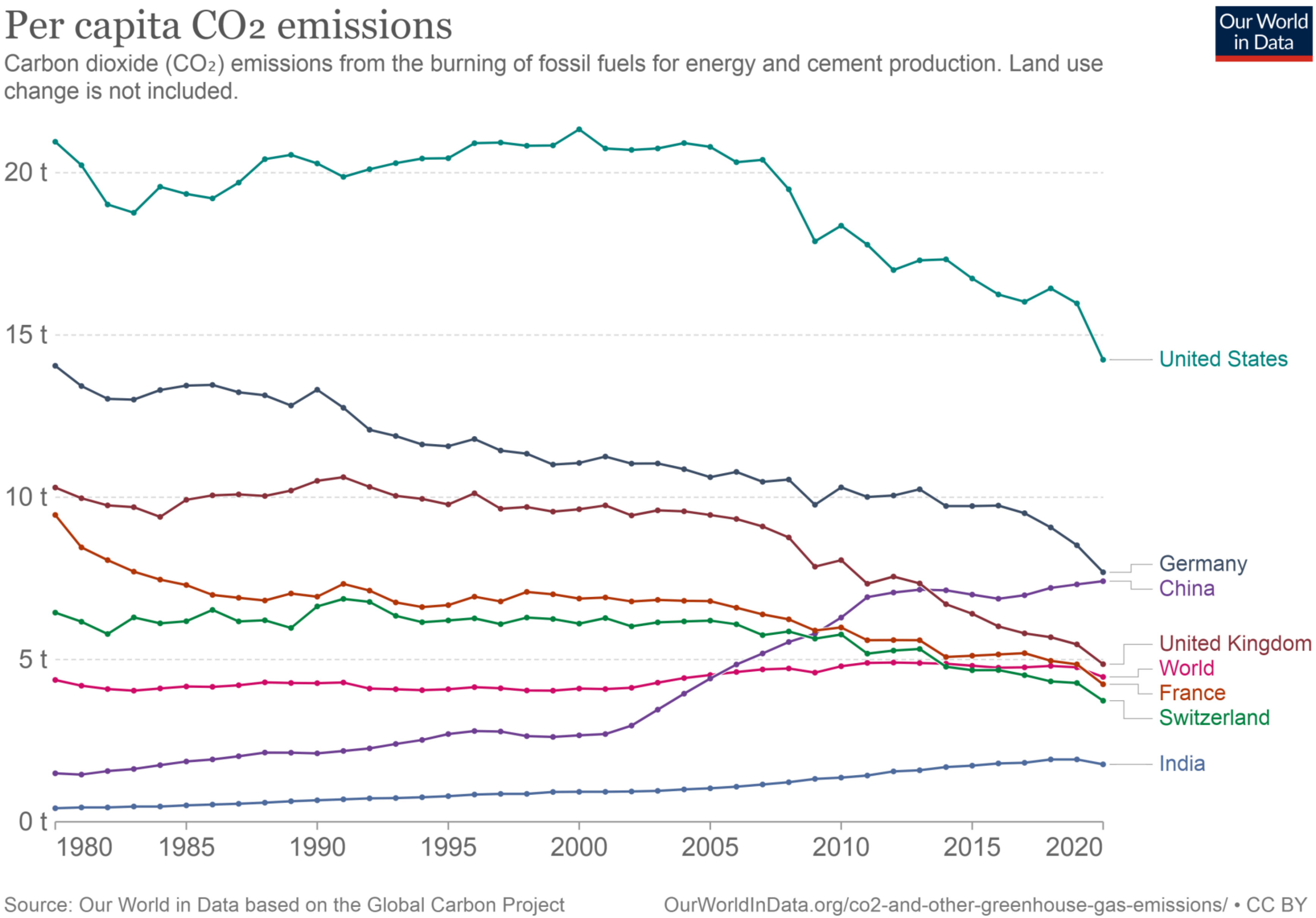
Rise in GHGs emissions



What do we need to do?



But there are huge variations across countries



Universität Zürich[UZH]

A simple decomposition

$$\text{Emissions} = \underbrace{\frac{Emissions}{Energy}} \times \underbrace{\frac{Energy}{GDP}} \times \frac{GDP}{Population} \times Population$$

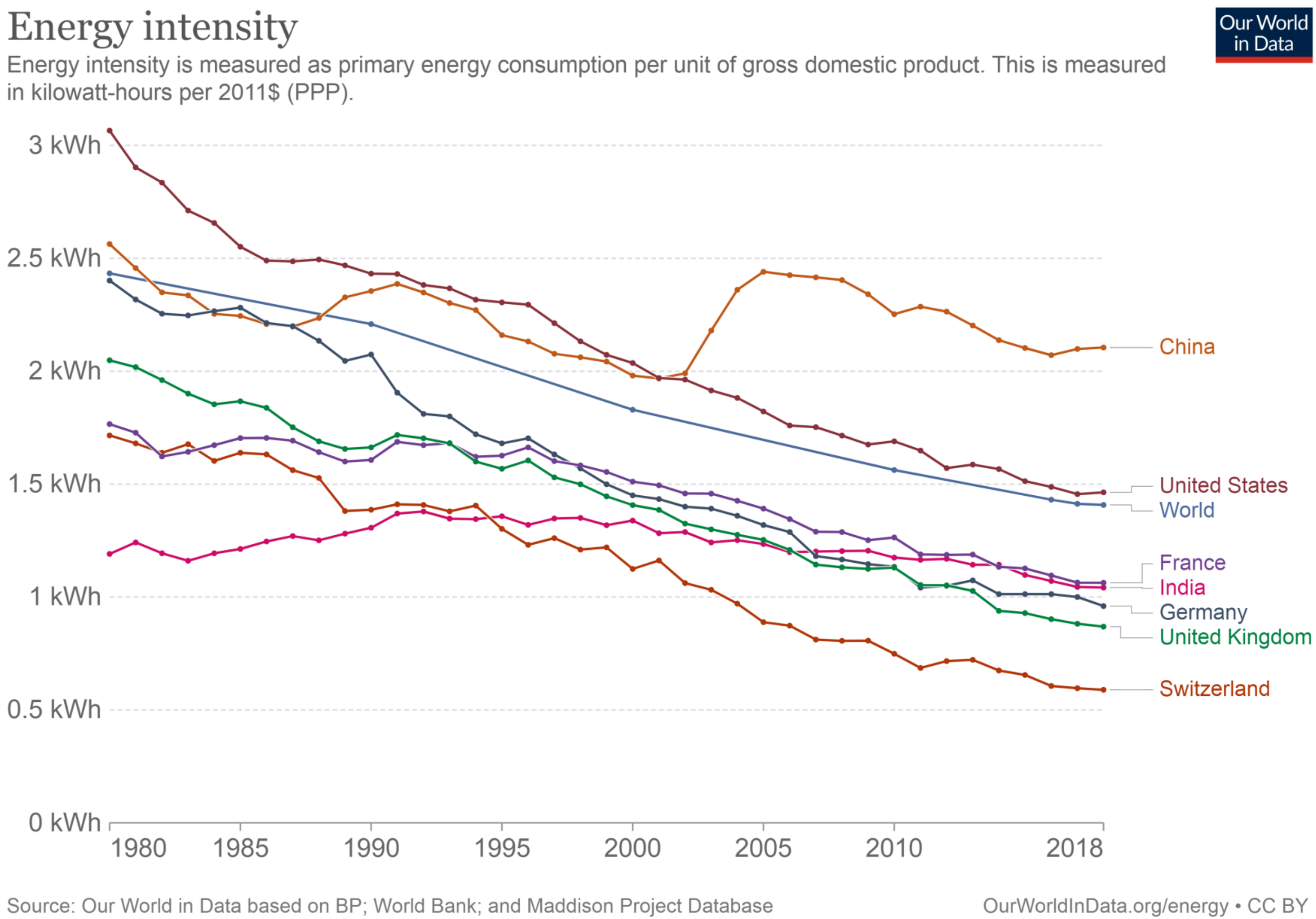
Substitution between clean and dirty energy

Energy efficiency;

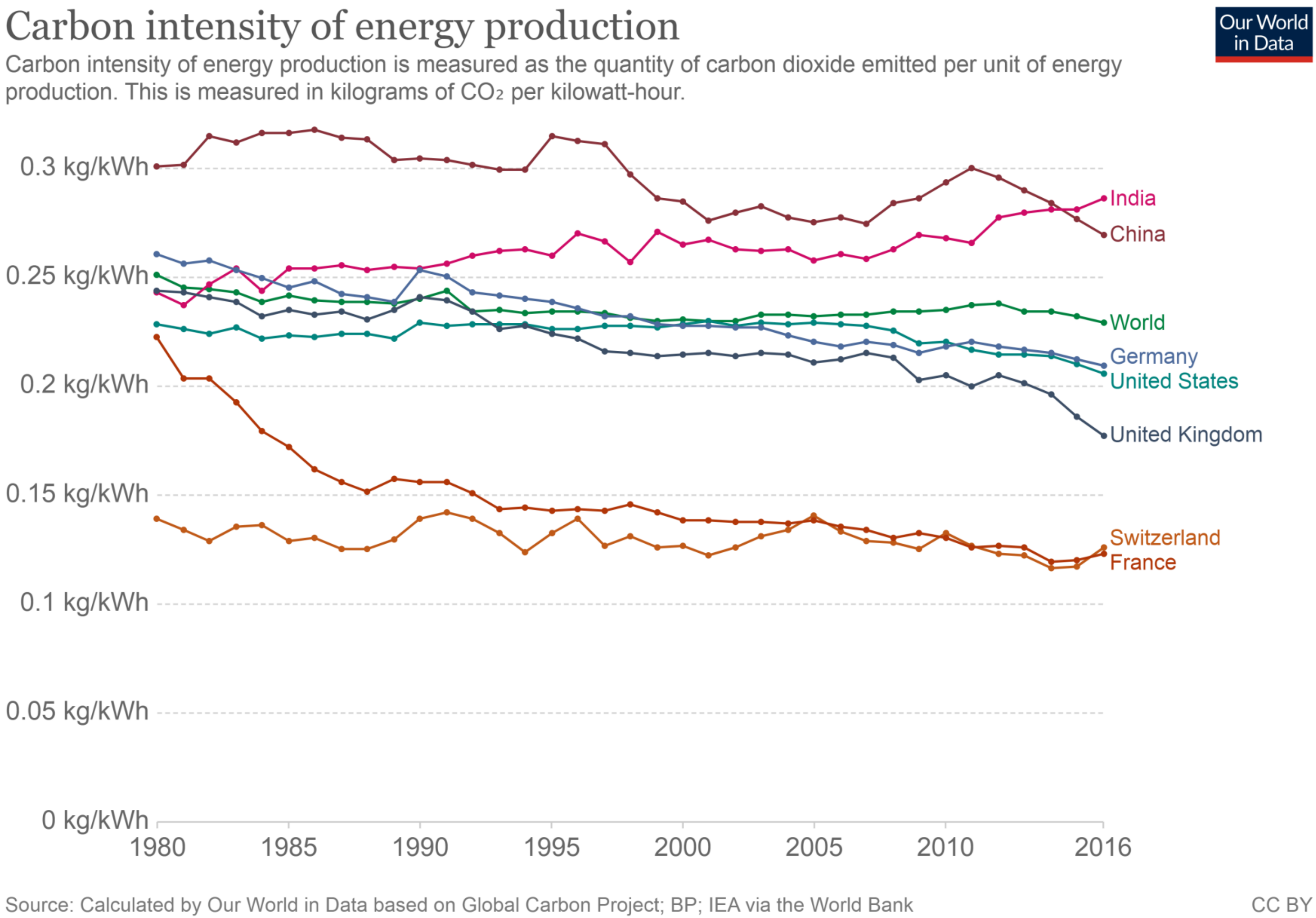
Energy sobriety;

Structural Change

Energy intensity is decreasing fast



Carbon intensity of energy is only decreasing in some countries



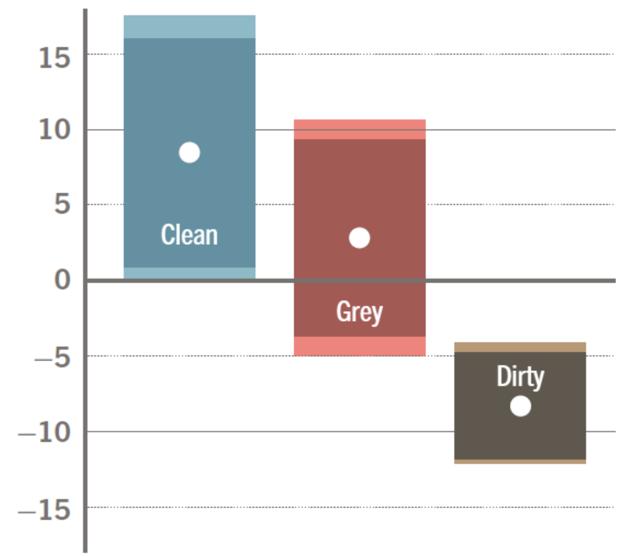
Taking stock

- “Technology’’ in a broad sense allows to reduce CO2 emissions without large reductions in GDP:
  - US emissions would fall by 70% if the US used the same technologies as France (though the transition would be costly).
  - UK emissions per capita declined by 48% between 1990 and 2019 while GDP per capita increased by 52%.
  - So far energy-saving technical change / structural transformation have done most of the job… but to reduce emissions more, one needs to develop and adopt clean substitutes.
- Is it possible to induce more green innovation?

Gas prices and innovation in the car industry

- Car industry is a good example where clean alternatives to fossil fuels exist.
- We analyze how an increase in gas prices favor clean innovation and hurts dirty innovation.
  - We measure innovations using patents and classify them
  - Showing a causal effect at the country level is impossible;
  - So we compare how firms in the car industry behave differently over time depending on the average gas price / tax in the countries that they sell to.
  - ``Shift-share'' measure.

Fig.10 **Effect of a 10% increase in fuel prices**

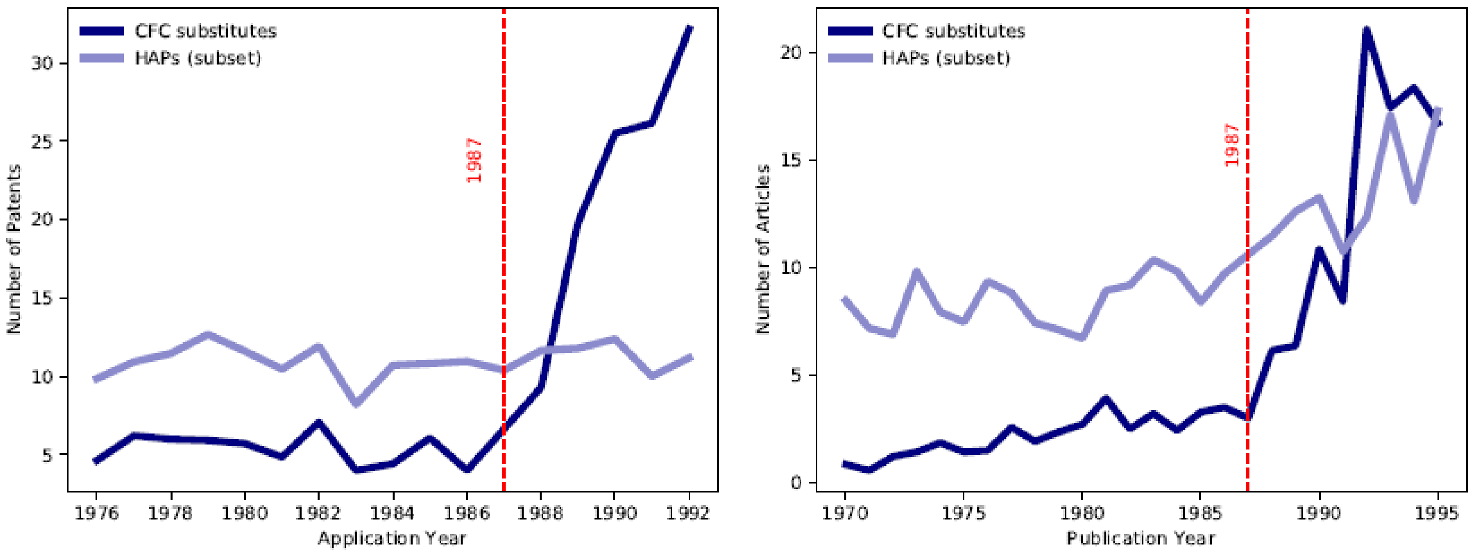


Notes: The bars denote the 90% and 95% confidence interval.

Source: Aghion, Dechezleprêtre, Hémous, Martin, and van Reenen (2016)

Montreal Protocol effect

- In the 80s, CFC emissions were causing a reduction in the ozone layer.
- Countries reached an agreement at Montreal in 1987 to progressively reduce CFCs.
- Dugoua (2022) compares the evolution of patents and scientific articles on CFC substitutes versus other similar chemicals.
- CFCs got removed very quickly and the ozone layer is recovering.



(a) Patents (b) Articles

FIGURE 4

Pre-Trends in Counts of Documents Mentioning CFC Substitutes and HAPs

Note: The graphs display the pre-trends for the treated group (CFC substitutes) and the control group constructed using a subset of the HAP molecules that have counts and pre-trends closest to the average CFC substitutes.

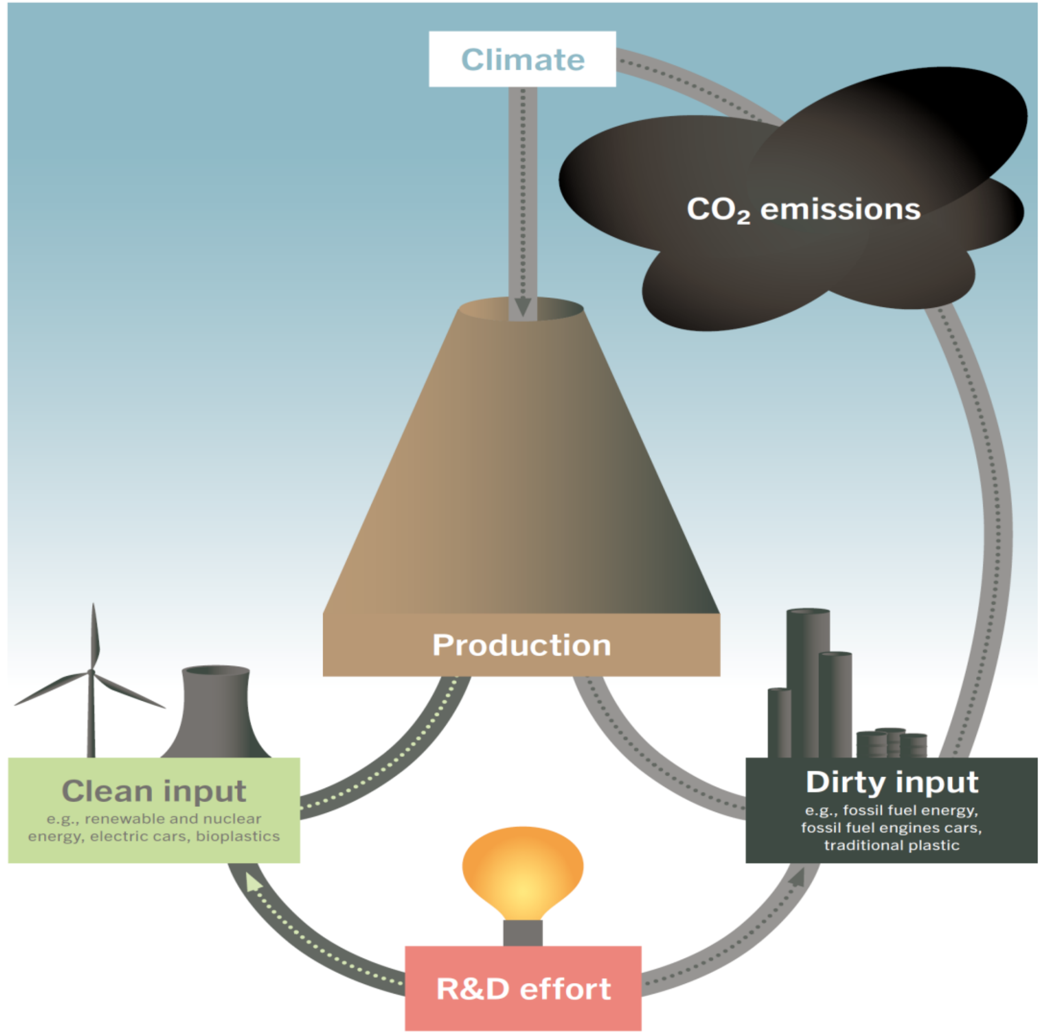
Taking stock and next steps

- Is it possible to induce more green innovation?
  - Yes
- What does this imply for climate policy?

Lessons from AABH (1)

- AABH (2012) ask if innovation is endogenous, how does that affect climate policy?
  - They introduce directed technical change in a climate model.
  - A final good can be produced with a clean and a dirty input which are substitute.
  - What do we learn from this framework?

- 1st lesson: there is path dependence in innovation.
  - In laissez-faire, innovation would be directed toward dirty technologies.

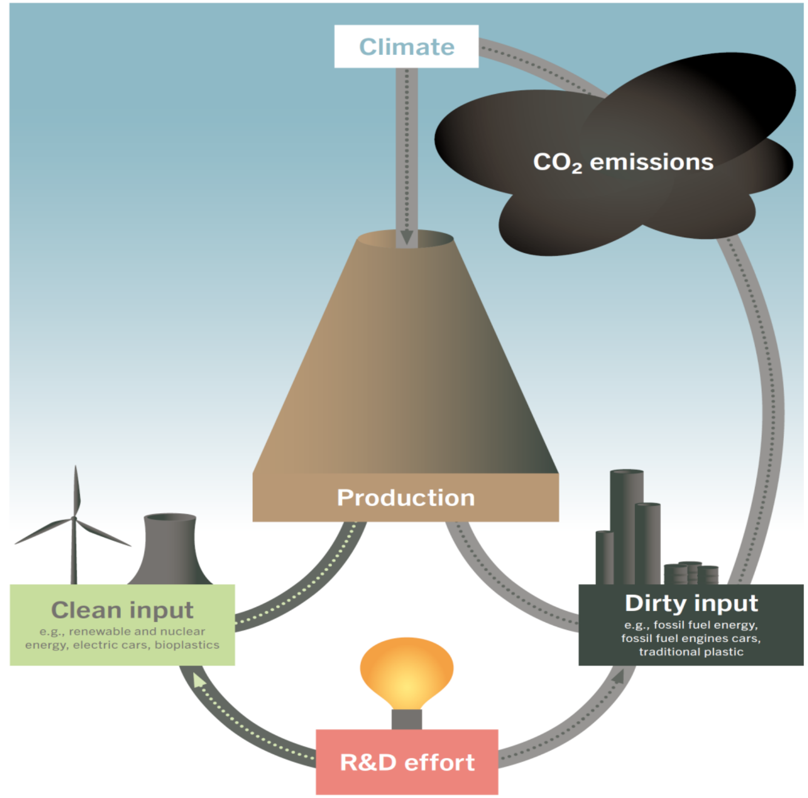


Innovation is endogenous and targets the sector with the largest profits.

Lessons from AABH (2)

- 2nd lesson: climate policies (carbon tax, research subsidies) can redirect innovation.

- 3rd lesson: delaying intervention is costly.
  - A larger gap between clean and dirty technologies means that it will take more time for clean to catch up;
  - And catch-up is associated with slow growth.



- 4th lesson: optimal policy involves both a carbon tax and subsidies to clean research:
  - Market discounts future benefits of innovation more heavily than a social planner (short patents, imitation, building on the shoulder of giants externality)
  - Most of the social value of clean technologies occur in the future (once energy transition has occurred)
  - Most of the social value of dirty technologies occur today.
  - Market favors too much dirty innovation relative to clean even with Pigovian taxation.

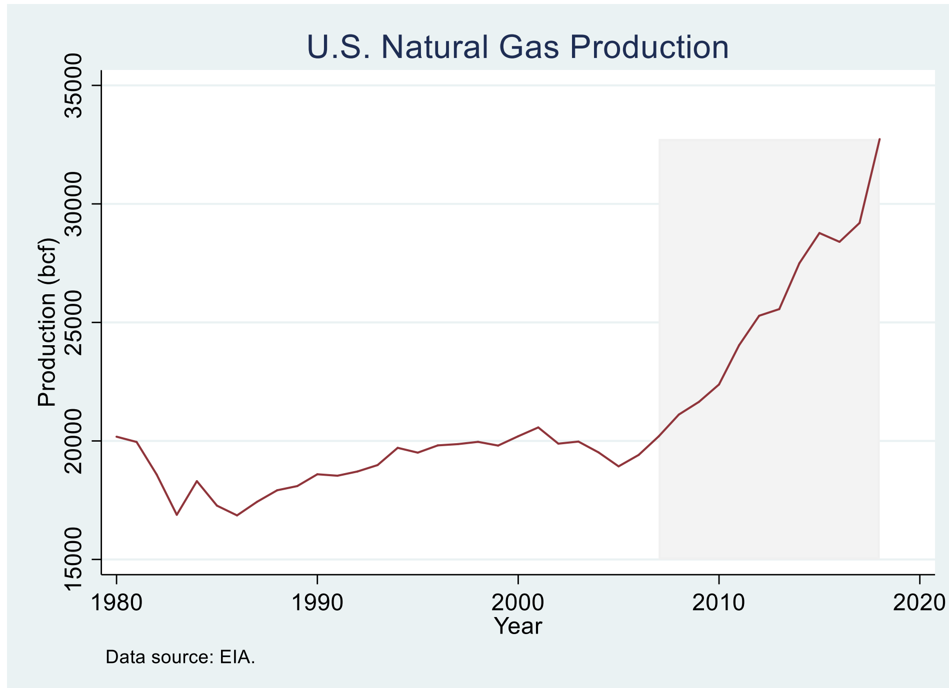
What if only part of the world is willing to implement an environmental policy?

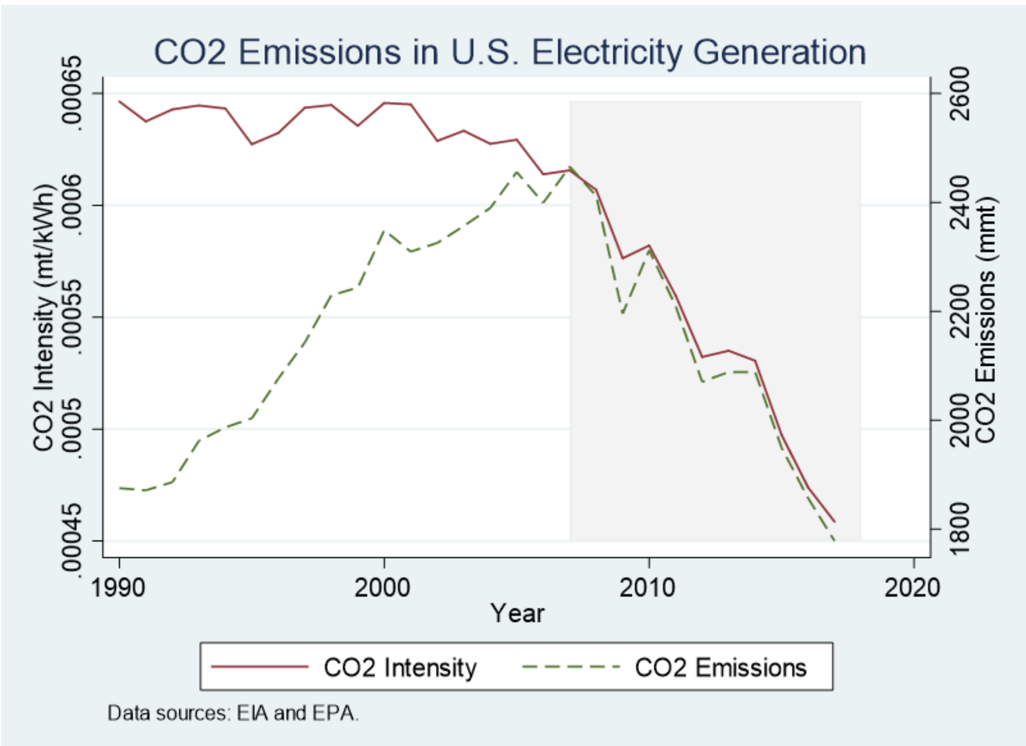
- If the EU imposes a high carbon price, “carbon leakage” is an important concern.
  - Energy-intensive manufacturing may move to countries with a lower carbon price (US, China,…).

vs

- But what about innovation?
  - The market for energy-intensive good becomes larger in the US which increases fossil fuel innovations there.
  - The market for energy-intensive good becomes smaller in Europe which decreases innovation in clean energy there.
- Consider instead a “Green industrial policy’’ which combines carbon pricing with carbon tariffs and subsidies to develop clean technologies:
  - Energy-intensive industries do not move as much to the US
  - Development of clean substitutes in the EU may spill over to the US leading to a decrease in emissions in both countries.

What are the implications for an intermediate technology (shale gas)?

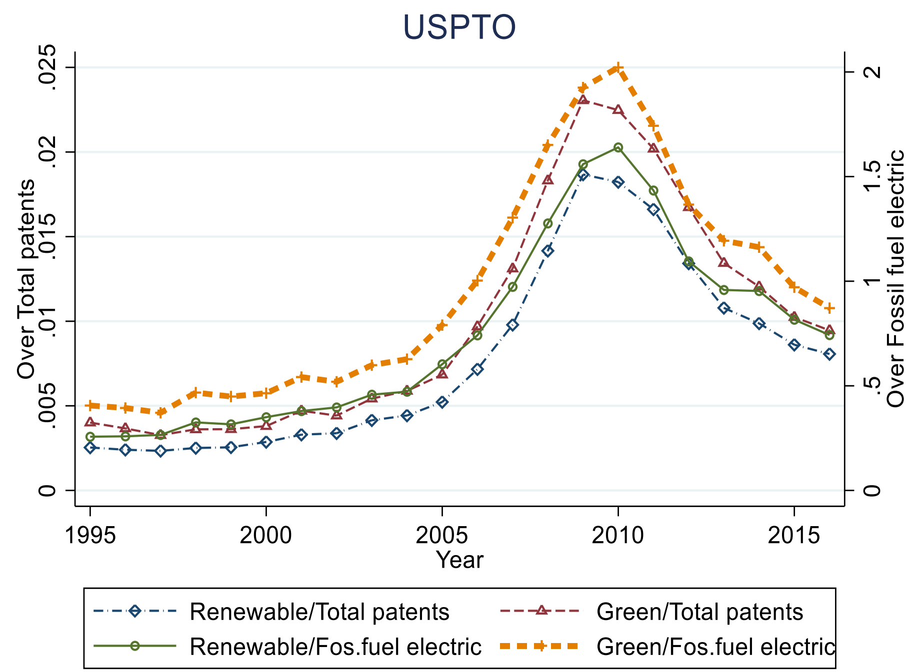


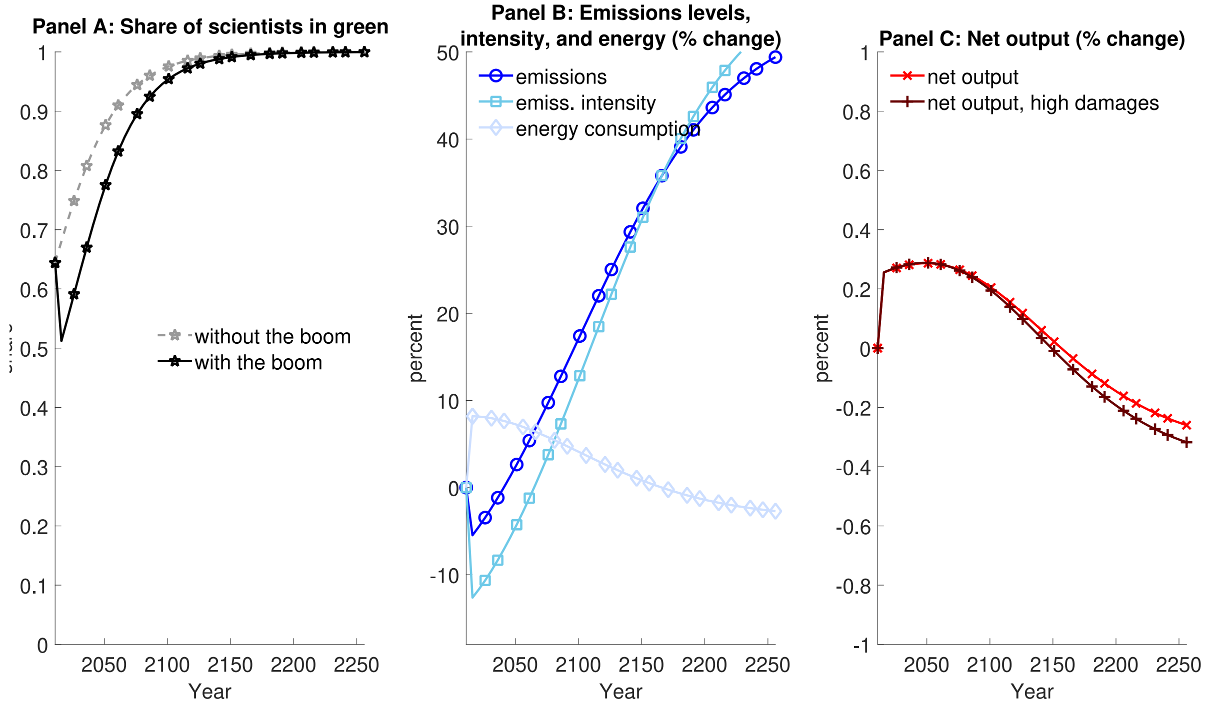


Universität Zürich[UZH]

The collapse of green innovation

- Number of patents in renewables has collapsed since the shale gas revolution.





- We estimate that in the long-run, the shale boom will actually lead to an increase in emissions (unless policy reacts).
- Policy should react by increasing support to clean technologies.

Conclusions

- Innovation is key to tackle climate change;
  - Innovation responds to market incentives
  - But that is a call for more not less governmental action.
  - (Of course, it is not only about innovation).

- Taking into account the response of innovation:
  - Calls for research subsidies on top of carbon pricing;
  - Calls for an earlier interventions;
  - Favors a local green industrial policy over a simple unilateral carbon tax;
  - Calls for caution when deploying ``bridge'' technologies such as natural gas.