



Institute for  
**New Economic Thinking**  
AT THE OXFORD MARTIN SCHOOL



Smith School  
of Enterprise and  
the Environment



# A new perspective on decarbonising the global energy system

COP26 Global Alliance of Universities on Climate

12th November 2021

***Dr Matthew Ives***

*with thanks to Prof J. Doyne Farmer & Dr Rupert Way*



Foreign, Commonwealth  
& Development Office



# Overview

What are decision-makers being told about climate mitigation pathways?

What is wrong with this story?

Is there a better perspective?

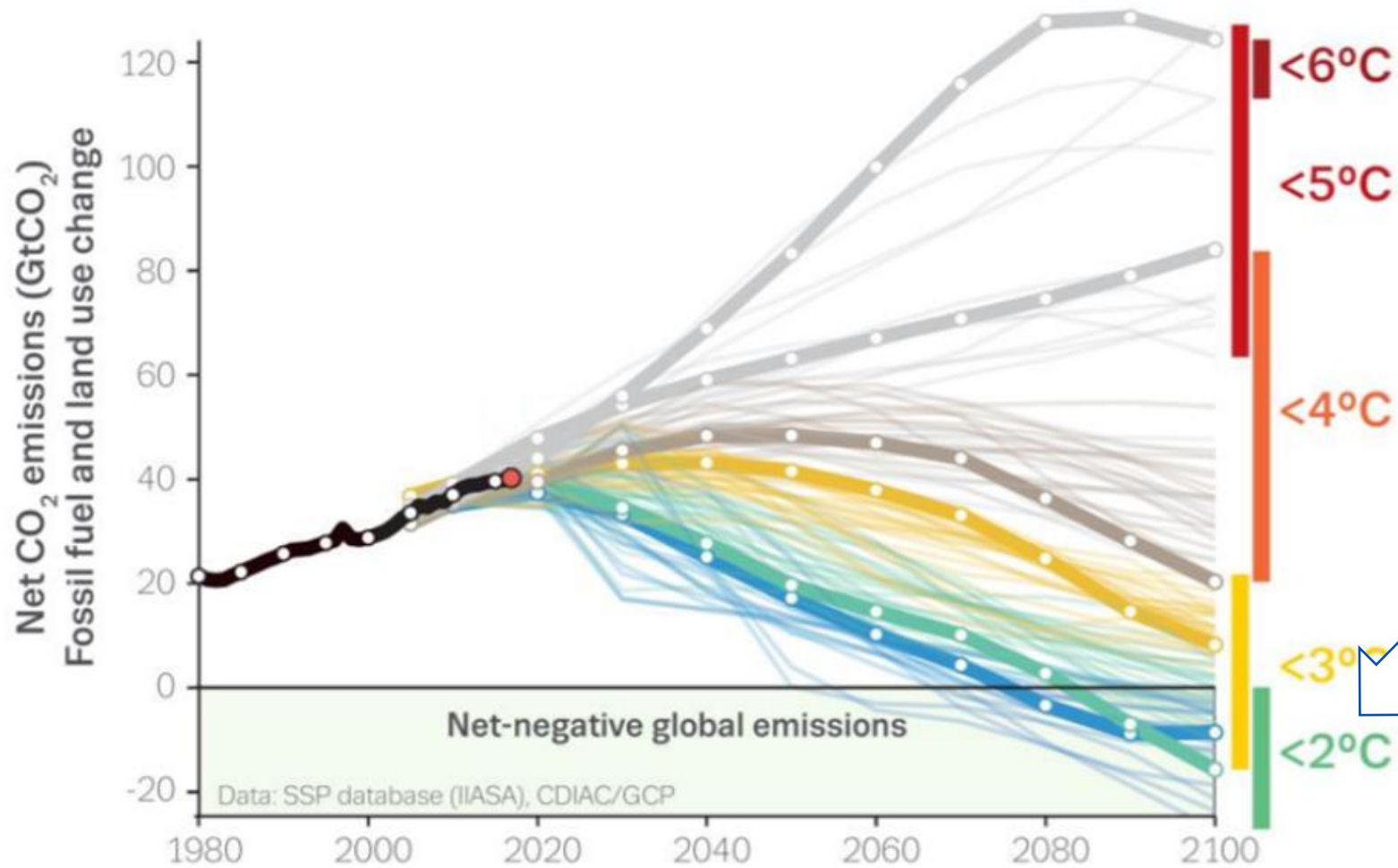
What is the cost of decarbonising the global energy system?

What does this mean for China?

Conclusions



# “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 may need to reduce our energy usage
- We need to build 13Gt or more of Carbon Capture and Storage plants by 2100
- Electricity prices are likely to be higher



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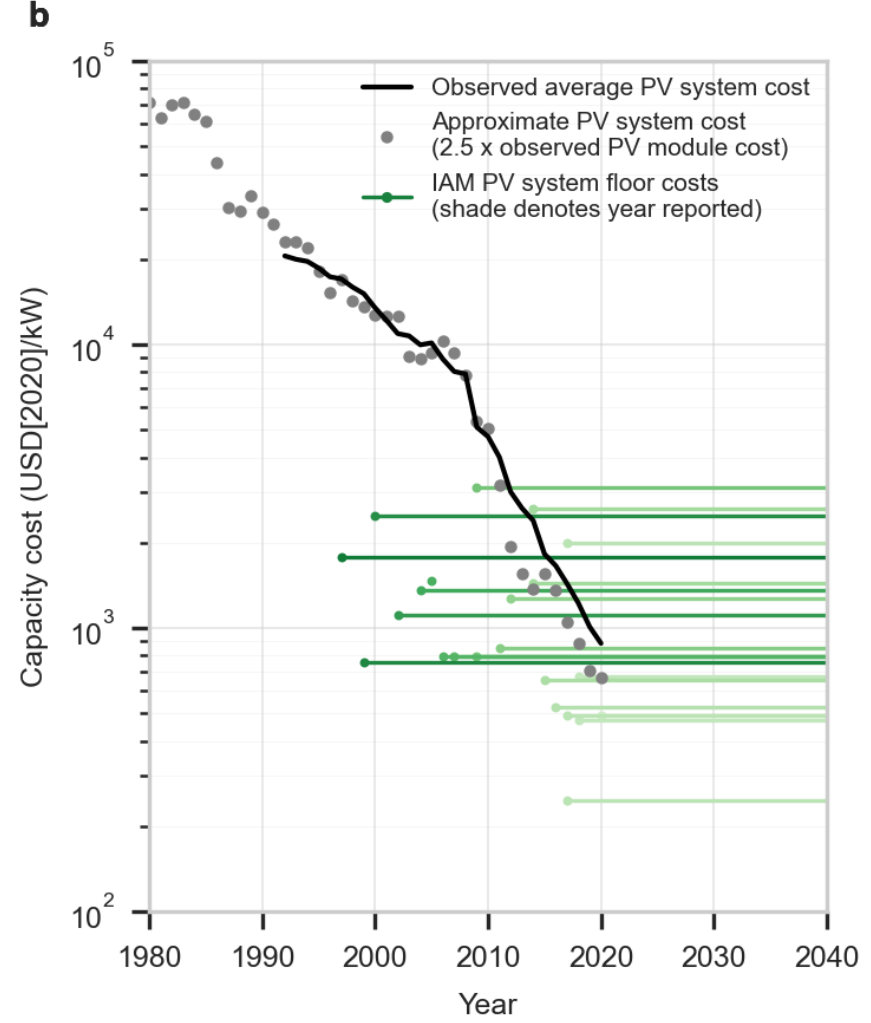
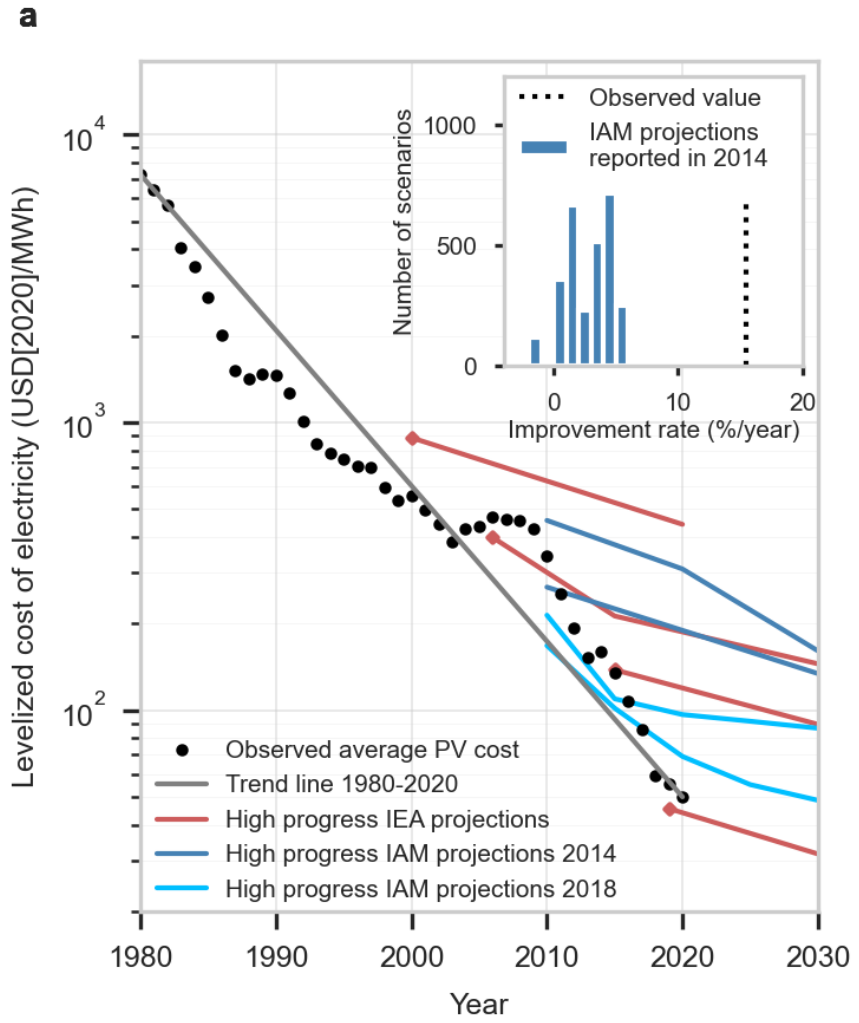
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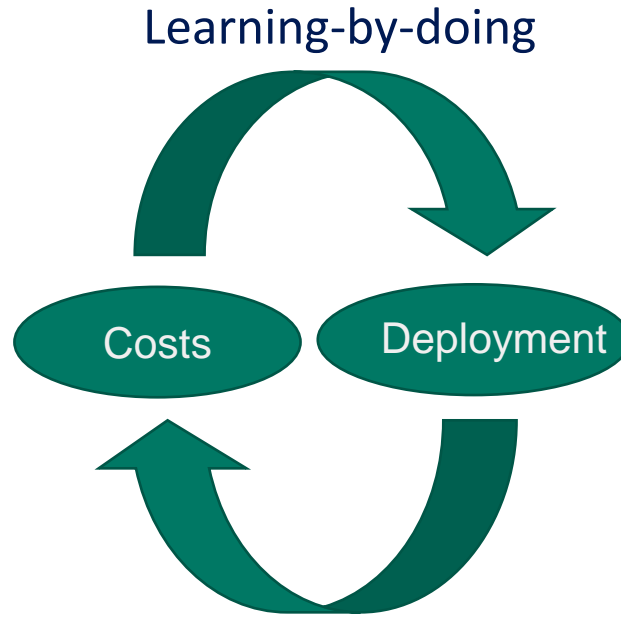
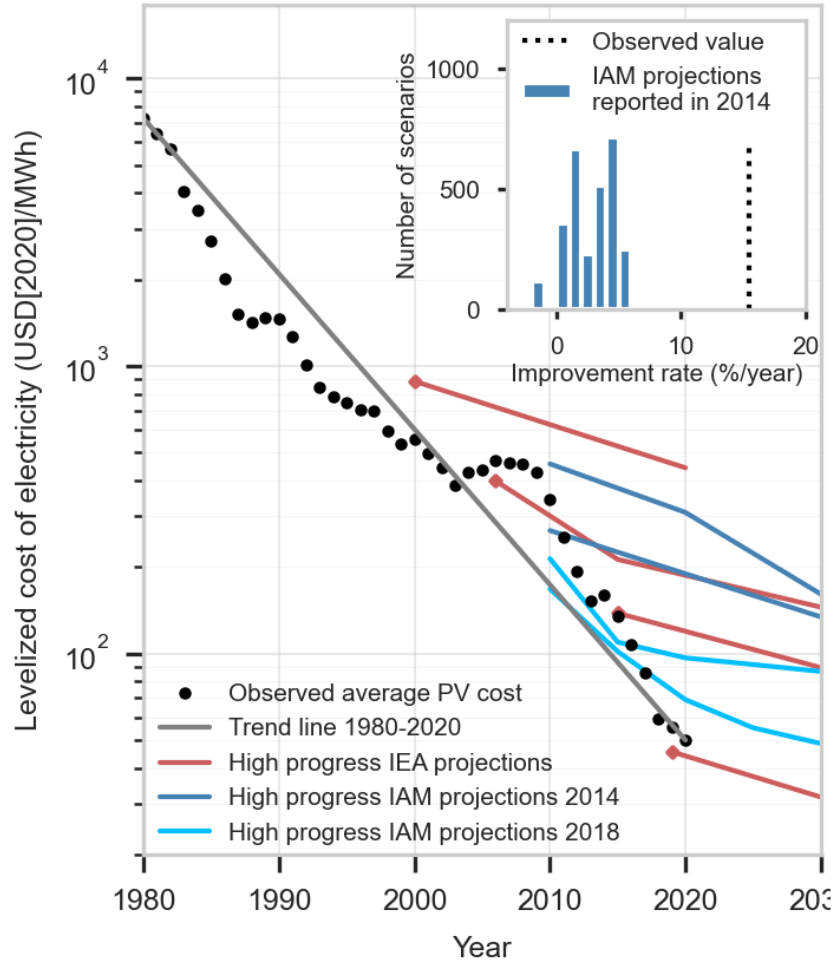


# The performance of the IEA and IAM projections are poor

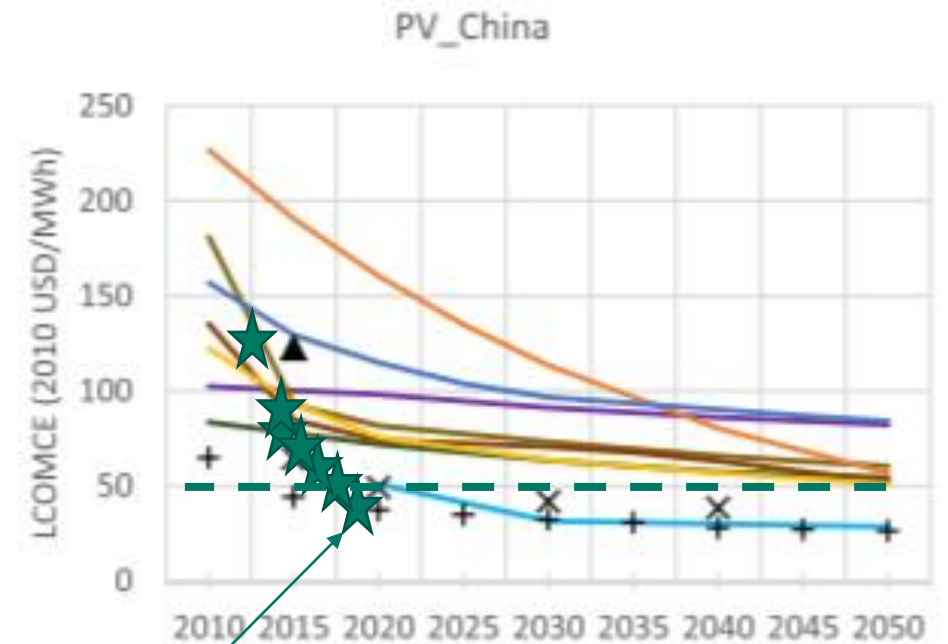


# ...and not entirely based on the latest empirical evidence

**a** PV cost projections are consistently too high



Models become quickly out of date



2019 China LCOE, \$46 (2010 USD/MWh)

Lines: climate models  
Shapes: energy agencies  
(Krey et al., 2019)

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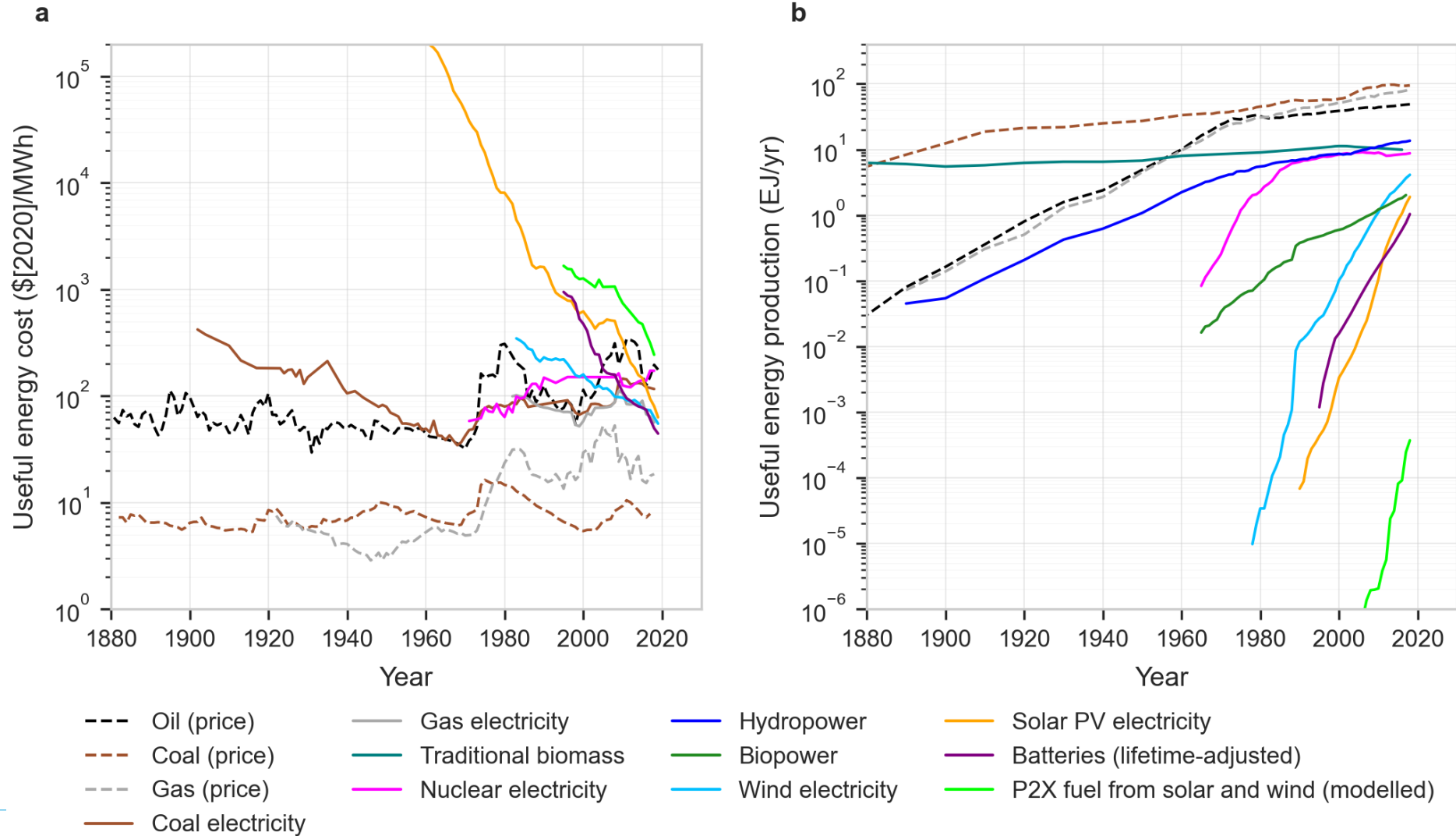
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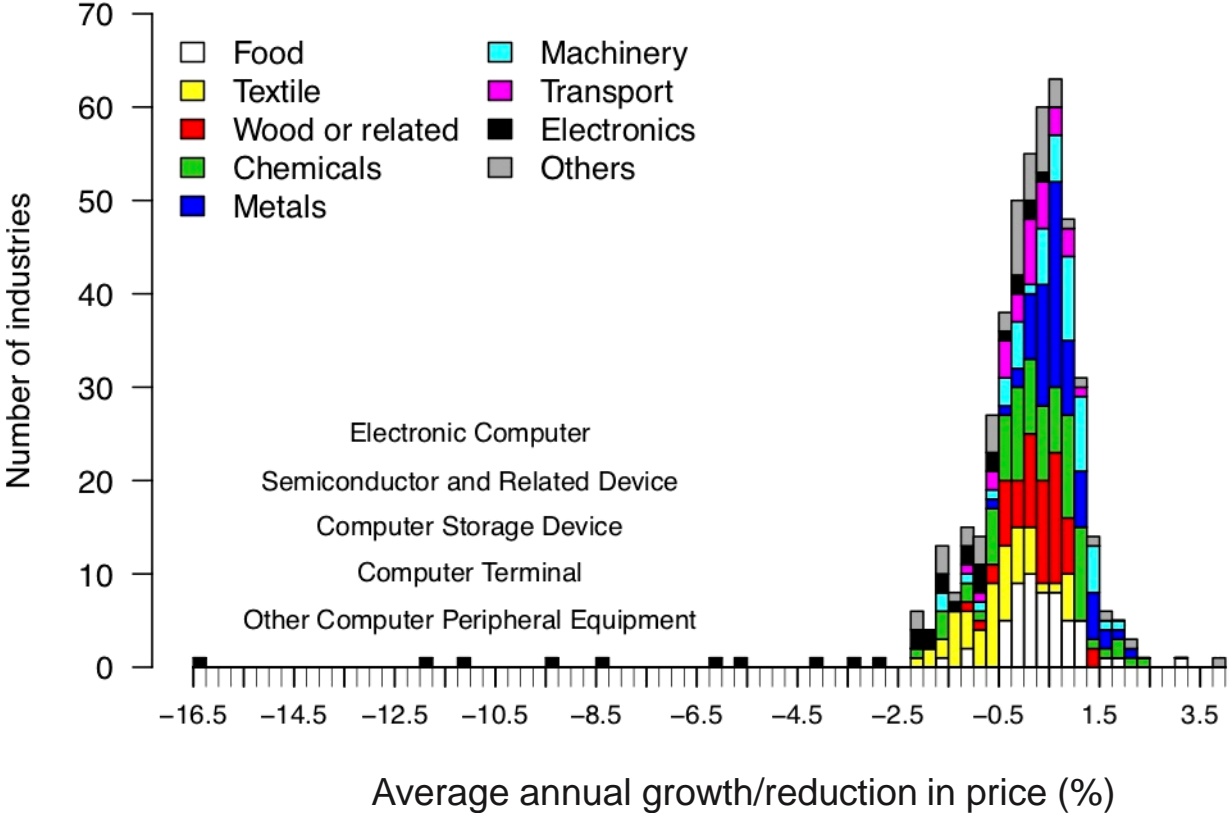
# Evolution of the global energy landscape





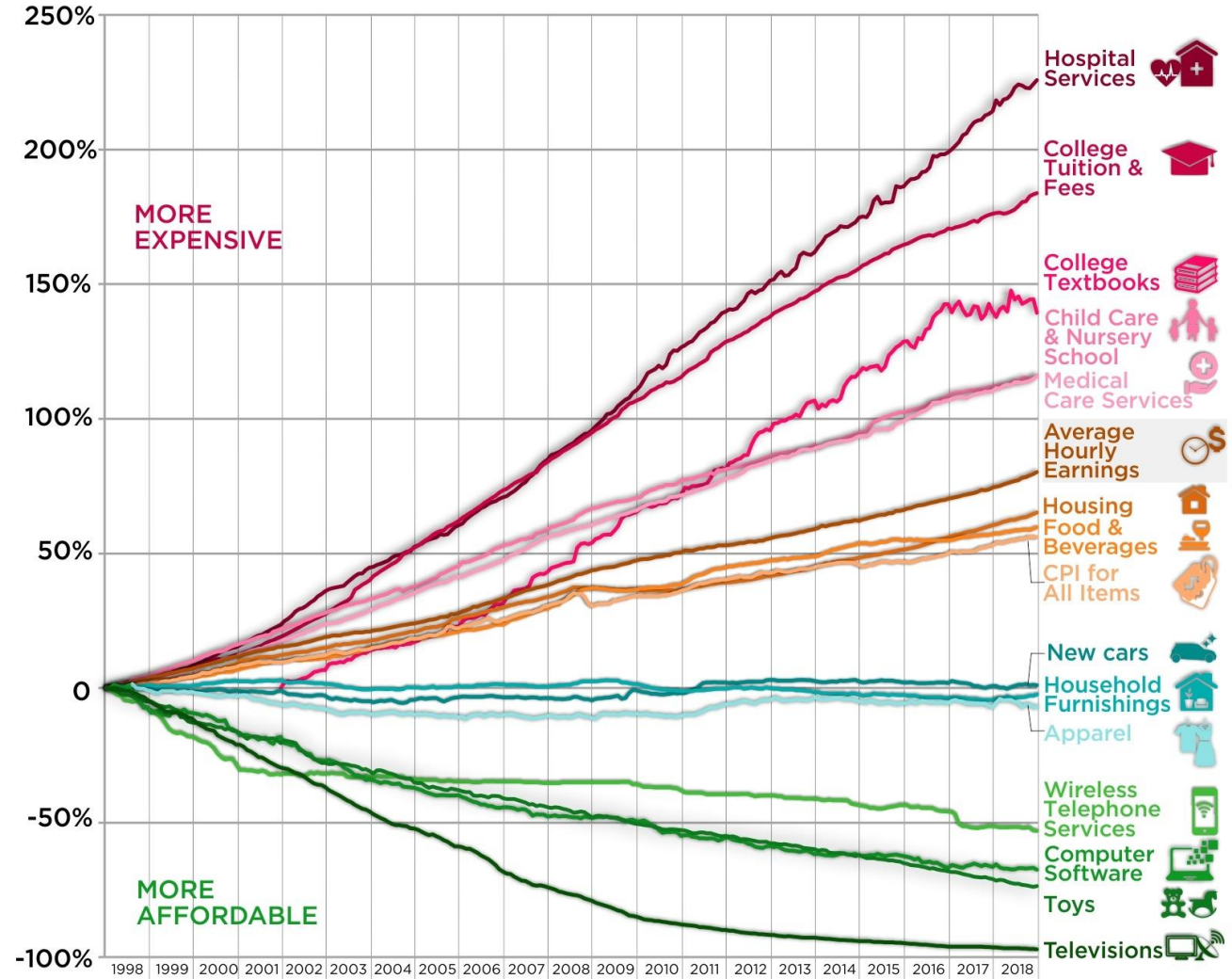
# Heterogeneity of Technological progress

Distribution of price annual growth rates  
U.S. Manufacturing, 1958–2011



# Consumer goods

## 20 Years of Price Changes in The United States Selected Consumer Goods & Services, Wages (January 1998 to December 2018)



Article & Sources:  
<https://howmuch.net/articles/price-changes-in-usa-in-past-20-years>  
CPI and other price indices - Bureau of Labor Statistics - <https://data.bls.gov/PDQWeb/cu>  
Average hourly earnings - Bureau of Labor Statistics - <https://data.bls.gov/timeseries/CES0500000008>

howmuch.net

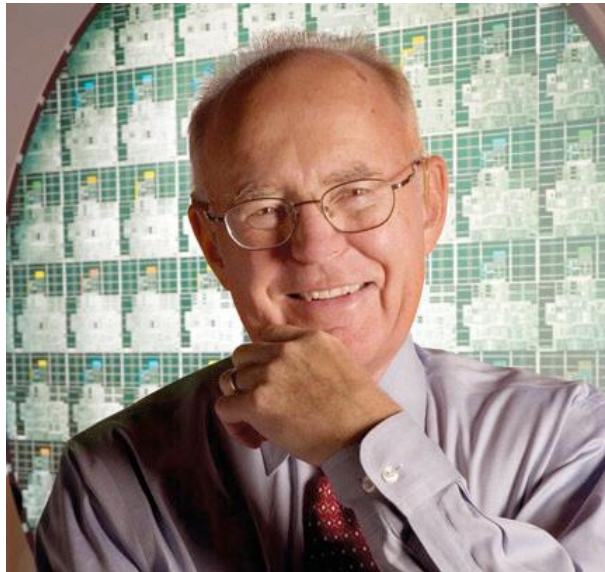
Thanks to Jangho Yang

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

**Make use of empirical laws.**

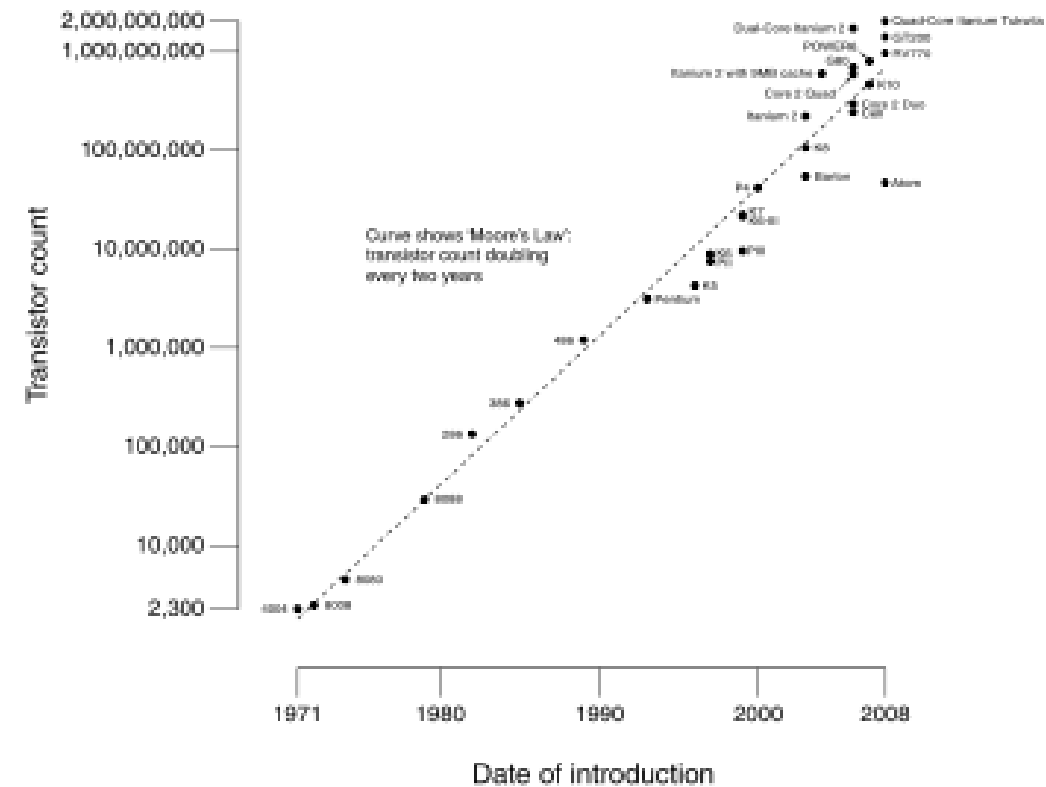


# Moore's Law (1965)



Originally a statement about density of transistors. We will use to refer to the hypothesis that **technological performance improves exponentially with time.**

CPU Transistor Counts 1971-2008 & Moore's Law



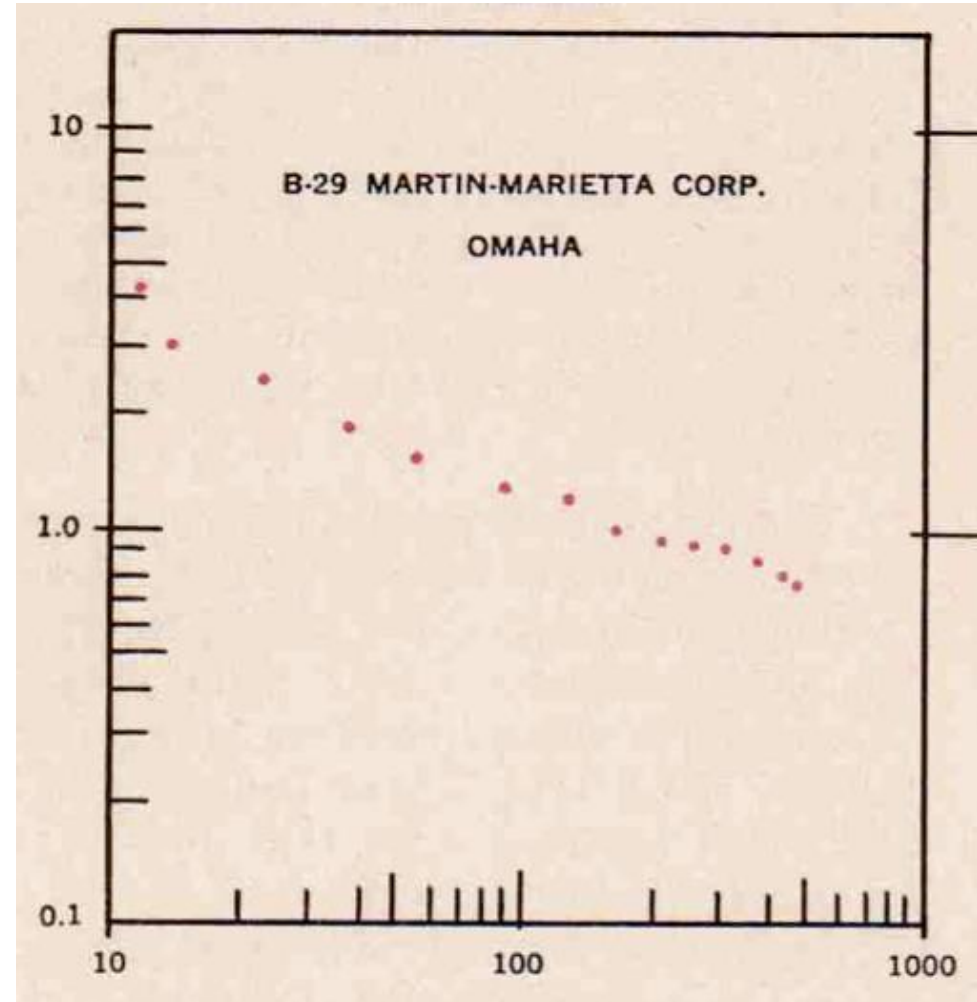


# Wright's Law (1936)

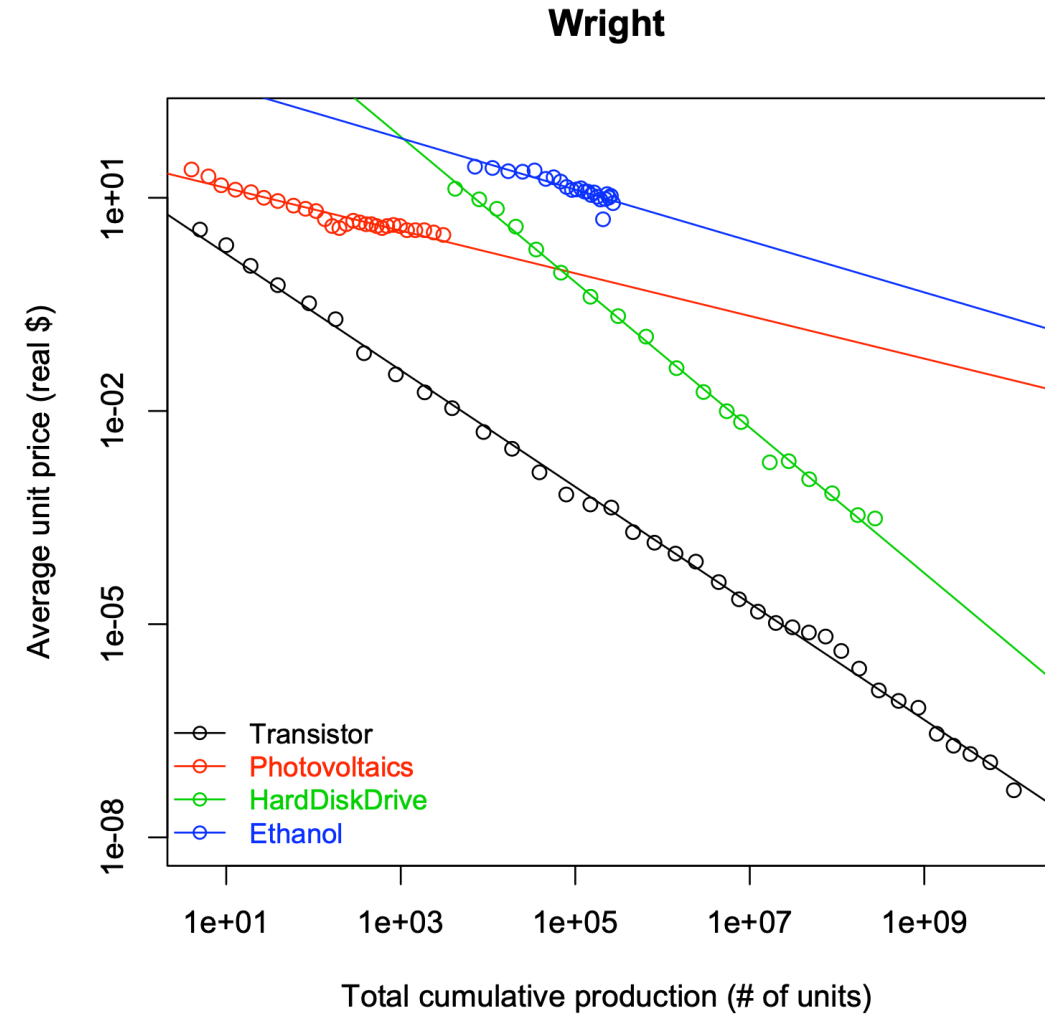
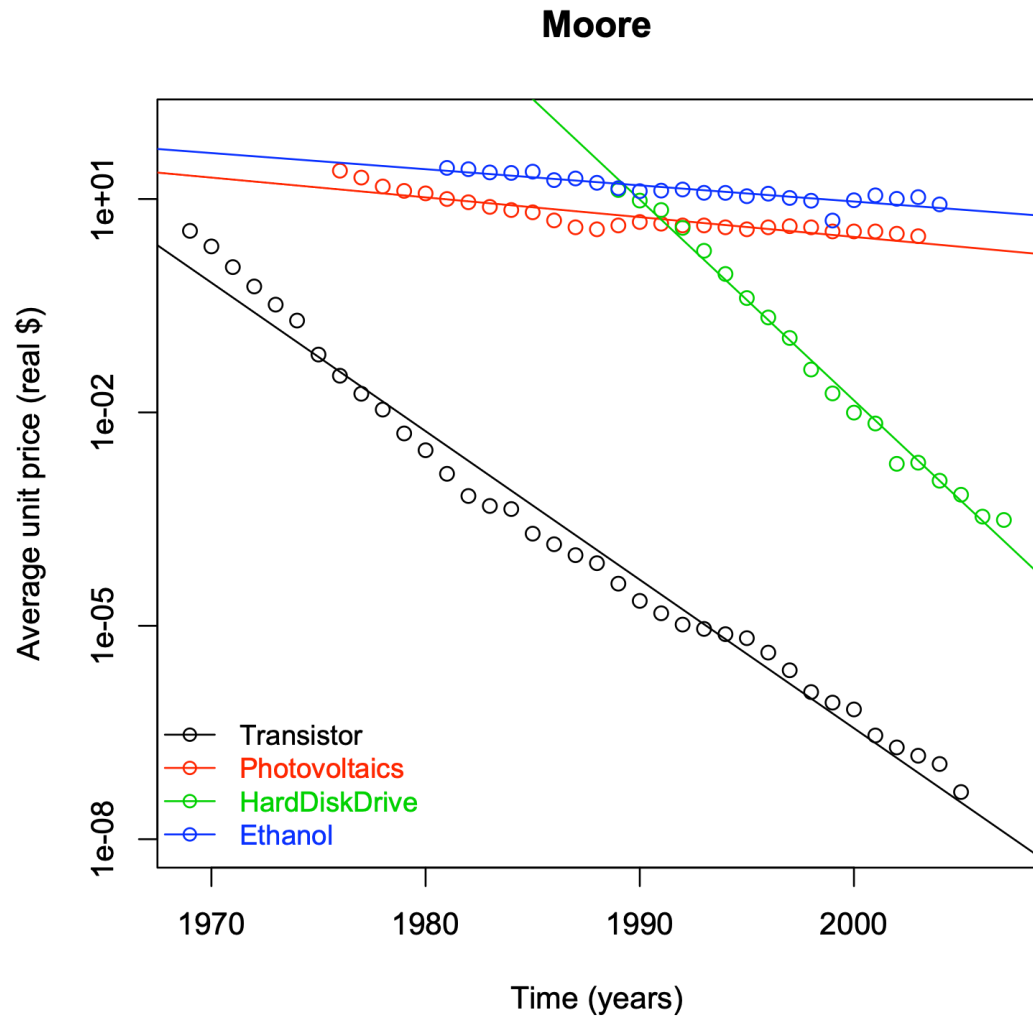


Cost vs. cumulative production follows a power law:  $y = x^{-\alpha}$

**Cumulative production a proxy for *experience***

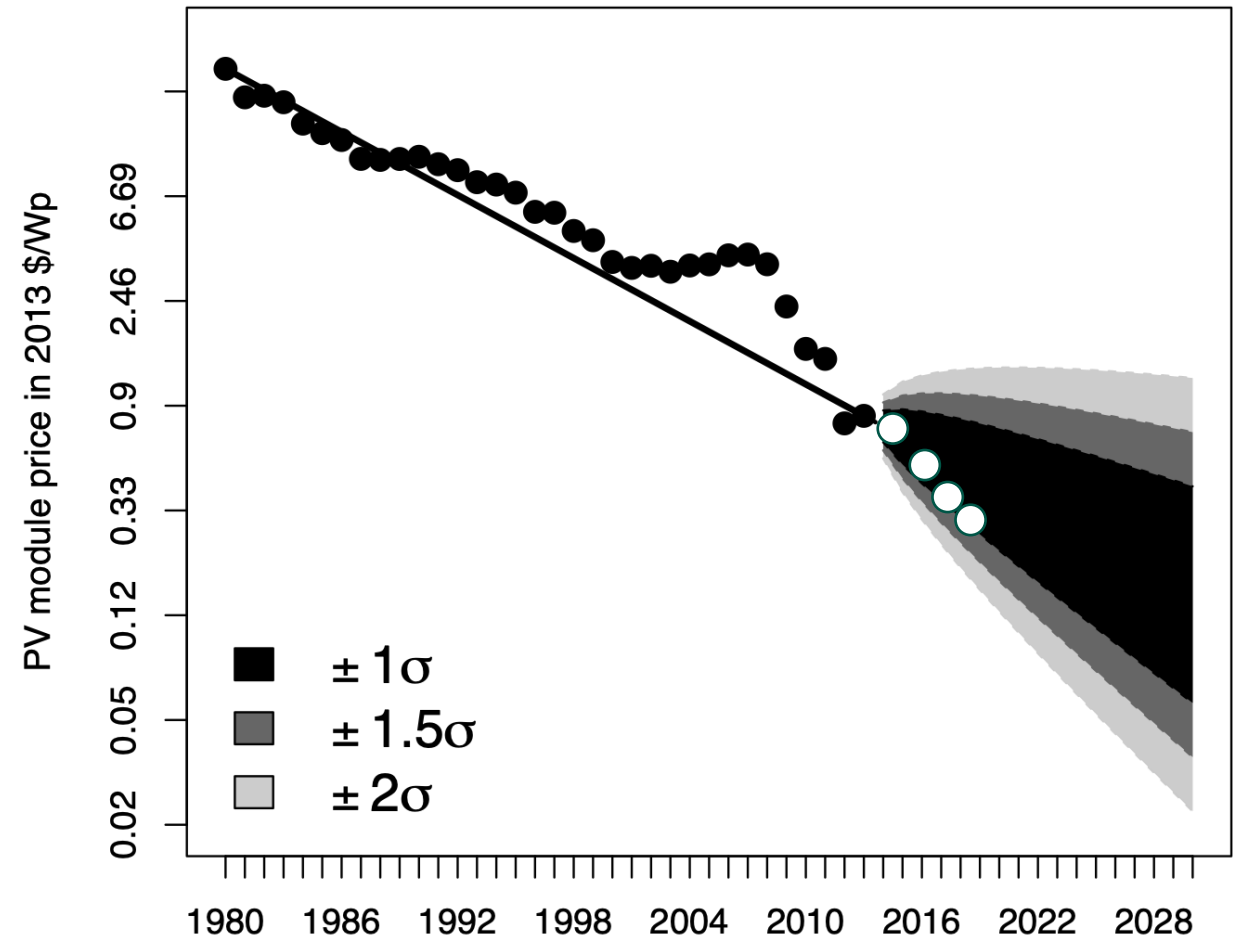


# Both laws work well for many technologies



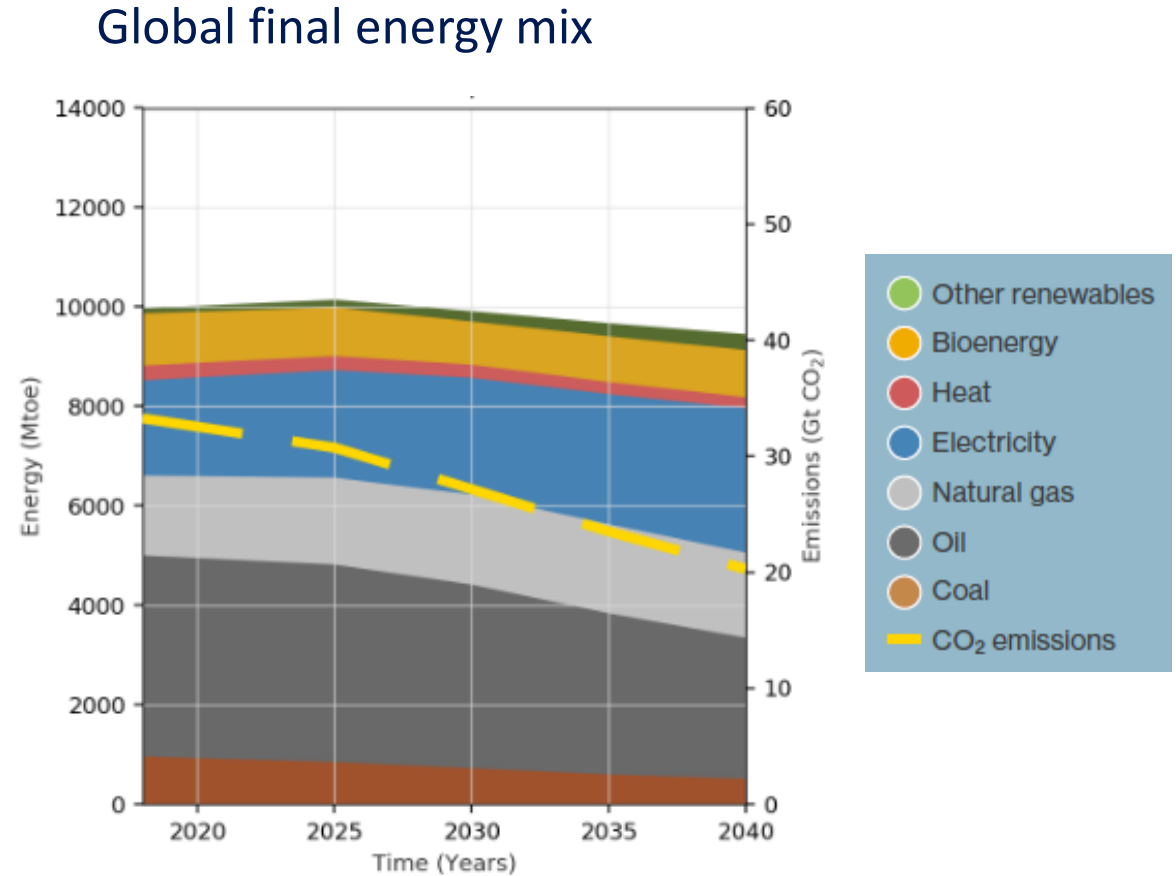
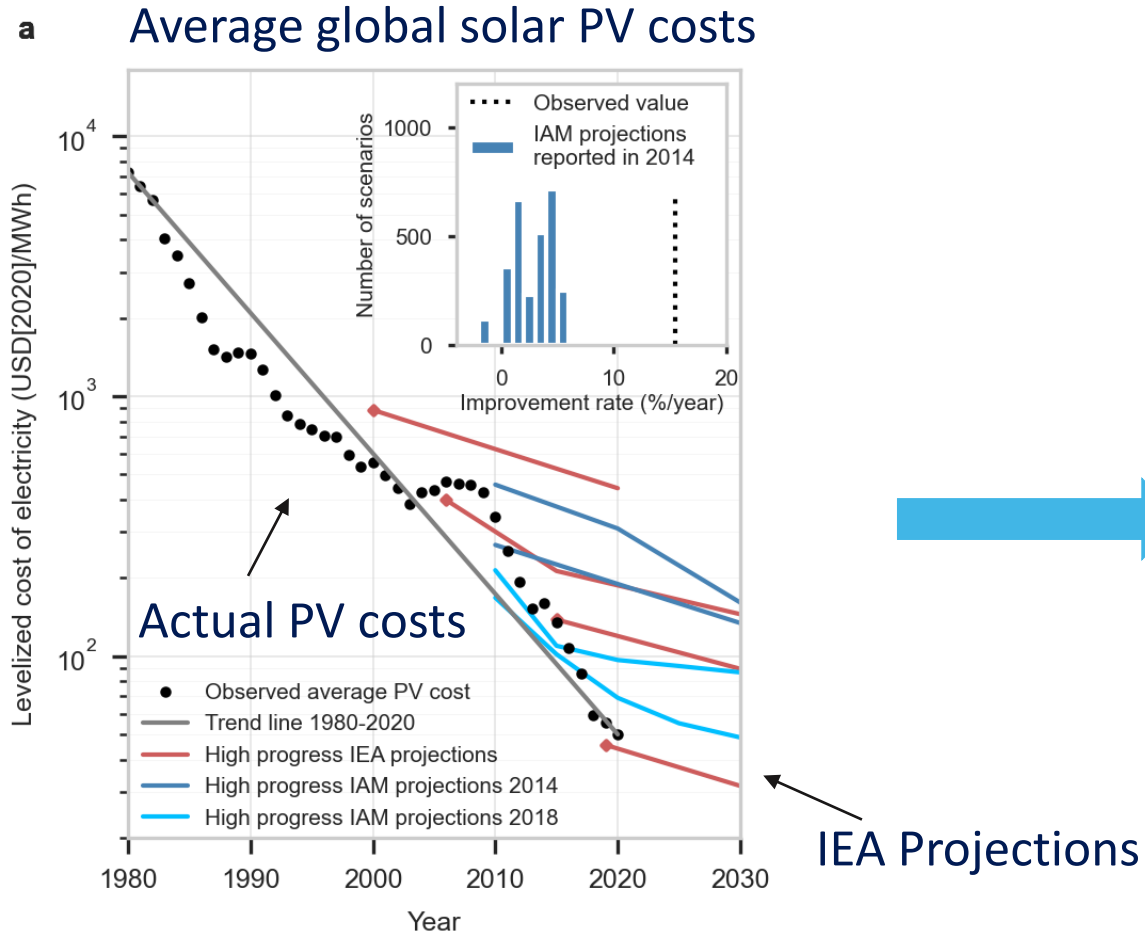
# Distributional forecast of solar PV assuming business as usual

- Reformulate Wright's law as a time series model (Lafond et al, 2018)
- Validated on over 50 technologies
- Provides experience curve forecasts with reliable error bars
- Forecasts are scenario-dependent: the more we produce, the higher our probability of moving down the experience curve



Farmer and Lafond (2016)

# IEA scenario only achieves 30% emission reductions by 2040

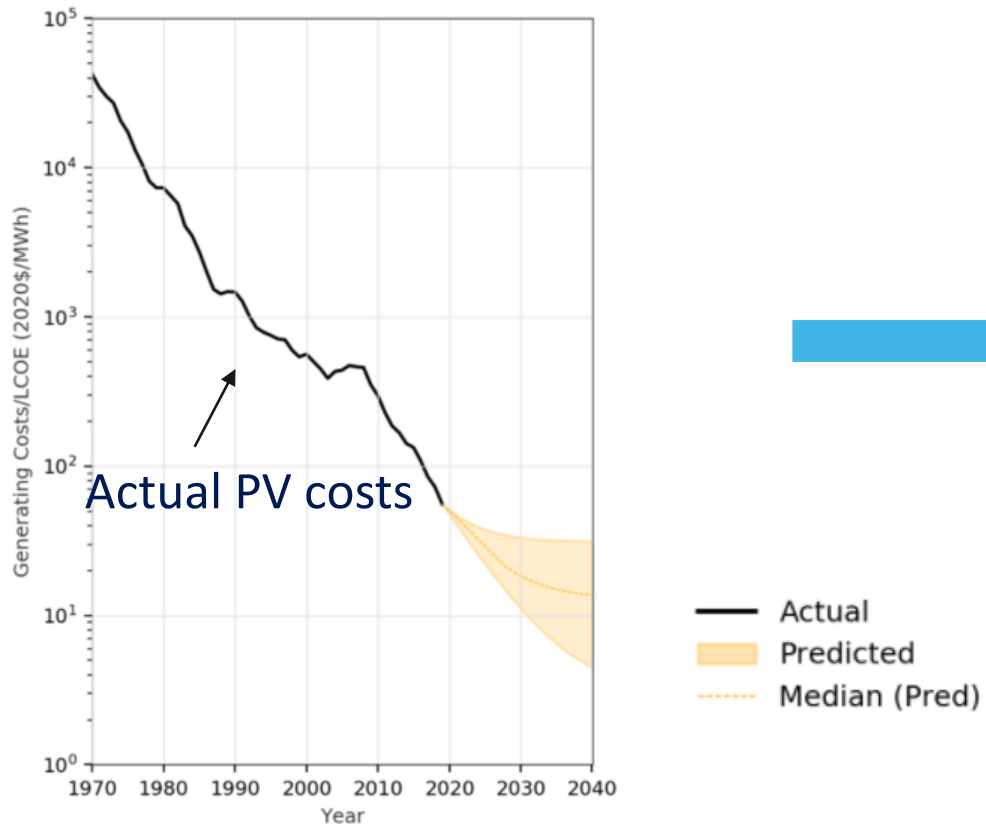


*IEA's Sustainable Development Scenario*

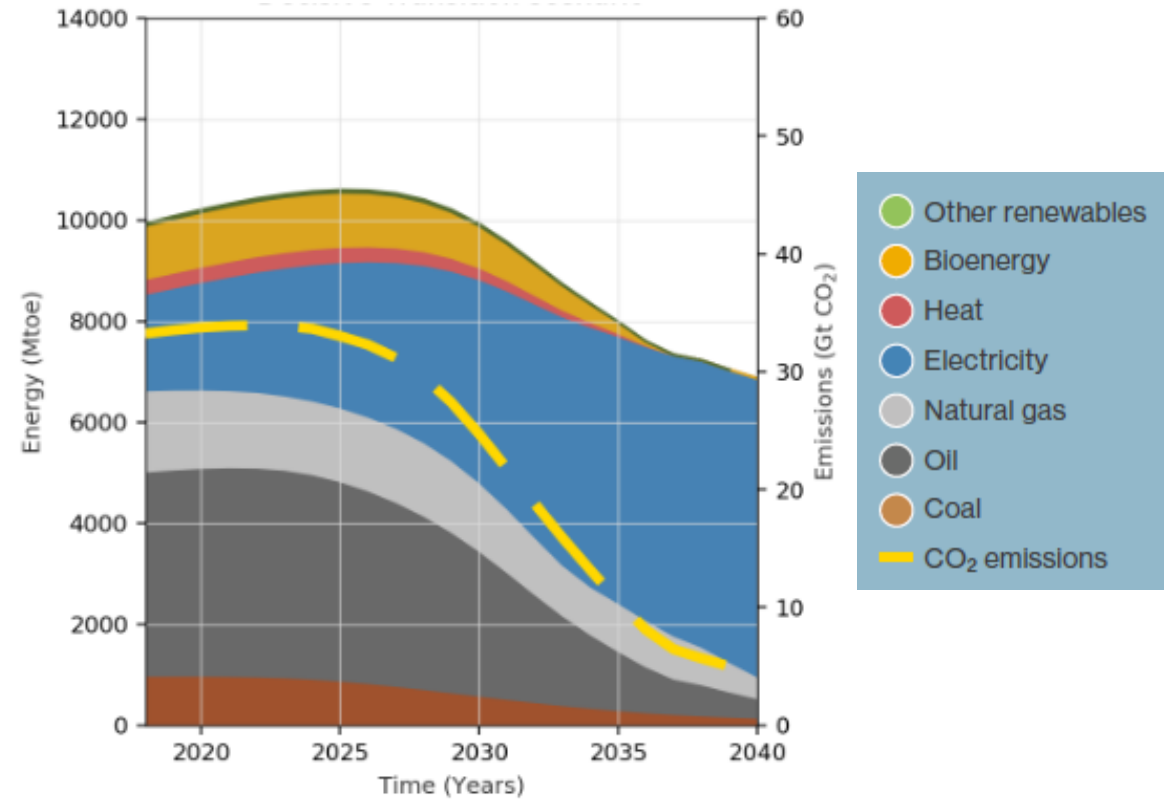


# Strong support for clean tech achieves >80% emission reductions by 2040

## Average global solar PV costs



## Global final energy mix



*Our Decisive Transition Scenario*

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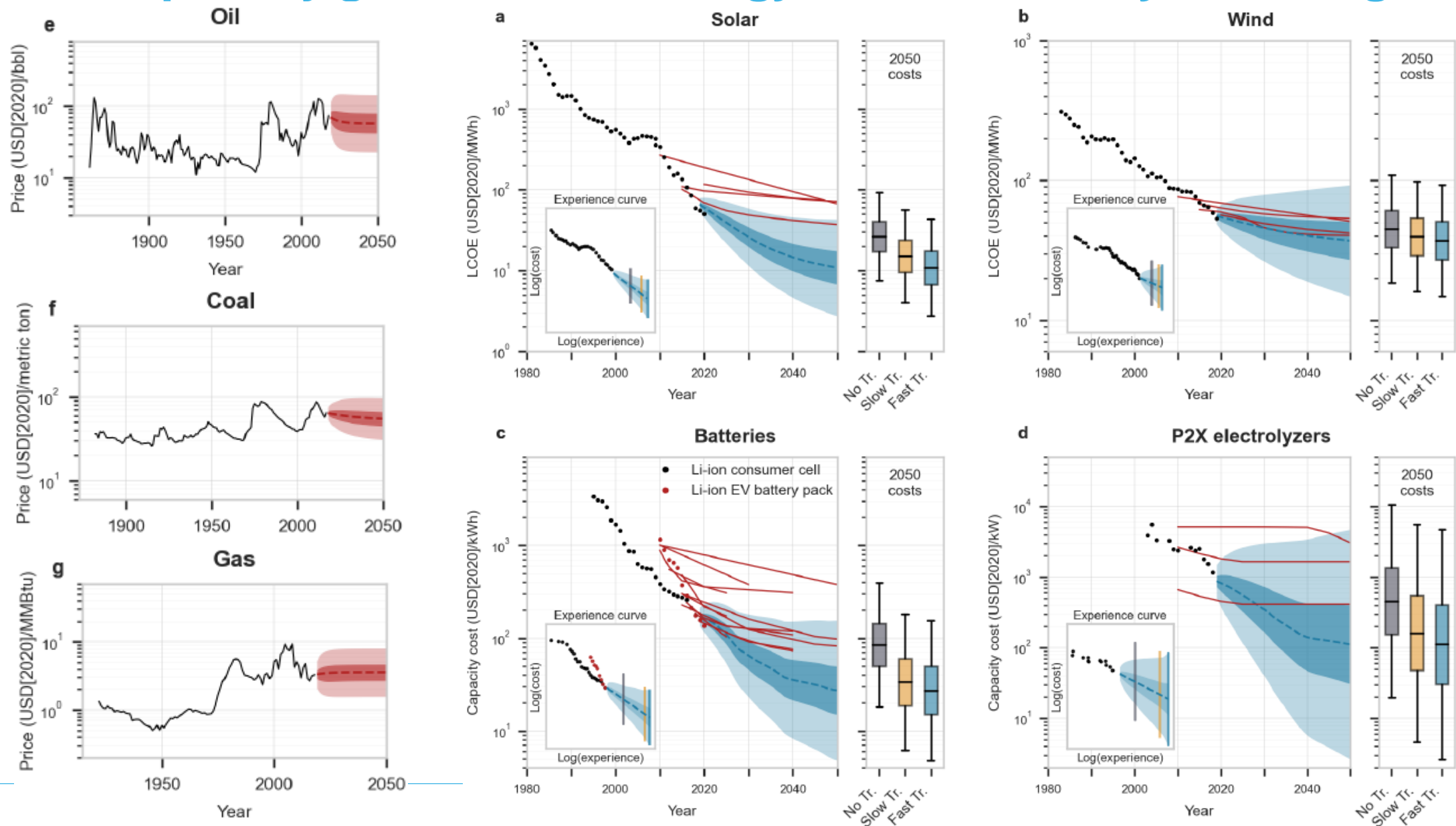
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# Empirically grounded technology forecasts for key technologies



# We built a simple, transparent model of the global energy system

Dispatchable, baseload energy



Renewables plus batteries



Liquid fuels



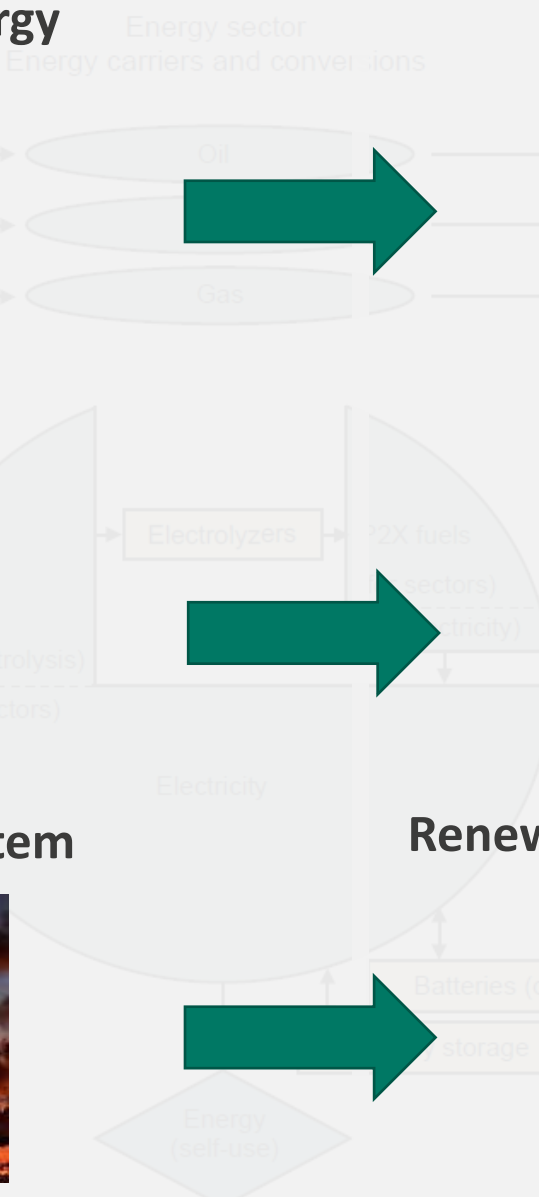
Renewables plus hydrogen



Entire fossil fuels energy system



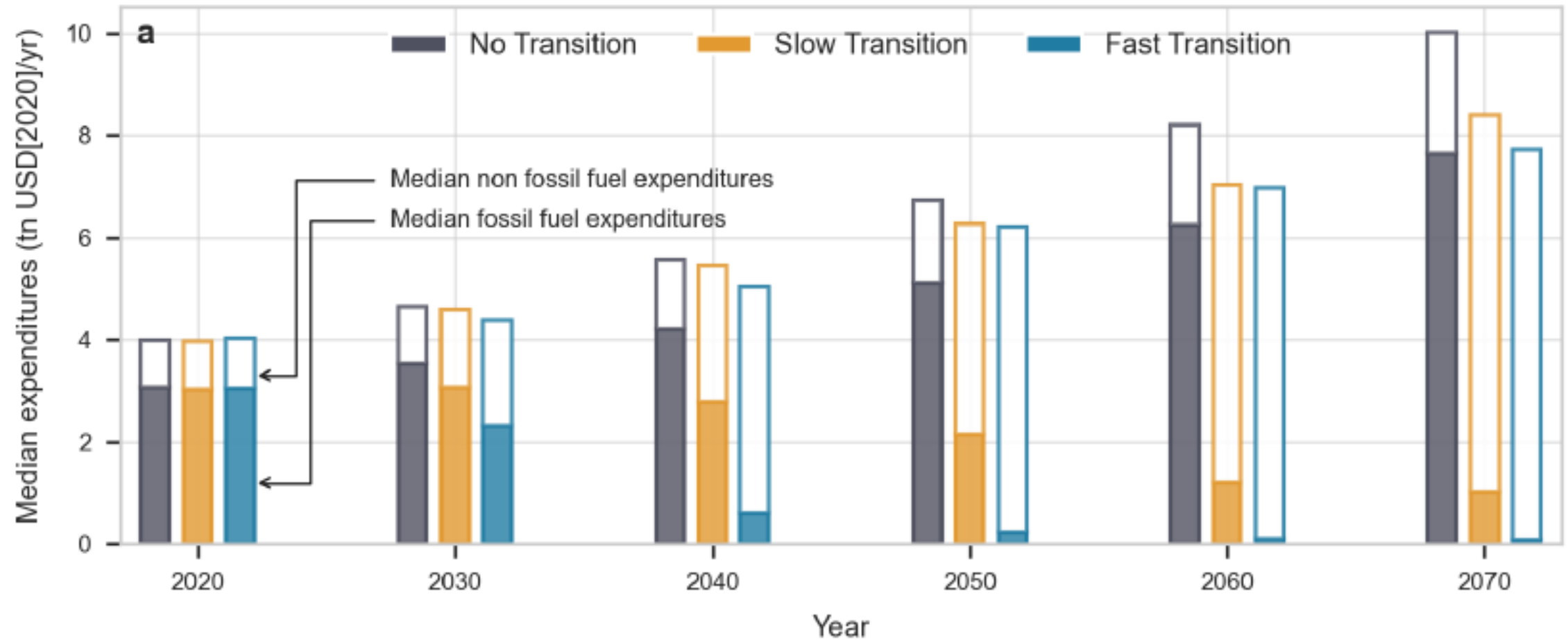
Renewables plus batteries plus hydrogen





# ...and found we will save trillions with a Fast Transition!

Median total savings of Fast Transition over No Transition = \$26 trillion by 2070



Median annual expenditures on fossil fuel and non fossil fuel technologies in each scenario (USD\$tn) at a 2% discount rate

(Way et al., 2021)

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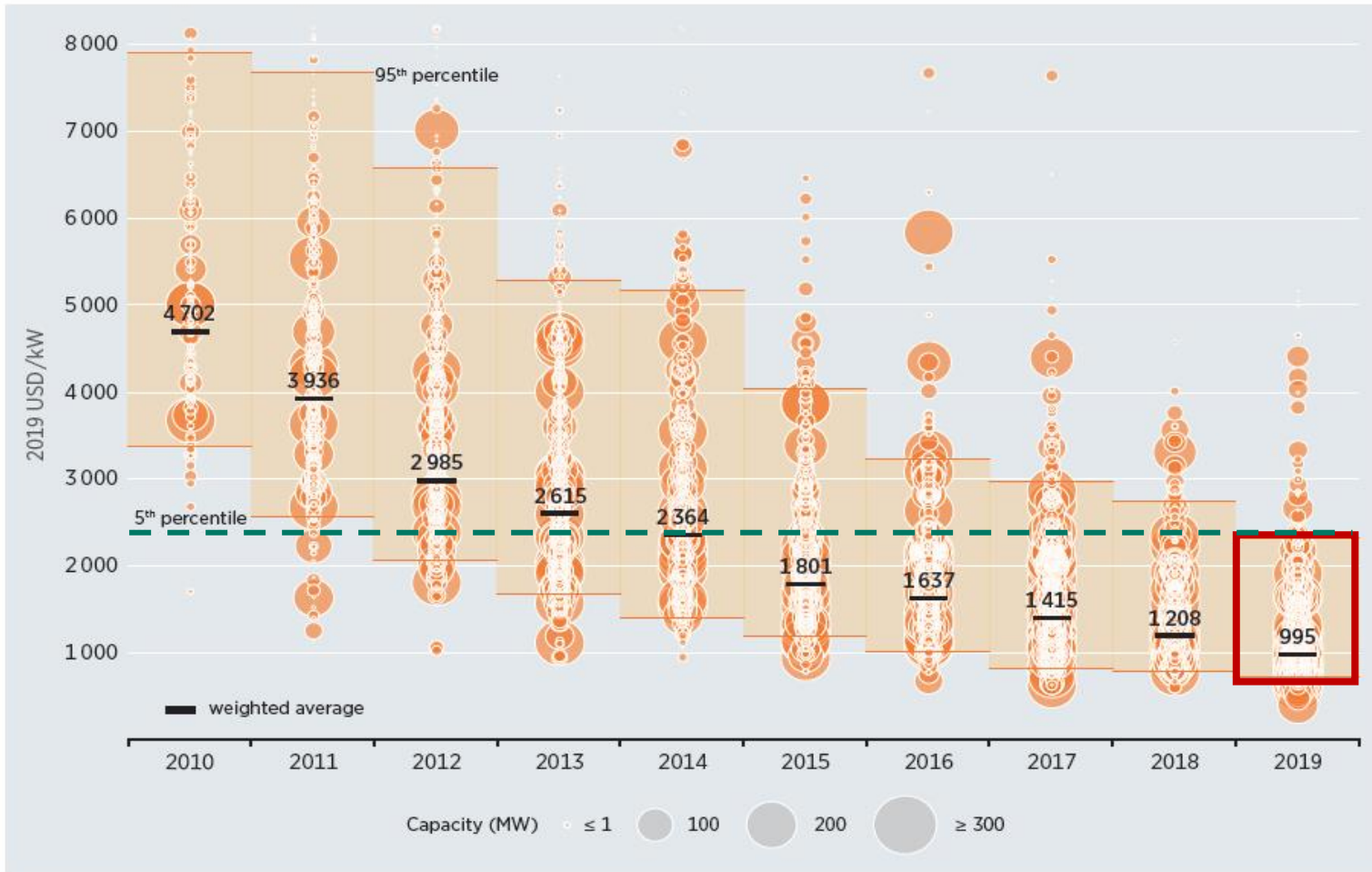
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# Renewables cheaper than fossil fuels for most of China in 5 years

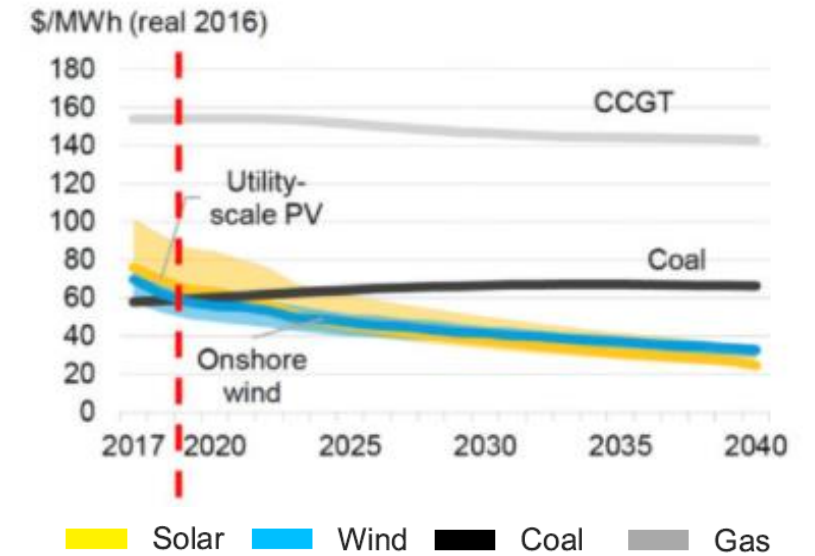
Figure 3.5 Detailed breakdown of utility-scale solar PV total installed costs by country, 2019

Figure 3.3 Total installed PV system cost and weighted averages for utility-scale systems, 2010-2019



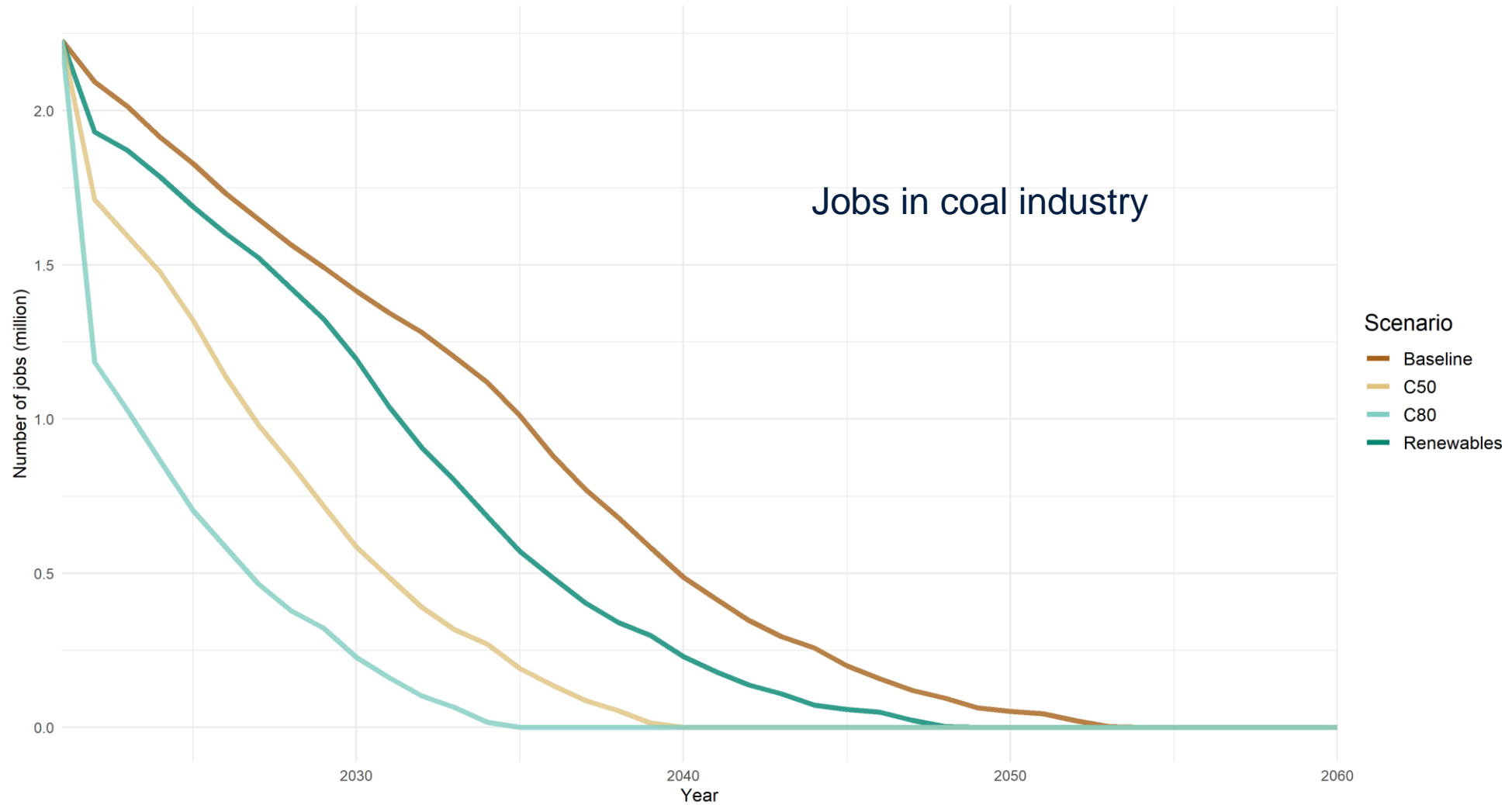
Source: IRENA Renewable Cost Database.

## China



Source: Bloomberg New Energy Finance

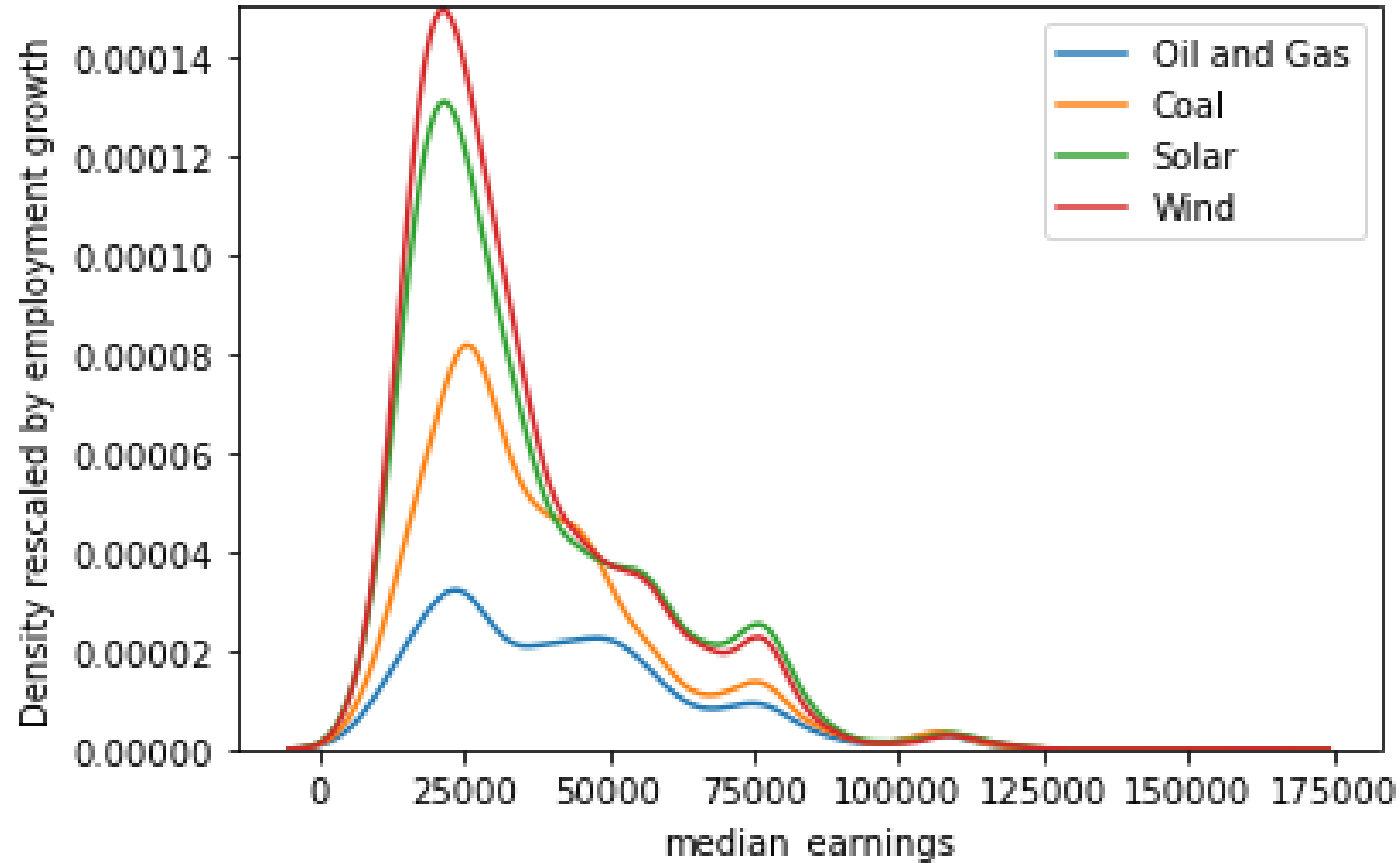
# Enormous structural change likely in China – potential for further job losses in coal



Thanks to Alex Clark - adapted from (He et al., 2020)



## More green jobs expected but strategies needed to manage the transition risks

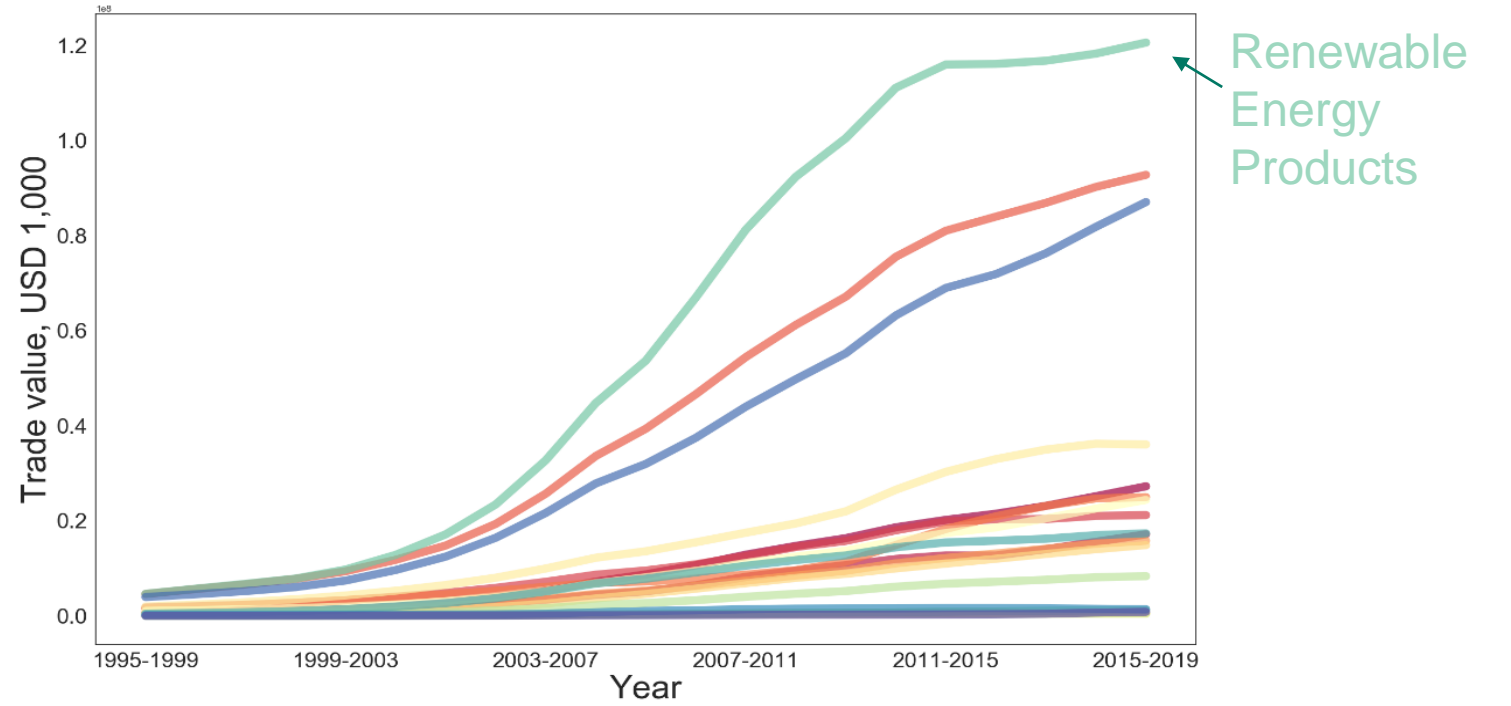


- More jobs in renewables but coal wages are higher on average
- There will be significant regional and skill shortages – **stranded locations**

Thanks to Joris Bucker

# China has enormous growth potential in green products

Category level trade value over time for China



- Air Pollution Control
- Clean Up or Remediation of Soil and Water
- Cleaner or More Resource Efficient Technologies and Products
- Efficient Consumption of Energy Technologies and Carbon Capture and Storage
- Energy Efficiency
- Environmental Monitoring, Analysis and Assessment Equipment
- Environmentally Preferable Products based on End-Use or Disposal Characteristics
- Gas Flaring Emission Reduction
- Heat and Energy Management
- Management of Solid and Hazardous Waste and Recycling Systems
- Natural Resource Protection
- Natural Risk Management
- Noise and Vibration Abatement
- Others
- Renewable Energy
- Resources and Pollution Management
- Waste Management, Recycling and Remediation
- Waste Water Management and Potable Water Treatment
- Water supply

Thanks to Penny Mealy & Pia Andres

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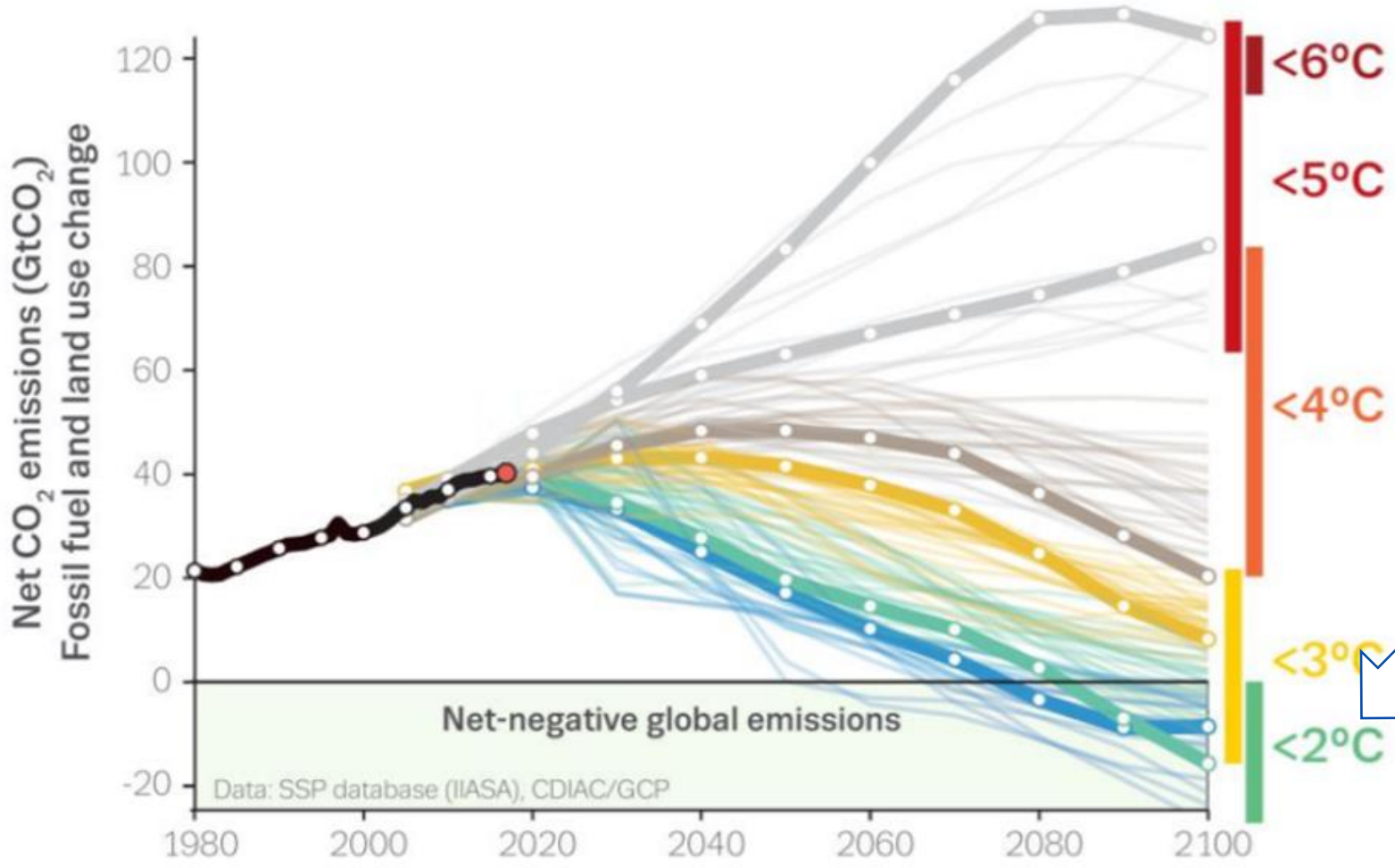
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# The IPCC story of meeting the Paris goals seems unachievable



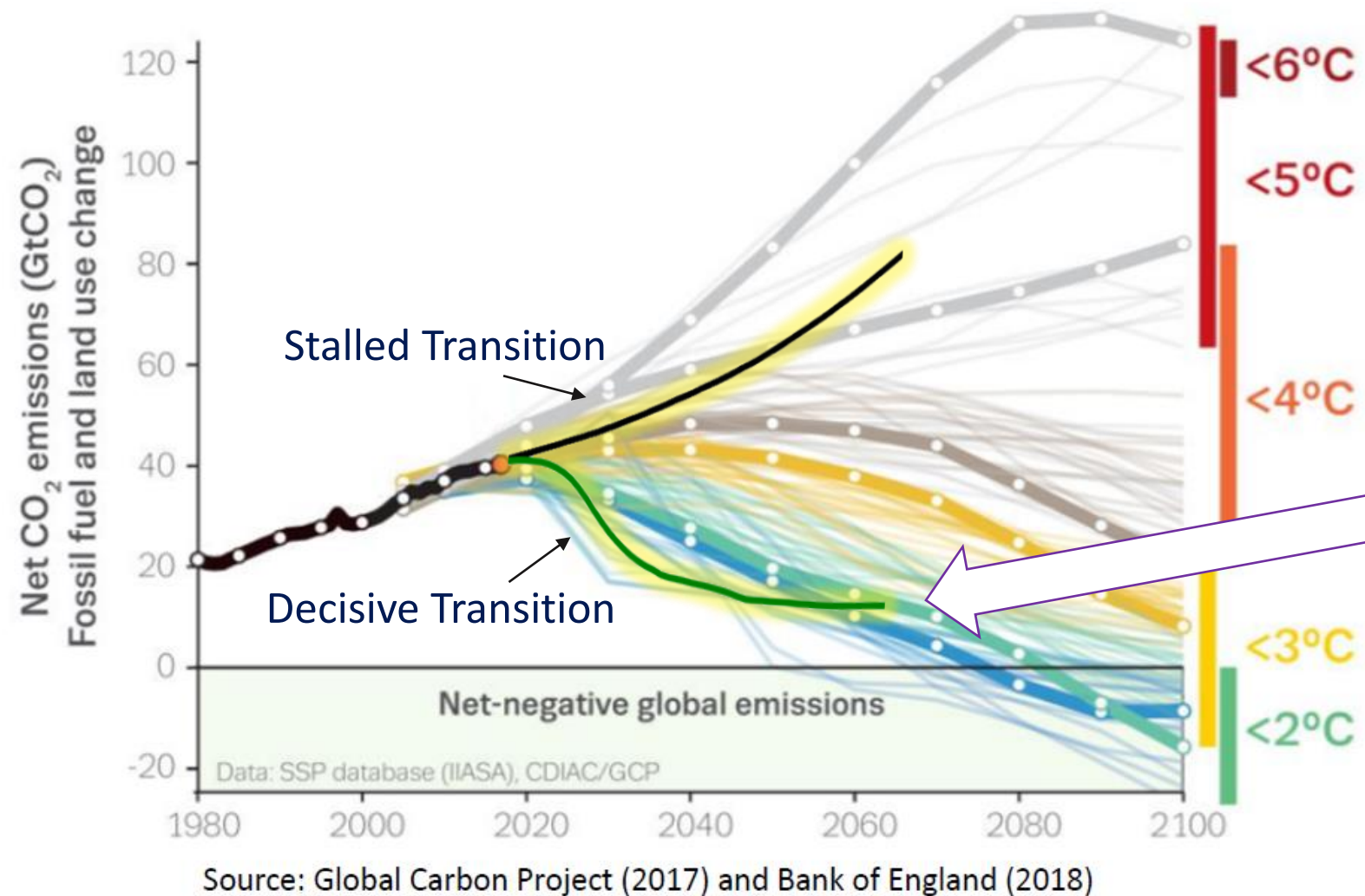
Source: Global Carbon Project (2017) and Bank of England (2018)

To achieve < 2 degrees:

- Economic growth will suffer
- We may need to reduce our energy usage
- We need to build a Carbon Capture and Storage plant every 3 days to 2100
- Electricity prices are likely to be higher



# Aligns the energy system with the Paris goals for much less cost



The Fast Transition has:

- No reduction in economic growth required
- No reduction in energy use applied (but could be)
- No Carbon Capture and Storage used (yet)
- Electricity prices ~ *one third* of “business-as-usual”

# Conclusions

- There is an opportunity to change the “mood music” being played to decision makers
- Continued strong growth in investment in key renewable and storage technologies over the next decade will:
  - Put us on track to meet the Paris emission reduction goals
  - Cost trillions less than business as usual
  - Need not reduce economic prosperity
  - And could make electricity much cheaper for everyone
- China faces a considerable challenge but has much to gain from the clean energy transition including huge growth in clean energy and storage exports



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# Thank you

[EnergyChallenge.info](https://www.energychallenge.info)

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## A new perspective on decarbonising the global energy system

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Cameron Hepburn

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