Could a clean energy economy be vastly cheaper?

JRC annual conference

17 November 2022

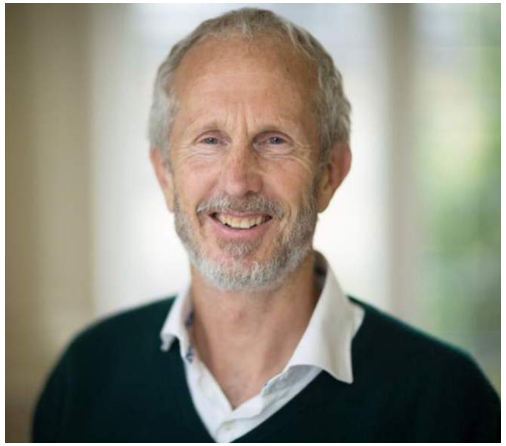
Dr Rupert Way

Affiliated researcher at INET, SSEE, OMS, University of Oxford

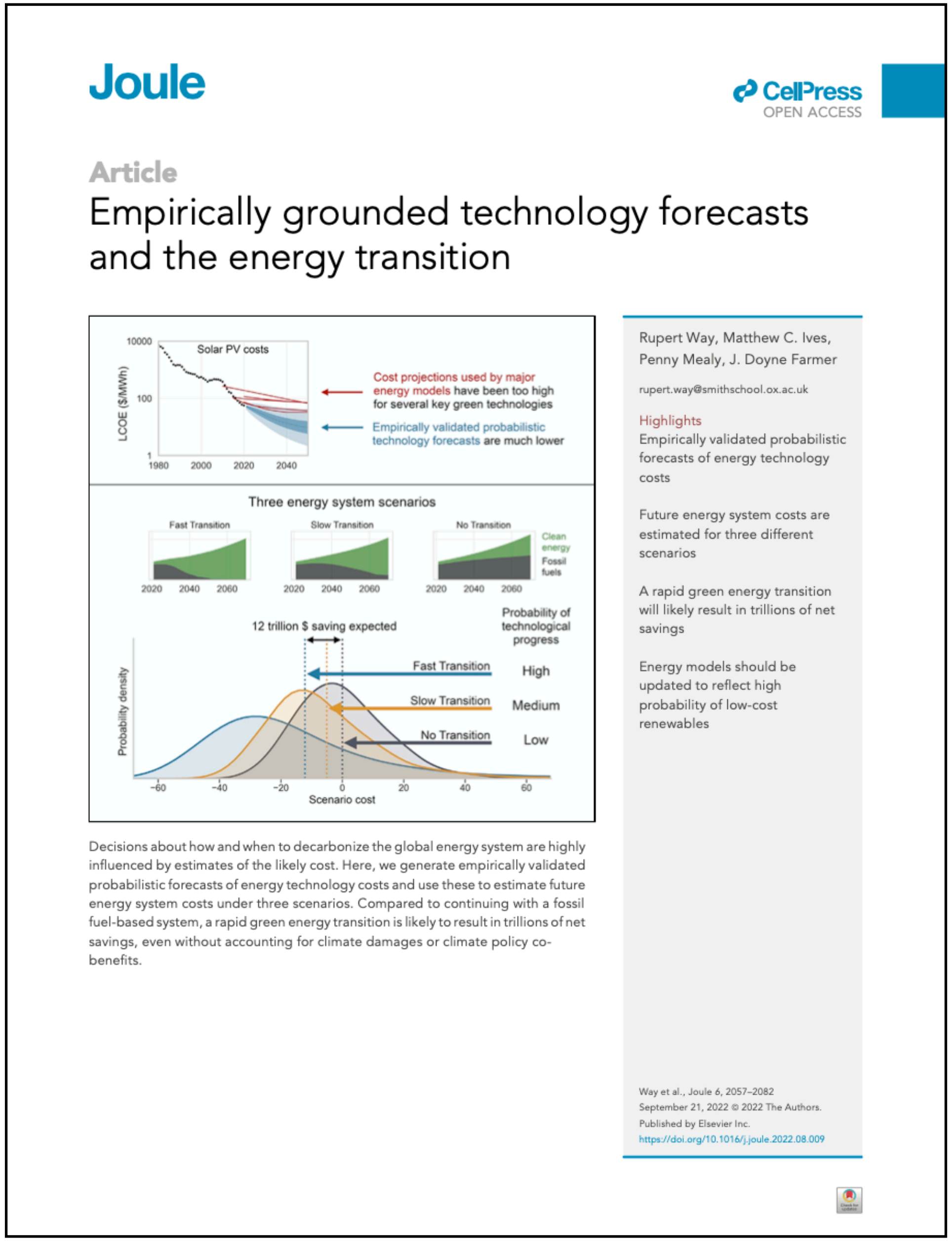
Rupert Way

Matt Ives

Penny Mealy



Doyne Farmer



Joule

CellPress OPEN ACCESS

Article

Empirically grounded technology forecasts and the energy transition

Rupert Way, Matthew C. Ives, Penny Mealy, J. Doyne Farmer

rupert.way@smithschool.ox.ac.uk

Highlights

Empirically validated probabilistic forecasts of energy technology costs

Future energy system costs are estimated for three different scenarios

A rapid green energy transition will likely result in trillions of net savings

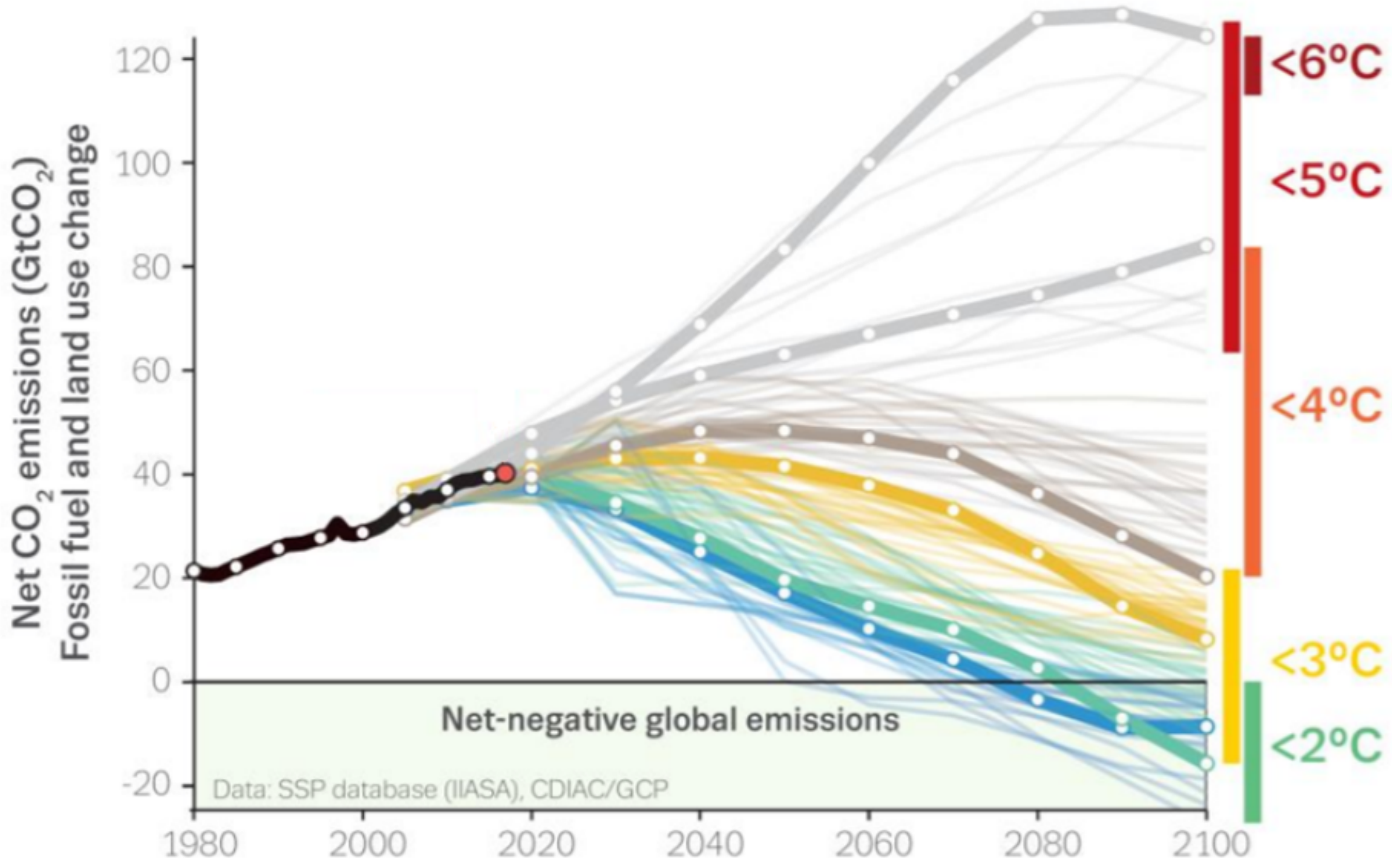
Energy models should be updated to reflect high probability of low-cost renewables

Decisions about how and when to decarbonize the global energy system are highly influenced by estimates of the likely cost. Here, we generate empirically validated probabilistic forecasts of energy technology costs and use these to estimate future energy system costs under three scenarios. Compared to continuing with a fossil fuel-based system, a rapid green energy transition is likely to result in trillions of net savings, even without accounting for climate damages or climate policy co-benefits.

Way et al., Joule 6, 2057–2082
September 21, 2022 © 2022 The Authors.
Published by Elsevier Inc.
https://doi.org/10.1016/j.joule.2022.08.009

How much will the net zero energy transition cost?

“Stopping climate change will be slow or very expensive”



Source: Global Carbon Project (2017) and Bank of England (2018)

To achieve < 2 degrees:

- Economic growth must suffer
- We will need to reduce our energy usage
- We need to build 13Gt or more of Carbon Capture and Storage plants by 2100
- Electricity prices will go up
- Paris goals appear impossible

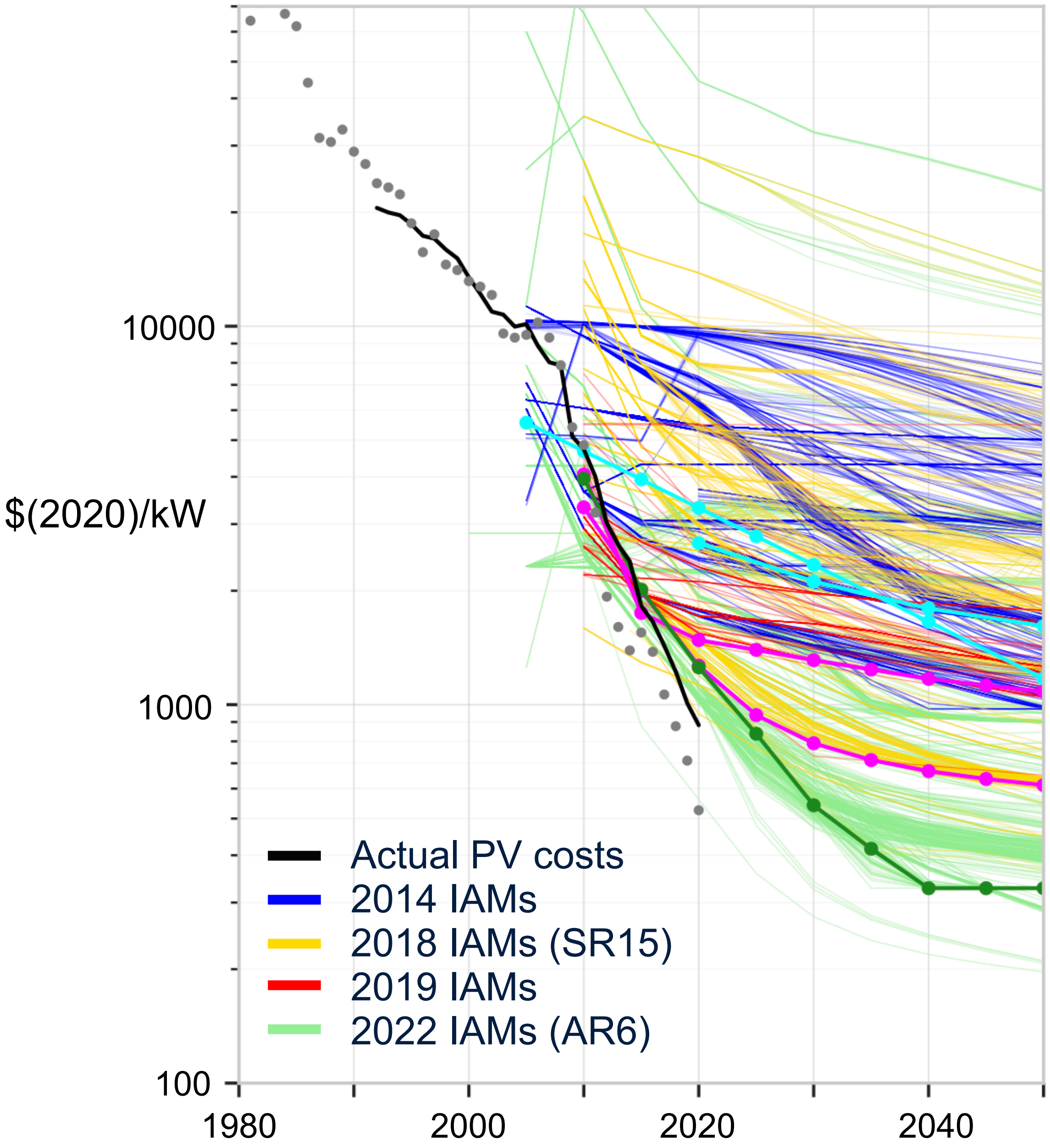
What’s wrong with this narrative?

“Solar power is by far the most expensive way to reduce carbon emissions.”

The Economist (2014)

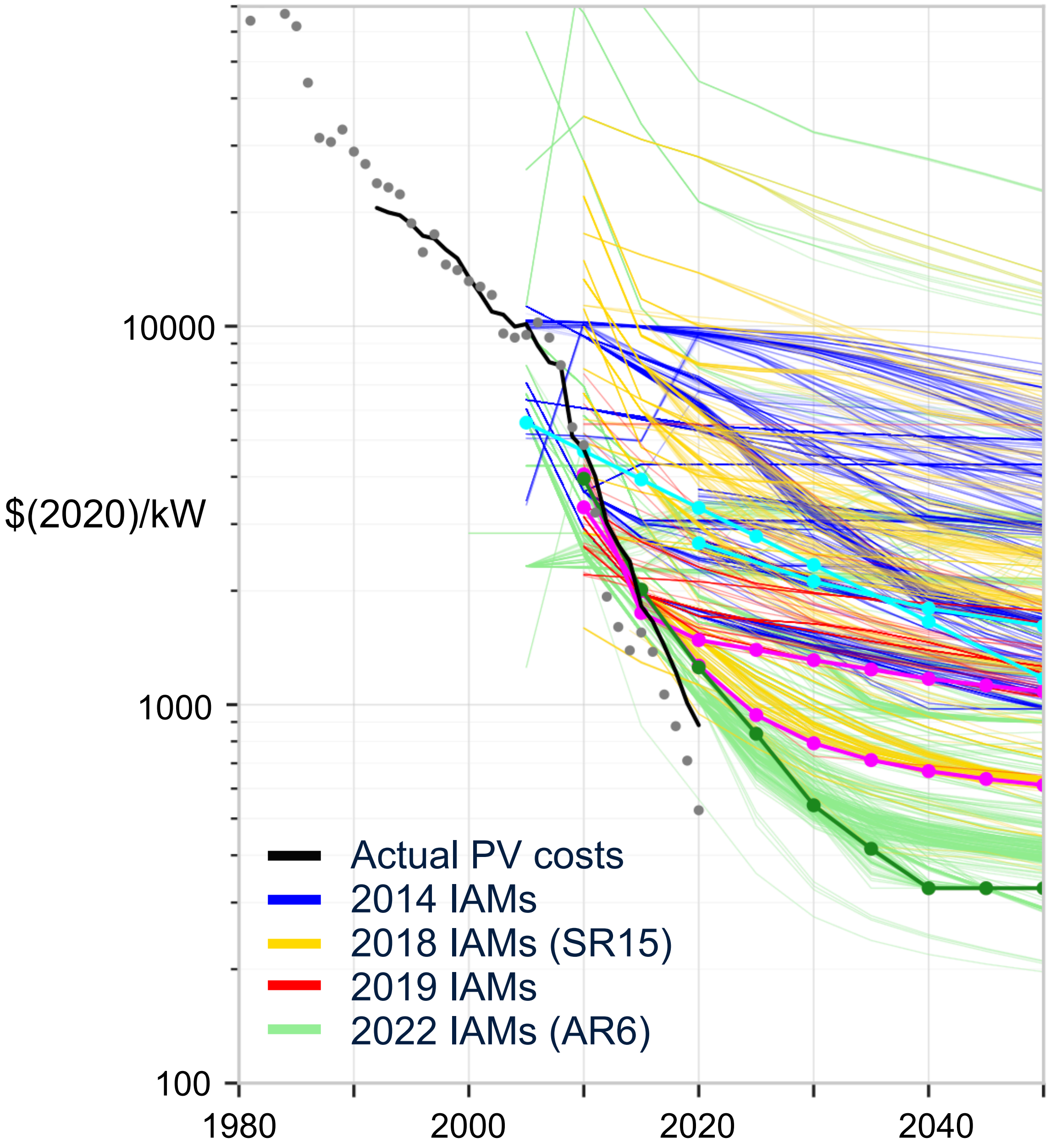
“For projects with low-cost financing that tap high-quality resources, solar PV is now the cheapest source of electricity in history.”

International Energy Agency (2020)



Why do we believe what we believe about mitigation costs?

- Our beliefs about future tech costs
- How good are major model forecasts?
- Consistently overestimated future costs of “*key green techs*” - solar, wind, batteries, electrolyzers
- Path dependence really matters - what if 50$/MWh had been their central projection?
- We mustn’t repeat this mistake



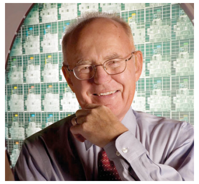
Why do we believe what we believe about mitigation costs?

- These issues inspired our project
- Our strategy:
  - Collect as much data as possible
  - Backtest different models for forecasting tech costs
  - Choose the “best”
  - Apply to energy system

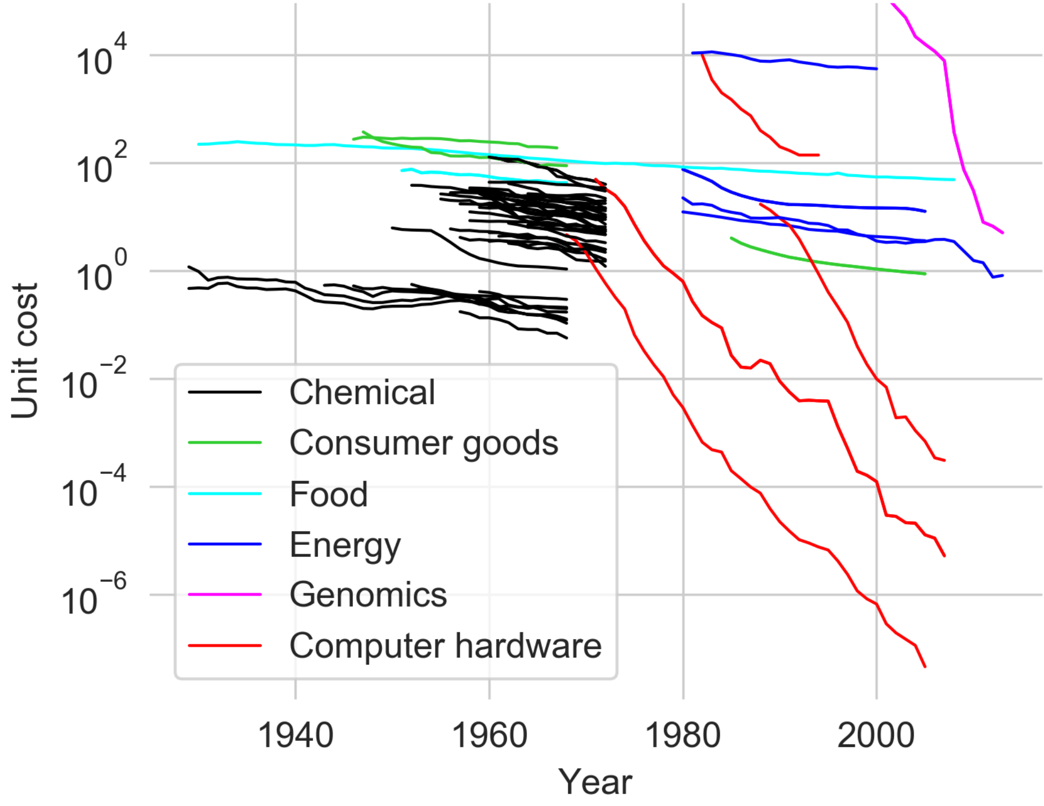
Technological change

- Technologies improve at very different rates
- The rates are highly persistent
- This is only clear with granular data

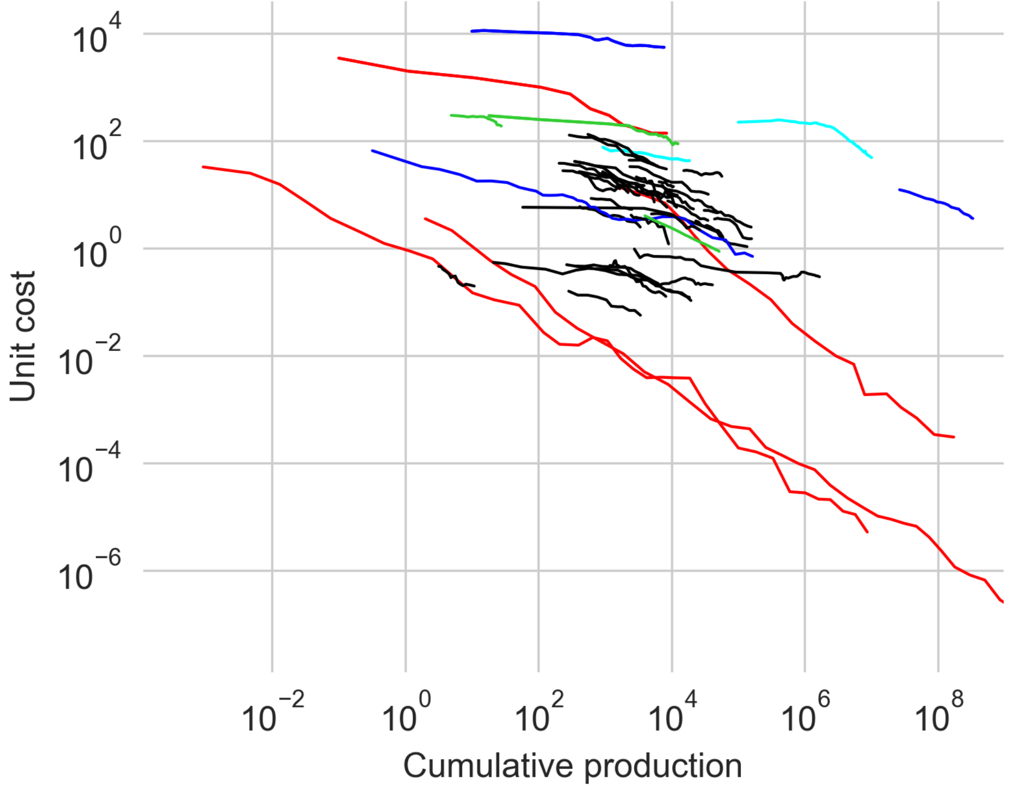
Empirical laws work well for many different technologies

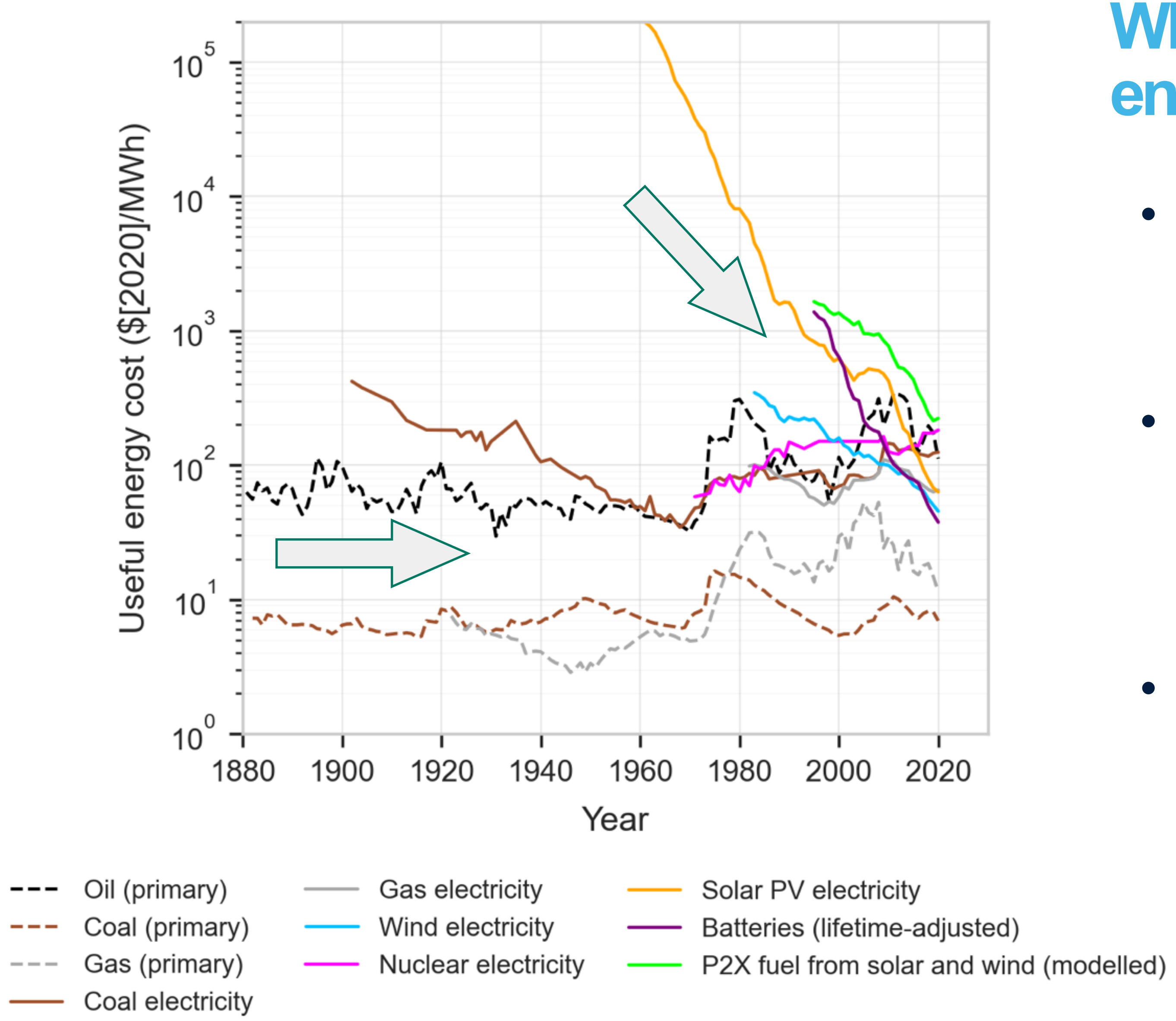


Moore's law



Wright's law





What are the trends for different energy technologies?

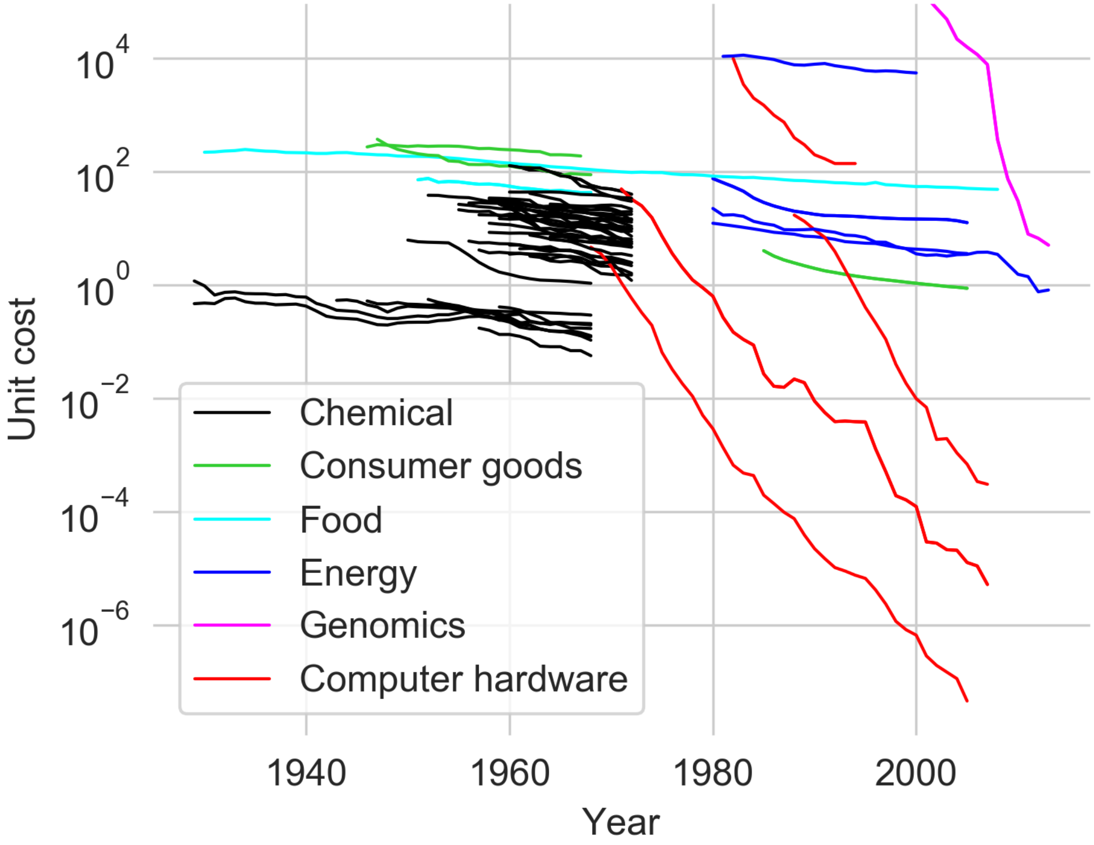
- “No-progress” techs: fossil fuels, nuclear, CCS, biofuels (pipes, pistons, fluids, combustion)
- Technologies in the electricity-electronics-computing ecosystem progress rapidly with increased investment (*i.e. power grid techs*)
- Some technologies can piggy back on rapid progress techs: P2X fuels, heat pump heating

How to take advantage of persistence and heterogeneity of technological change?

Make use of empirical laws for forecasting technology costs based on historical data

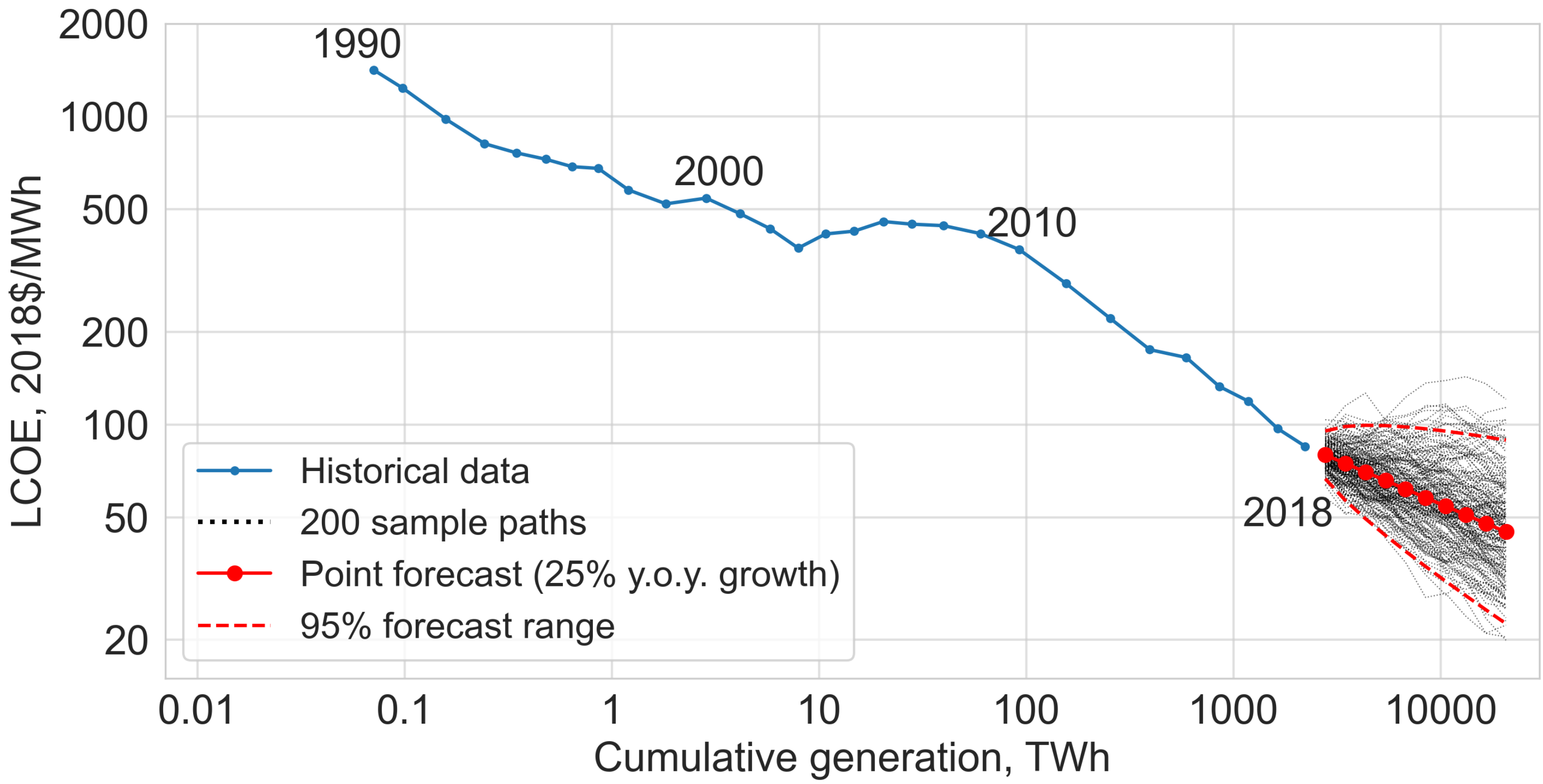
Forecast model validation

- Collected data (60+ techs)
- Backtested many different models…
- Pretend to be at a given date in the past
- Forecast cost at each "future" date
- Observe forecast error
- Repeat for all past dates
- Score methods on forecasting errors



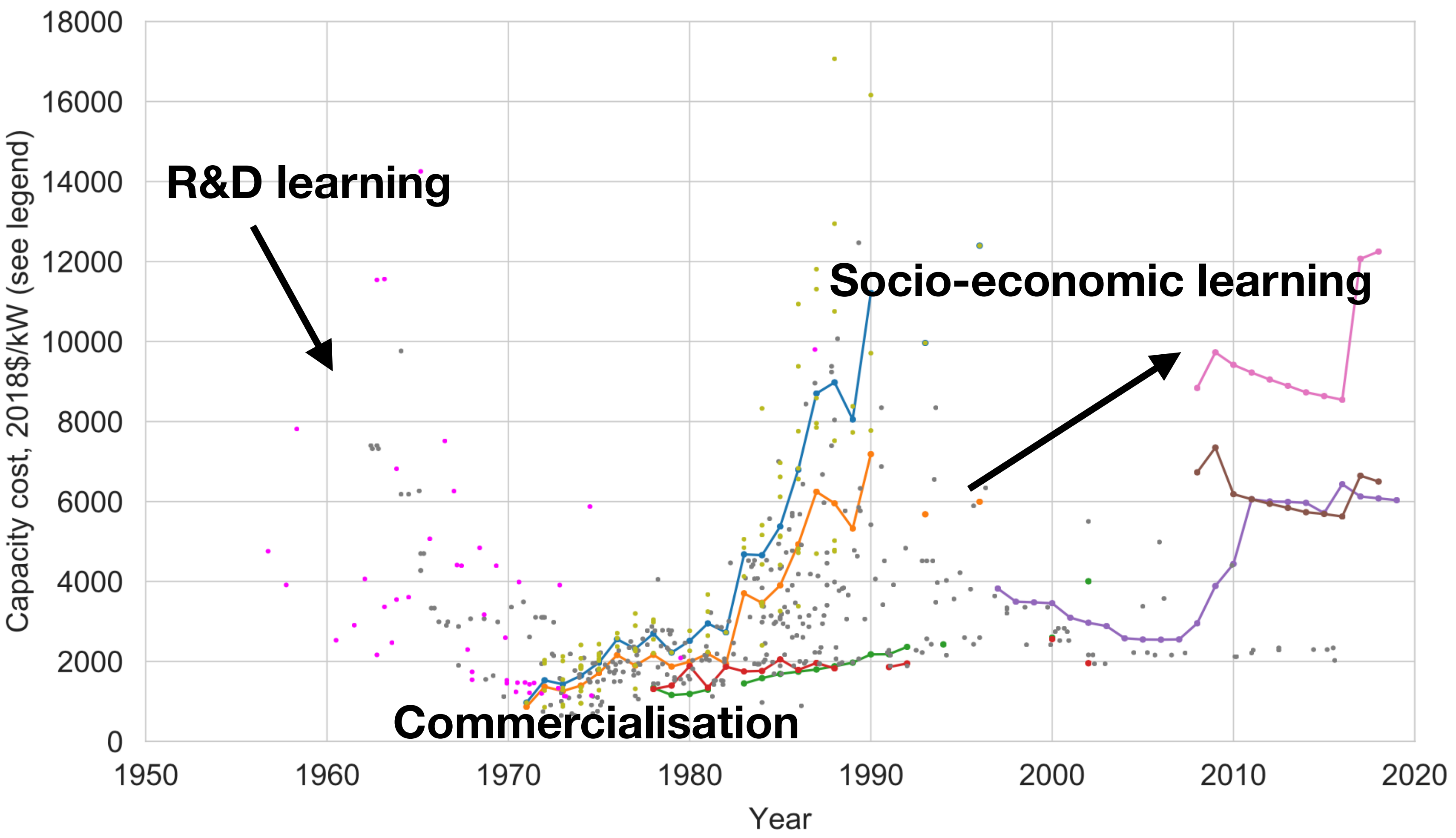
Source: Lafond et al. 2018

Probabilistic experience curve forecasts work well for key green techs



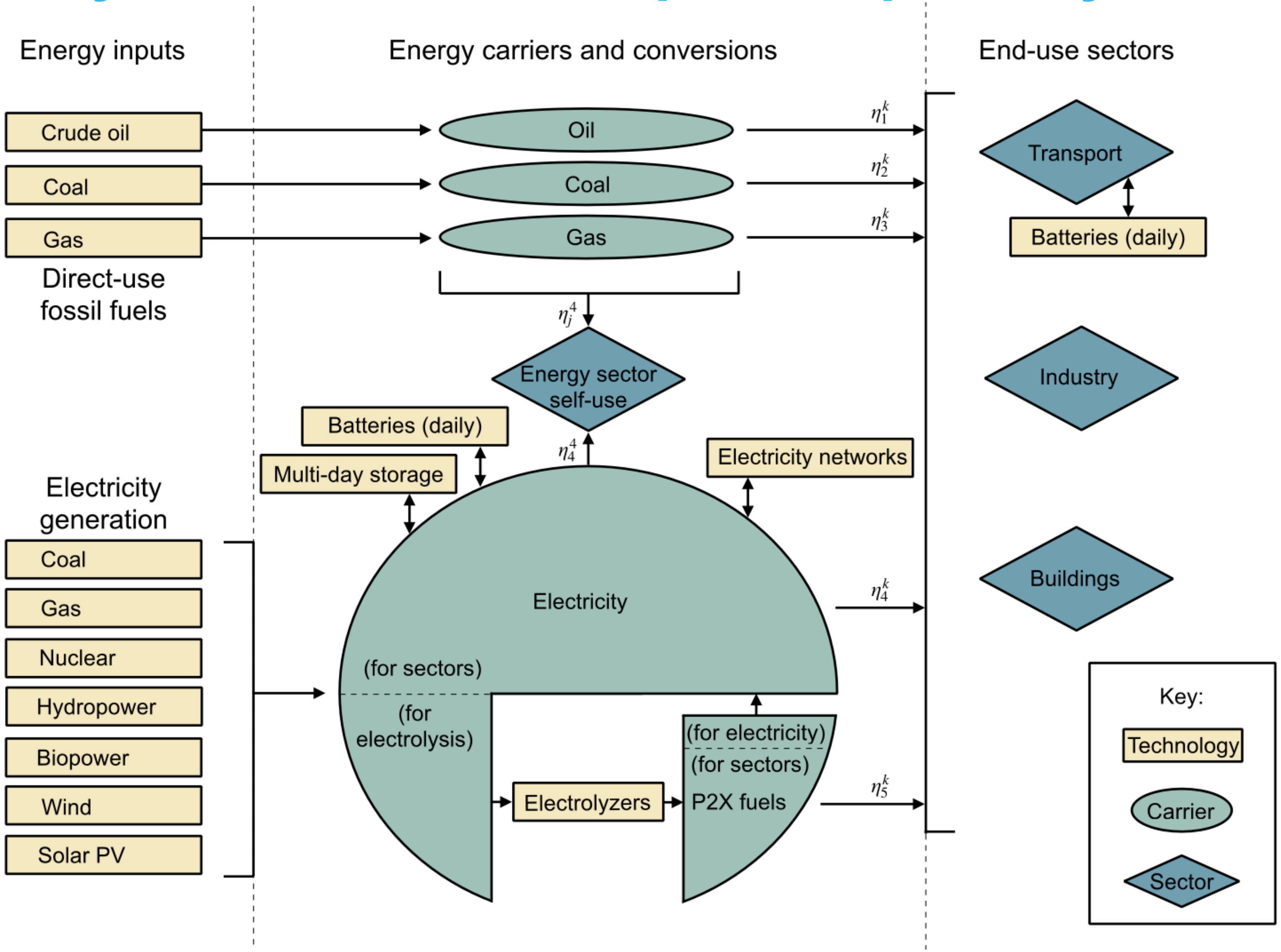
- Forecasts depend on the scenario: the more we produce, the further we move along the experience curve
- Error bars tested by making 6,000 forecasts for 50 different techs

Warning! Not all techs follow an encouraging learning curve: e.g. nuclear

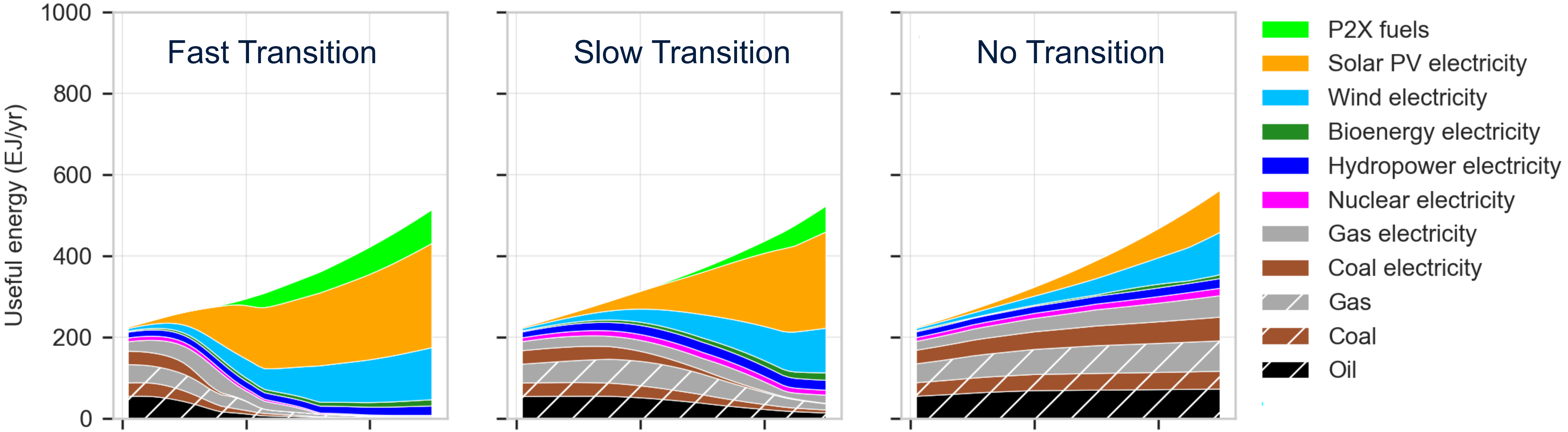


- Public opinion
- Politics
- Cost overruns
- Waste
- Safety
- -> Interest rates

We model system costs with a simple, transparent system model



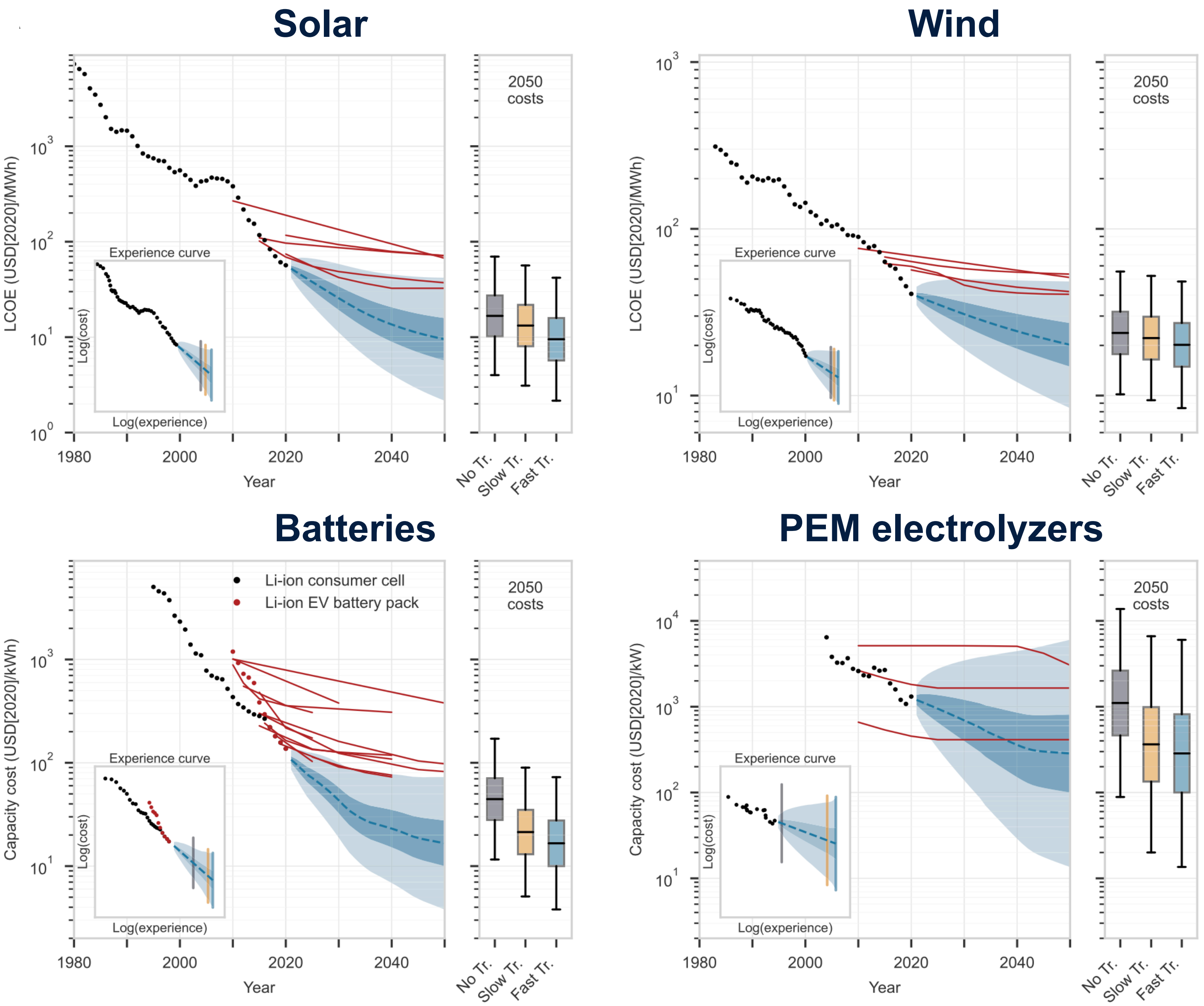
Focus on three scenarios that provide identical energy services



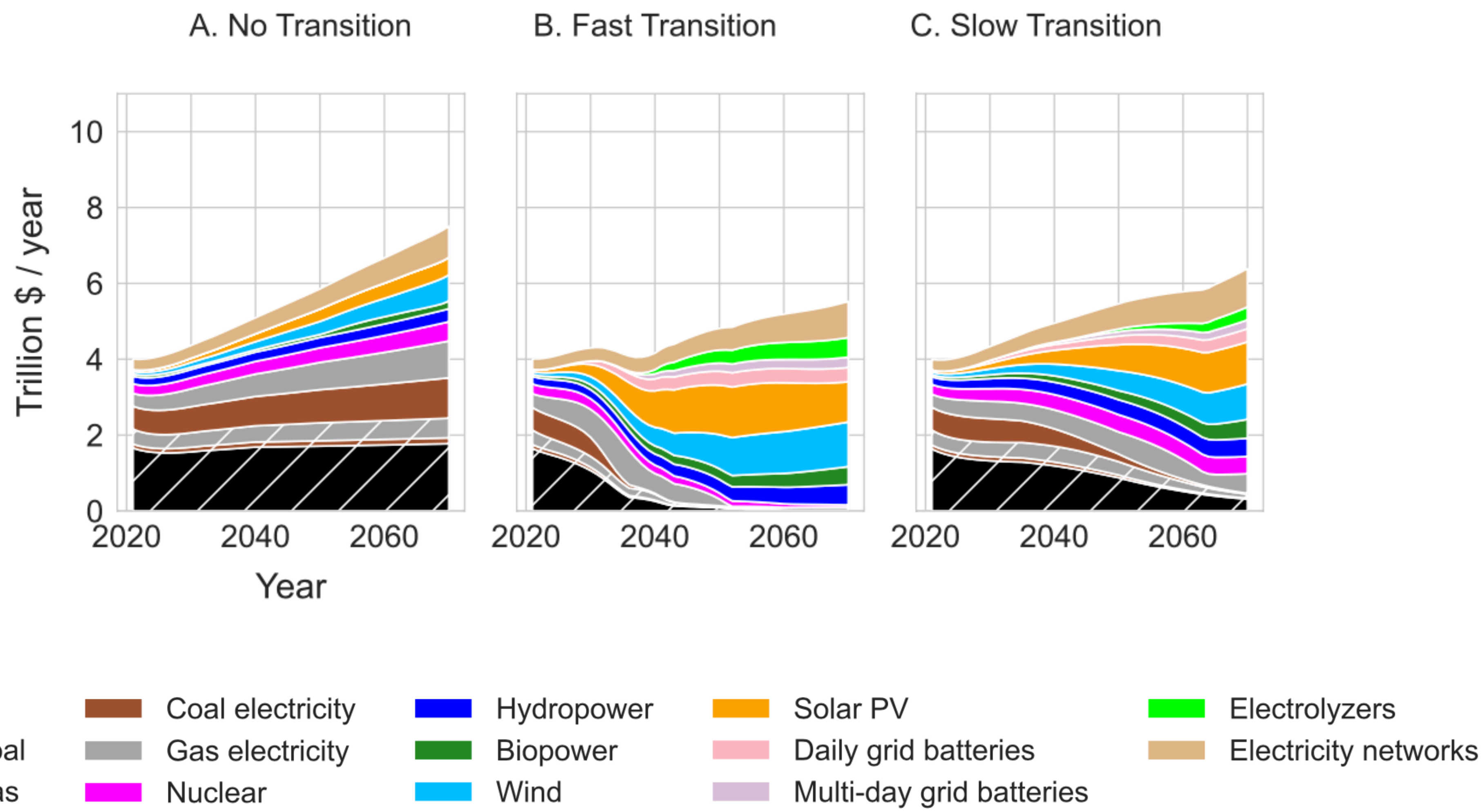
- Fast Transition -
  - Electrify as much as possible (huge expansion), P2X fuels for the rest
  - EVs, grid-scale batteries, electrolyzers, P2X fuels to support grid

Results:

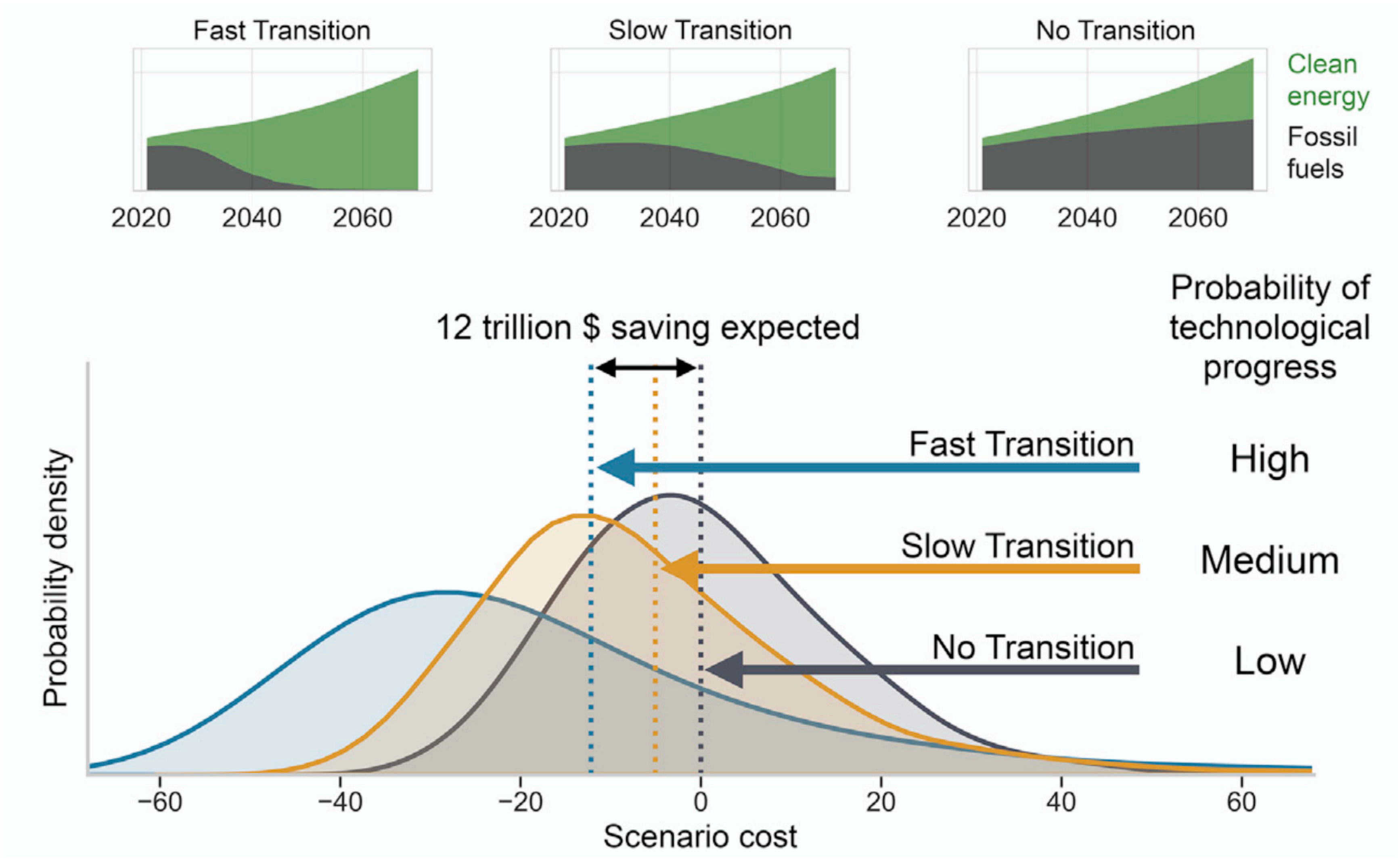
Empirically validated forecasts for key green technologies



Median expenditures on each technology



Cost forecast distributions



- Faster deployment of key green techs will push costs down

At 1.4% discount rate, the Expected NPC *saving* is $12 TN

What have we missed out?… a lot!

- Higher resolution models will be needed for detailed planning, e.g. grids
- We made conservative assumptions throughout: new techs are likely to make Fast Transition even cheaper – demand-side response, better batteries, buildings, insulation, heat pumps, new storage techs…
- We haven’t even mentioned **climate damages:** with a social cost of carbon of 30-300 $/tCO2, expected Fast Transition savings are $31-$775 TN

Summary

- Solar, wind, battery, electrolyzer costs are likely to continue falling, undercutting fossil fuels in most areas
- Rapid deployment is the cheapest pathway - the faster we go, the more we save
- We can keep experimenting with other techs, but should ground prospects in evidence, not opinion
- Major models are likely still overestimating costs of key green techs
- There will be bumps in the road, but trends are highly persistent
- We can’t know the future but these are the right techs to bet on

Key messages for policy makers

- Different techs respond differently to investment - e.g. hydrogen cars, nuclear, CCS have made no progress despite large, sustained effort
- Investing in grid is a relatively cheap but *essential* part of the long term picture, we need it to unlock large future savings
- Grid techs are in the ecosystem of rapid progress technologies
- The scale-up required is huge - factories, supply chains, grids, EV charging etc, plus… **skills** to get all of this equipment working
- Each sector must be ready to use cheap renewables as soon as they can. This will unlock the largest savings
- Oil in transport is the single biggest saving available - electrify faster
- *We must overturn the notion that transition is expensive, it's not*

Thank you