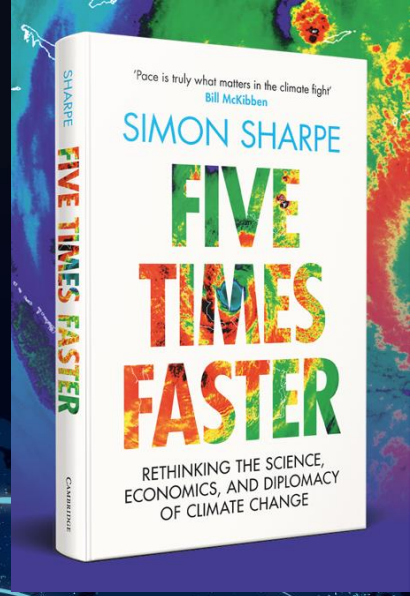
ECONOMICS OF ENERGY INNOVATION AND SYSTEM TRANSITION

s-curve economics

C3A Coalition for Capacity on Climate Action



Analytical tools for policymaking in the energy transition

Simon Sharpe, Managing Director, S-Curve Economics

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Equilibrium: *'a situation in which nobody has any immediate reason to change their actions, so that the status quo can continue, at least temporarily'*

(Oxford dictionary of economics)

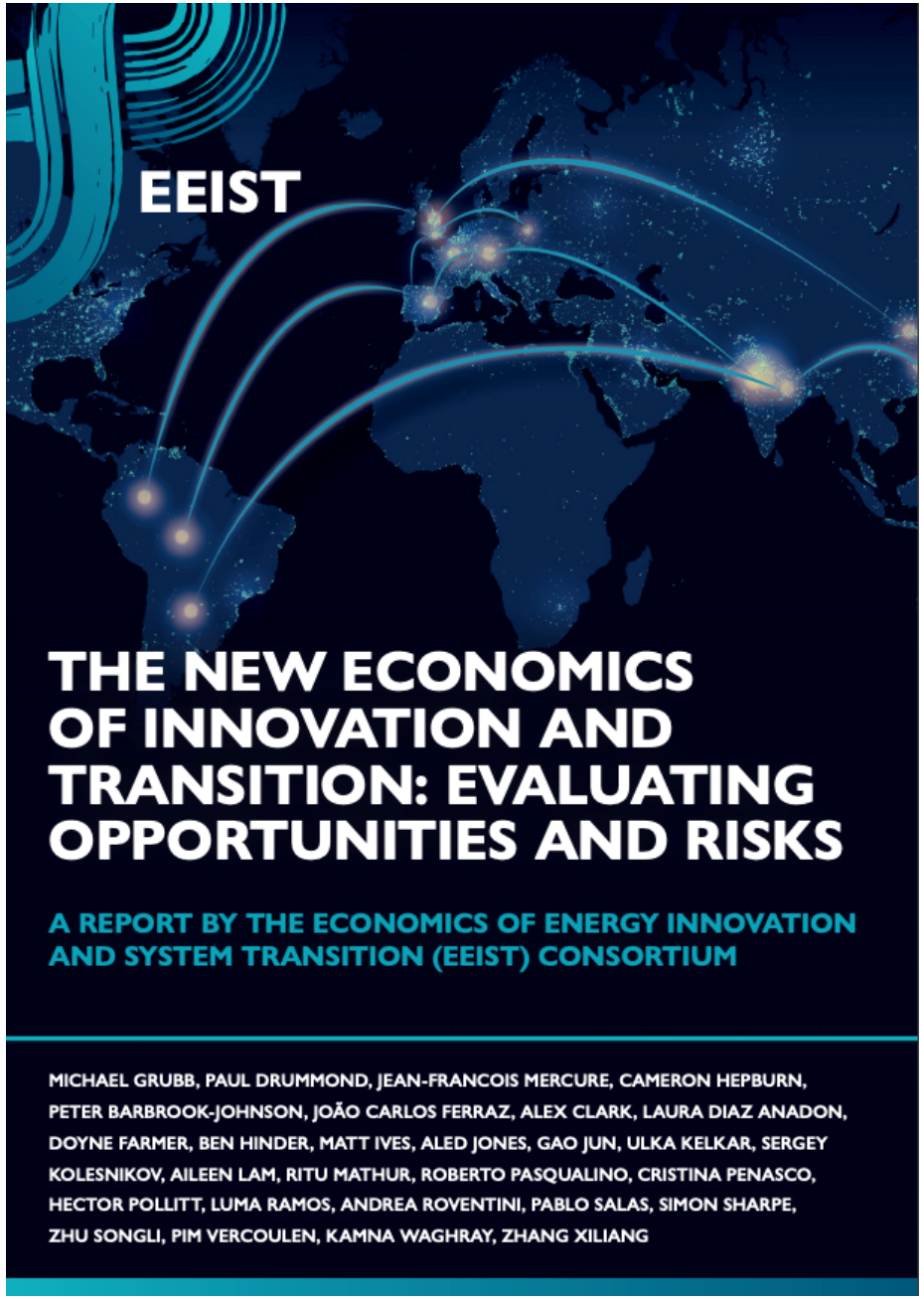
Meeting climate goals requires…

*'rapid and far-reaching **systems transitions…** unprecedented in terms of scale'*

Intergovernmental Panel on Climate Change (2018)

Decision-making frameworks

From costs and benefits to risks and opportunities



Policies critical to the most outstanding successes so far in low carbon transitions in China, India, Brazil, the UK and EU were generally implemented ***'despite, not because of, the predominant economic analysis and advice.'***

eeist.co.uk

Offshore wind:
"among the most expensive ways of marginally reducing carbon emissions known to man".
– Dieter Helm, **2014** quoted in *The Economist*

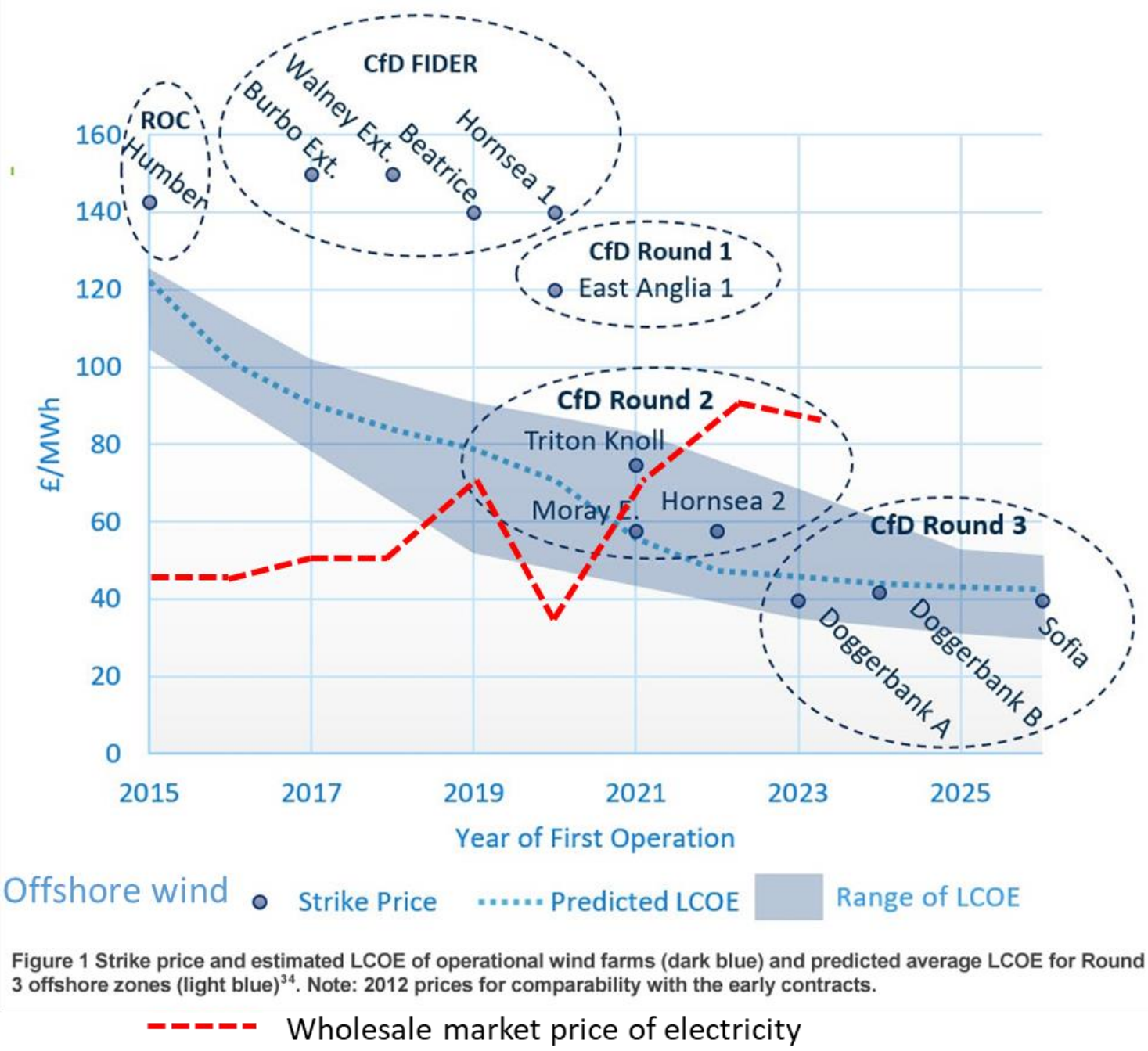
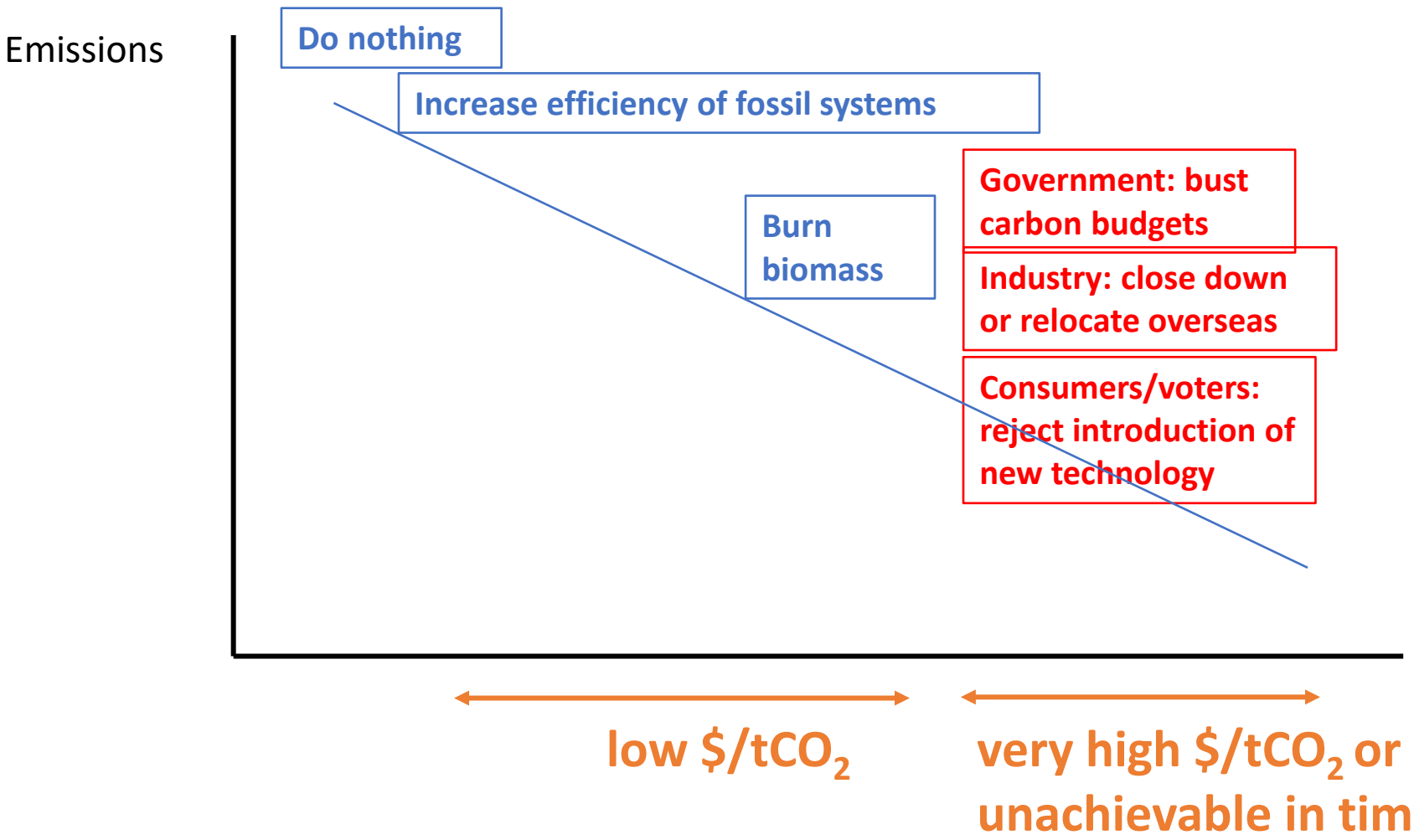


Figure 1 Strike price and estimated LCOE of operational wind farms (dark blue) and predicted average LCOE for Round 3 offshore zones (light blue)[34]. Note: 2012 prices for comparability with the early contracts.

Offshore wind becomes cheaper than gas power ~2021

A focus on short-term emissions reduction can lead to the wrong results

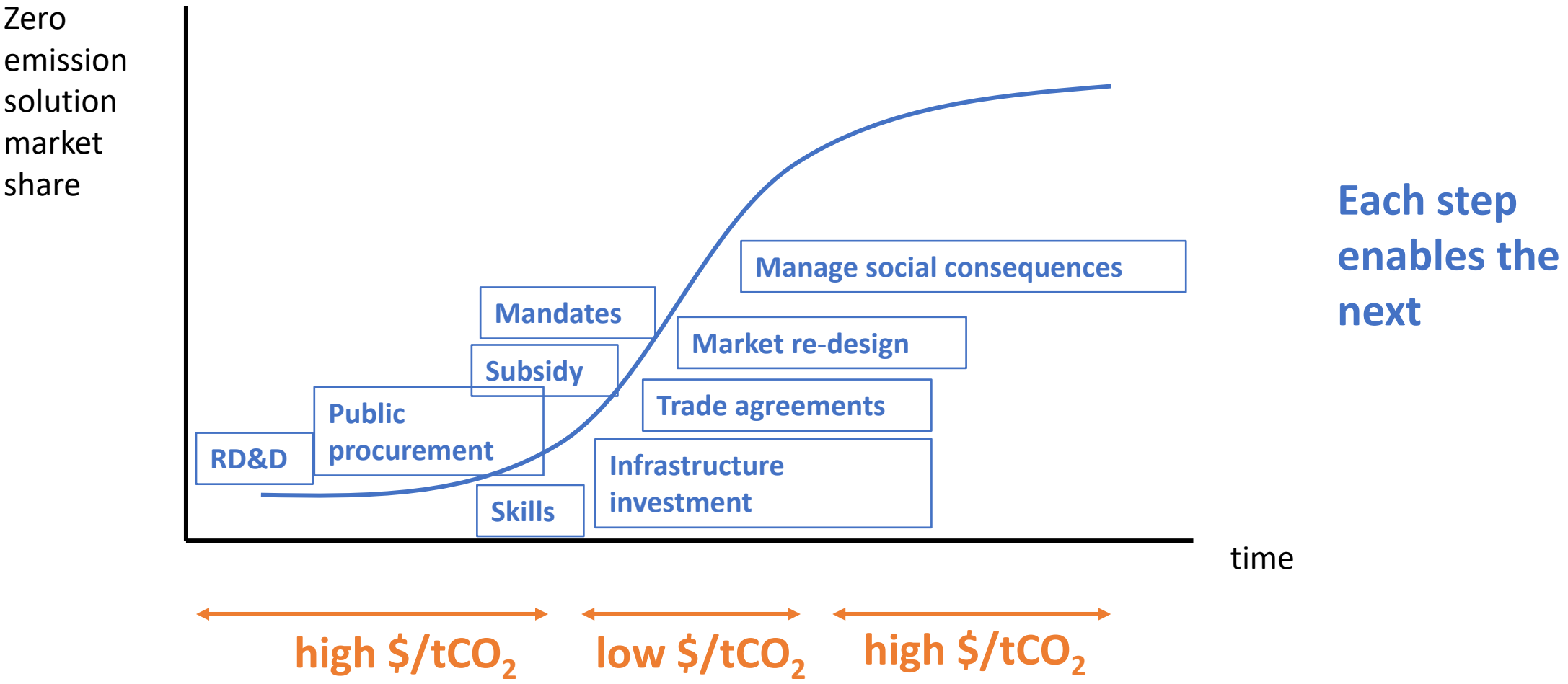


Each step delays the necessary

path-dependent development in zero-emission-related:

- Technologies
- Infrastructure systems
- Supply chains, and business models
- Workforce skills
- Consumer / investor confidence

Focus instead on deployment of zero-emission solutions

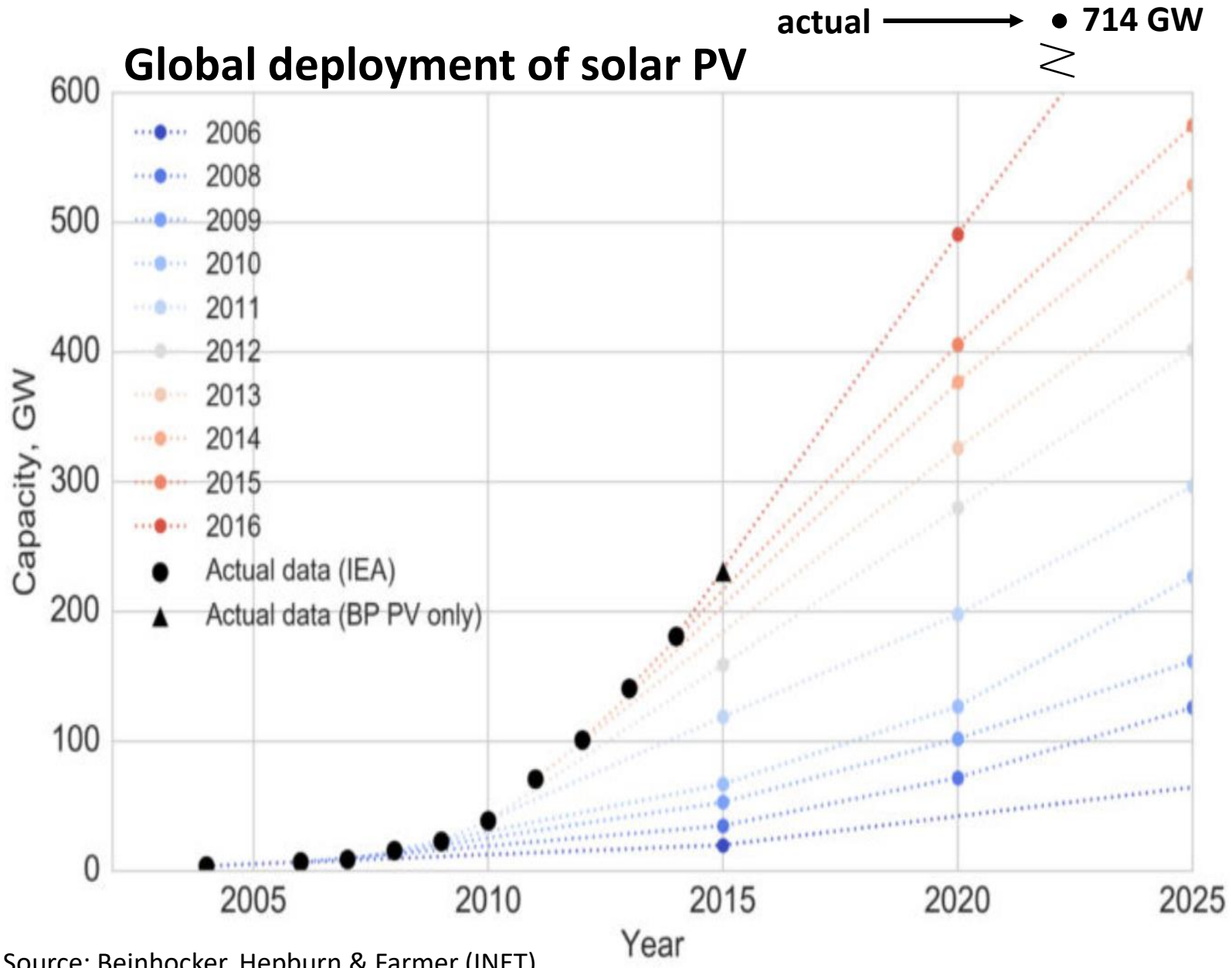


Each step enables the next

Principles for policymaking

From equilibrium to disequilibrium

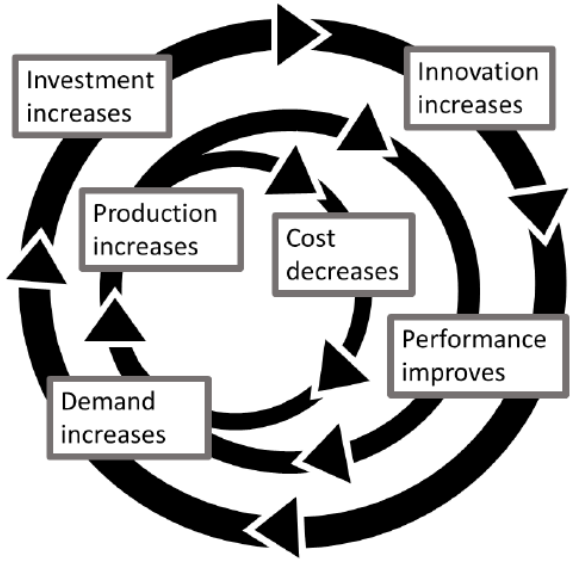
Invest in the new technology to bring down costs



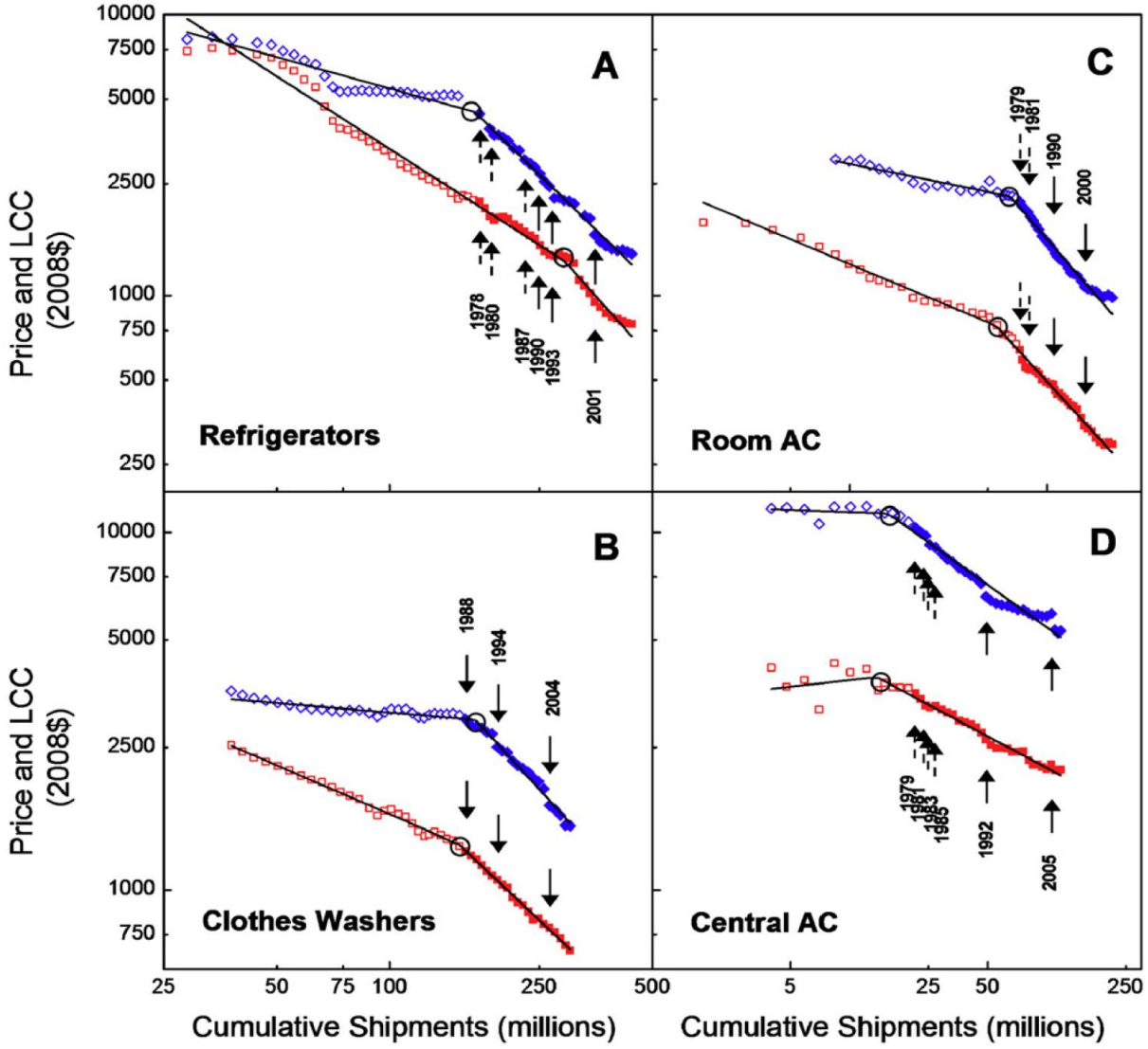
Source: Beinhocker, Hepburn & Farmer (INET)

Equilibrium-based assumption: carbon pricing is the most efficient policy for decarbonisation

Reality: carbon pricing is dynamically inefficient, early in the transition. Investment in new solutions benefits from self-amplifying feedbacks (learning by doing, economies of scale, complementary technologies); taxing the incumbent system does not.



Regulate to reallocate finance and accelerate innovation



Equilibrium-based assumption: regulation is distortive and increases costs.

Reality: regulation can accelerate innovation and cost reduction.

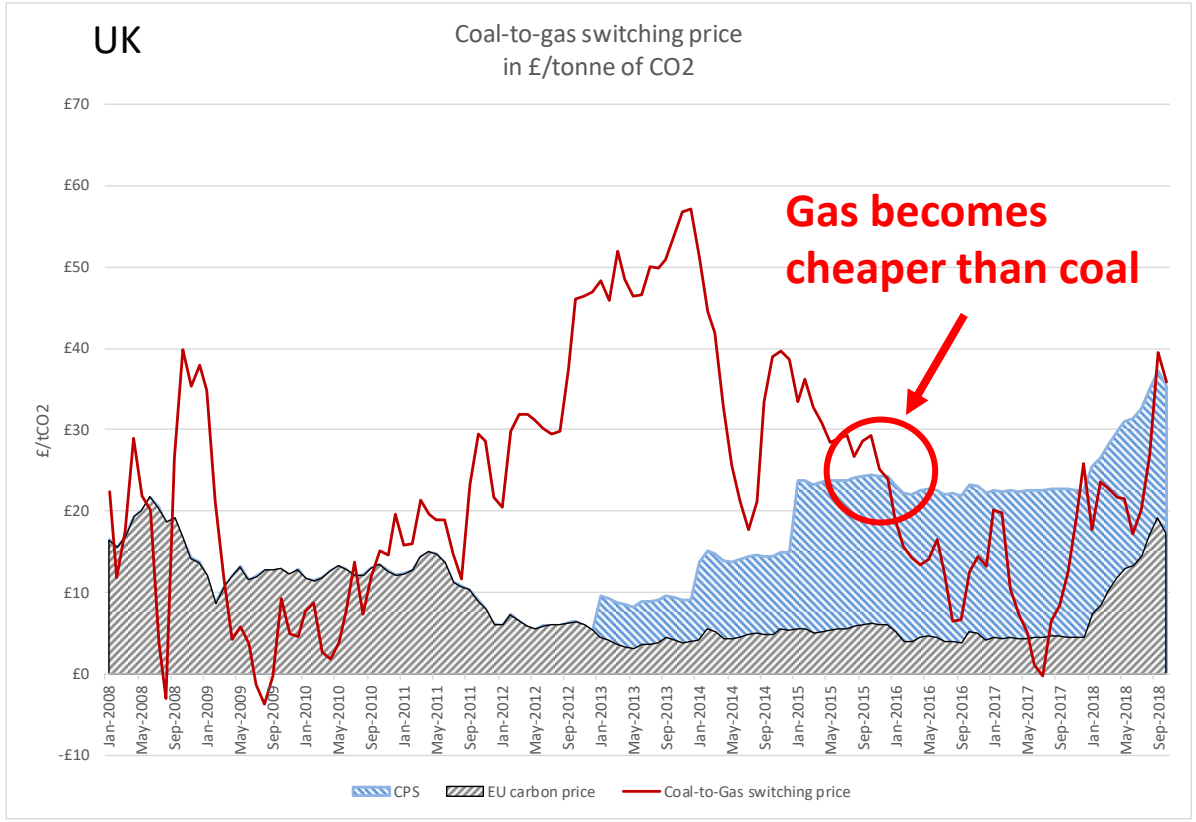
Regulation can re-shape the fitness function of a part of the economy, prompting businesses to shift resources from exploitation to exploration.

"In contrast to the classical picture of the impact of efficiency standards, the introduction and updating of appliance standards is not associated with a long-term increase in purchase price; rather, quality-adjusted prices undergo a continued or accelerated long-term decline."

A retrospective investigation of energy efficiency standards: policies may have accelerated long term declines in appliance costs
R D Van Buskirk, C L S Kantner, B F Gerke and S Chu

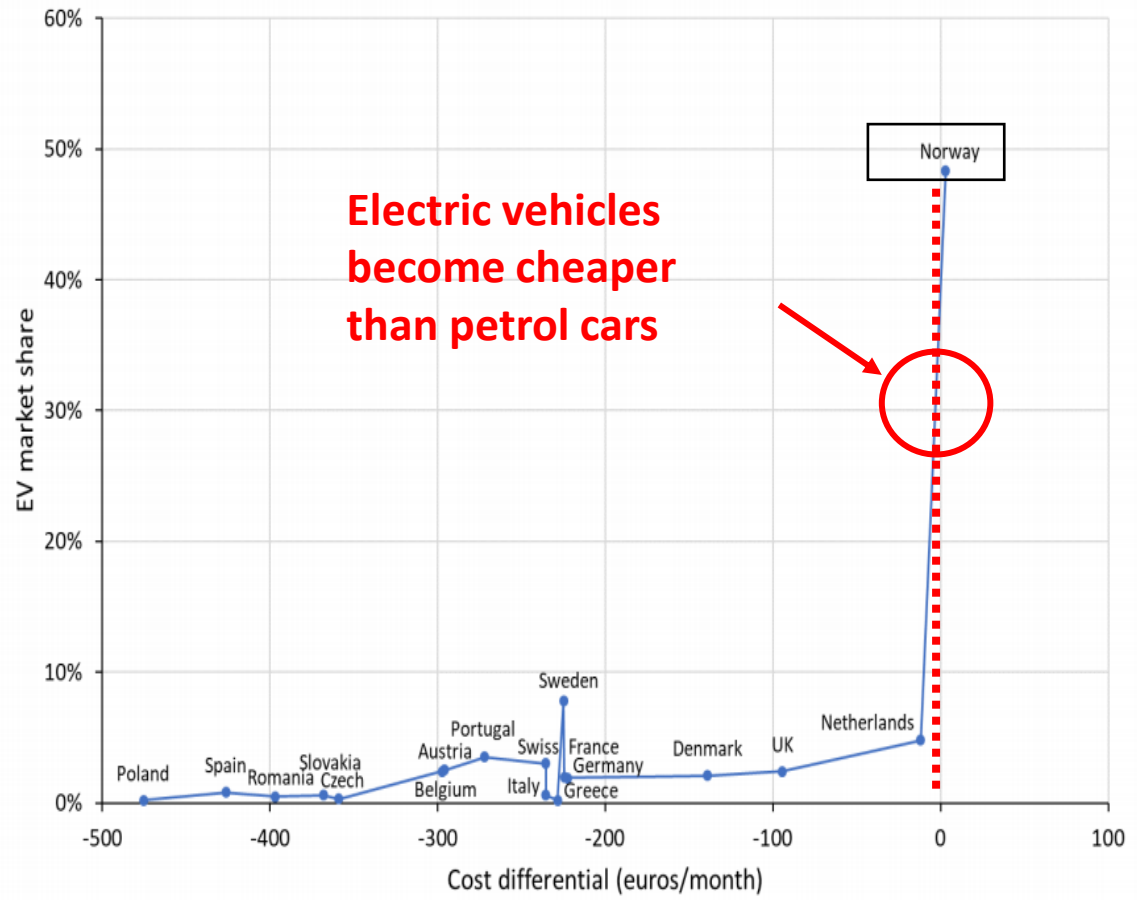
Use tax to target tipping points

World's fastest power sector decarbonization



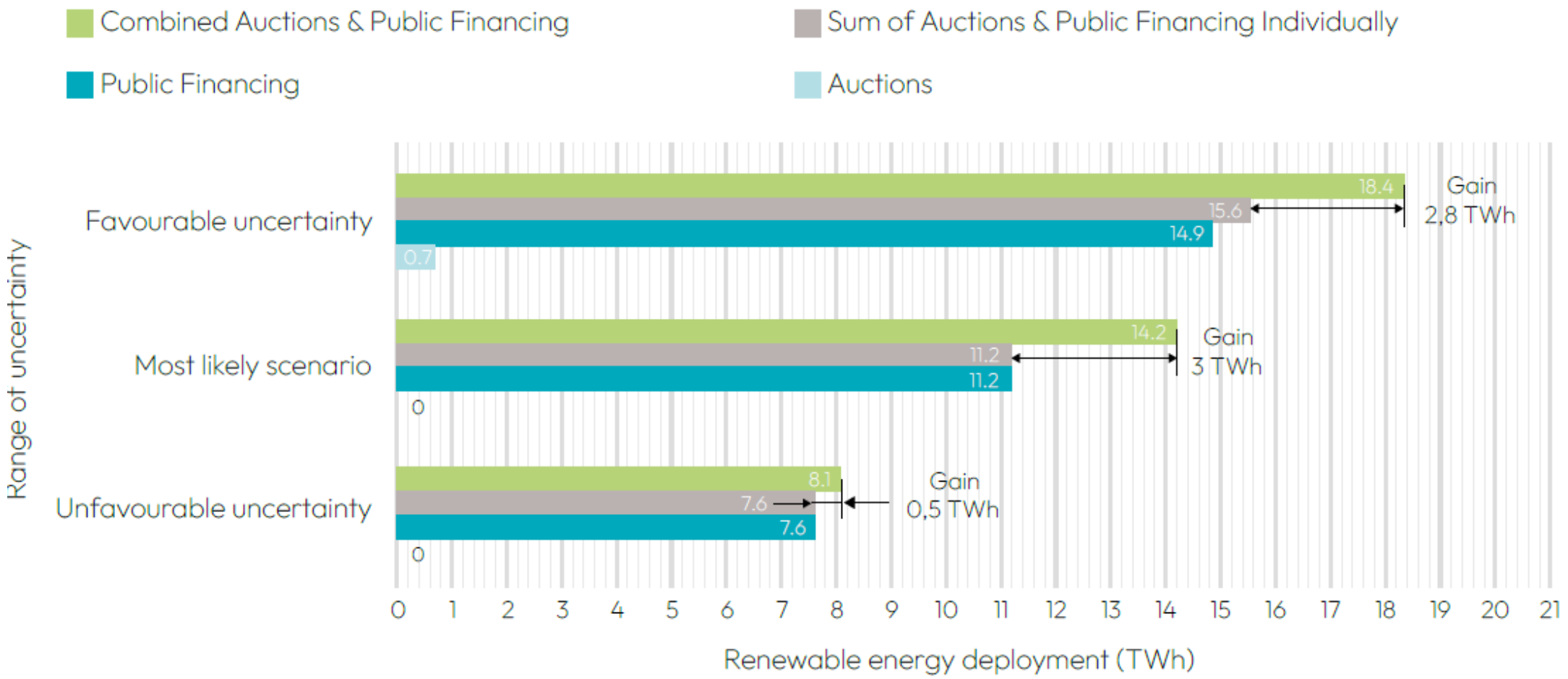
Grey shading: EU emissions trading carbon price
Blue shading: UK carbon price floor
Red line: coal-to-gas switching price

World's fastest transition to electric vehicles



Sharpe & Lenton: Upward-scaling tipping cascades to meet climate goals: plausible grounds for hope

Combine policies for better outcomes



Example: comparing the effect of public financing and auction policies individually and in combination on renewable energy investment in Brazil, using an agent-based model

Andreao et al, 2023. Positive nonlinear change from combining low carbon energy policies

Principles for policymaking are different in situations of innovation and structural change

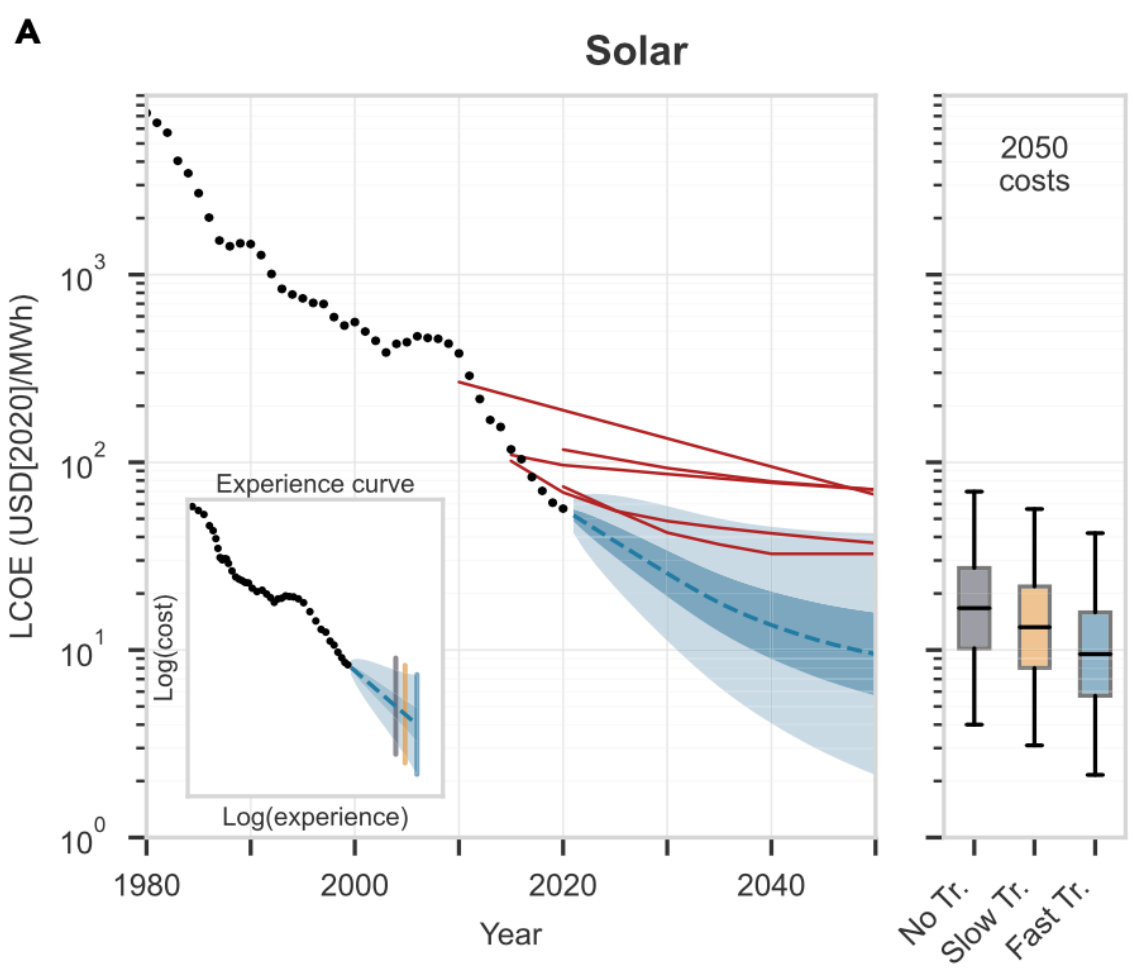
Traditional principle	Principle for the transition	
Policy should be technology neutral	Technology choices need to be made	← *Choosing offshore wind over biomass*
Government interventions raise costs	Invest and regulate to bring down costs	← *Subsidies for renewables drive deployment and cost reduction*
Markets on their own optimally manage risks	Actively manage risks to crowd in investment	← *Contracts for difference*
Price carbon at a level that internalises the damages of climate change	Target tipping points	← *Carbon tax makes coal more expensive than gas*
Consider policies individually based on distinct 'market failures'	Combine policies for better outcomes	← *Capacity market 'fossil fuel subsidy' enables growth of renewables*
Policy should be optimal	Policy should be adaptive	
and more…		

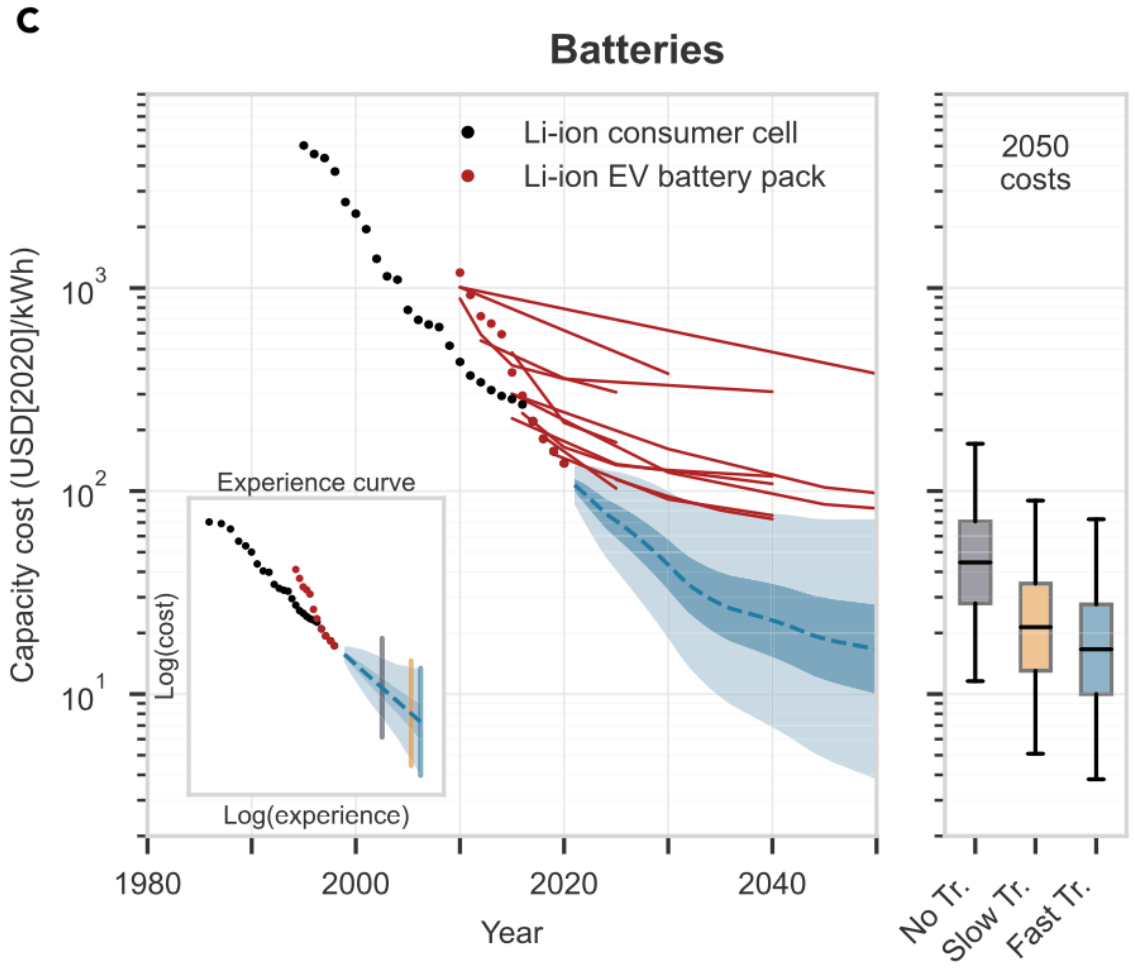
Example: the world's fastest power sector decarbonisation (UK):

Models

From optimising to simulating

TECHNOLOGY CHOICE





"Solar power is by far the most expensive way of reducing emissions… *governments should target emissions reductions from any other source rather than focus on boosting certain kinds of renewable energy."* The Economist magazine, 2014

"Solar is now the cheapest form of electricity in history"
International Energy Agency, 2020

Way et al (2022): Empirically grounded technology forecasts and the energy transition

POWER GENERATION – CHEAPEST SOURCE BY REGION AND TIME

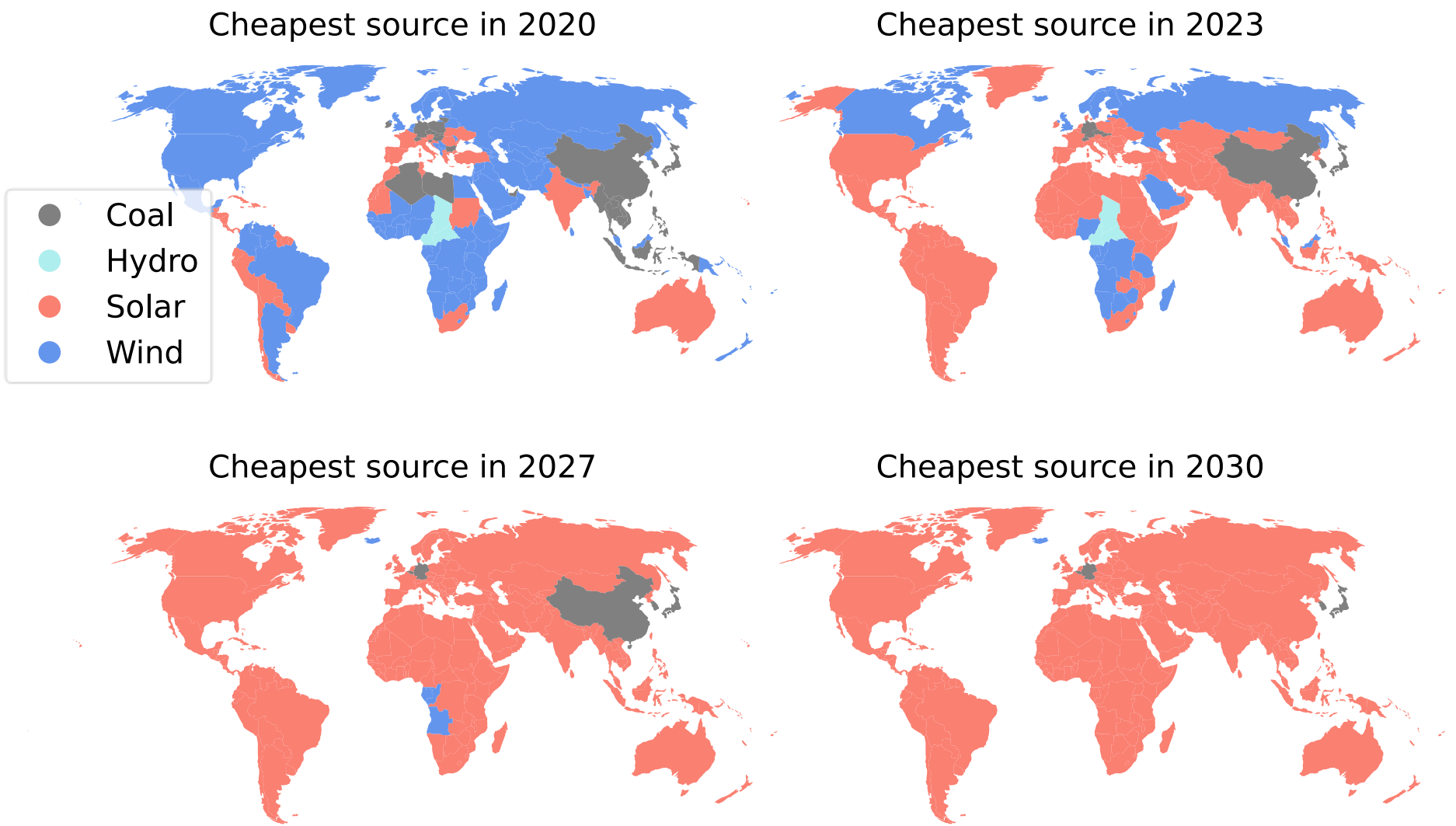
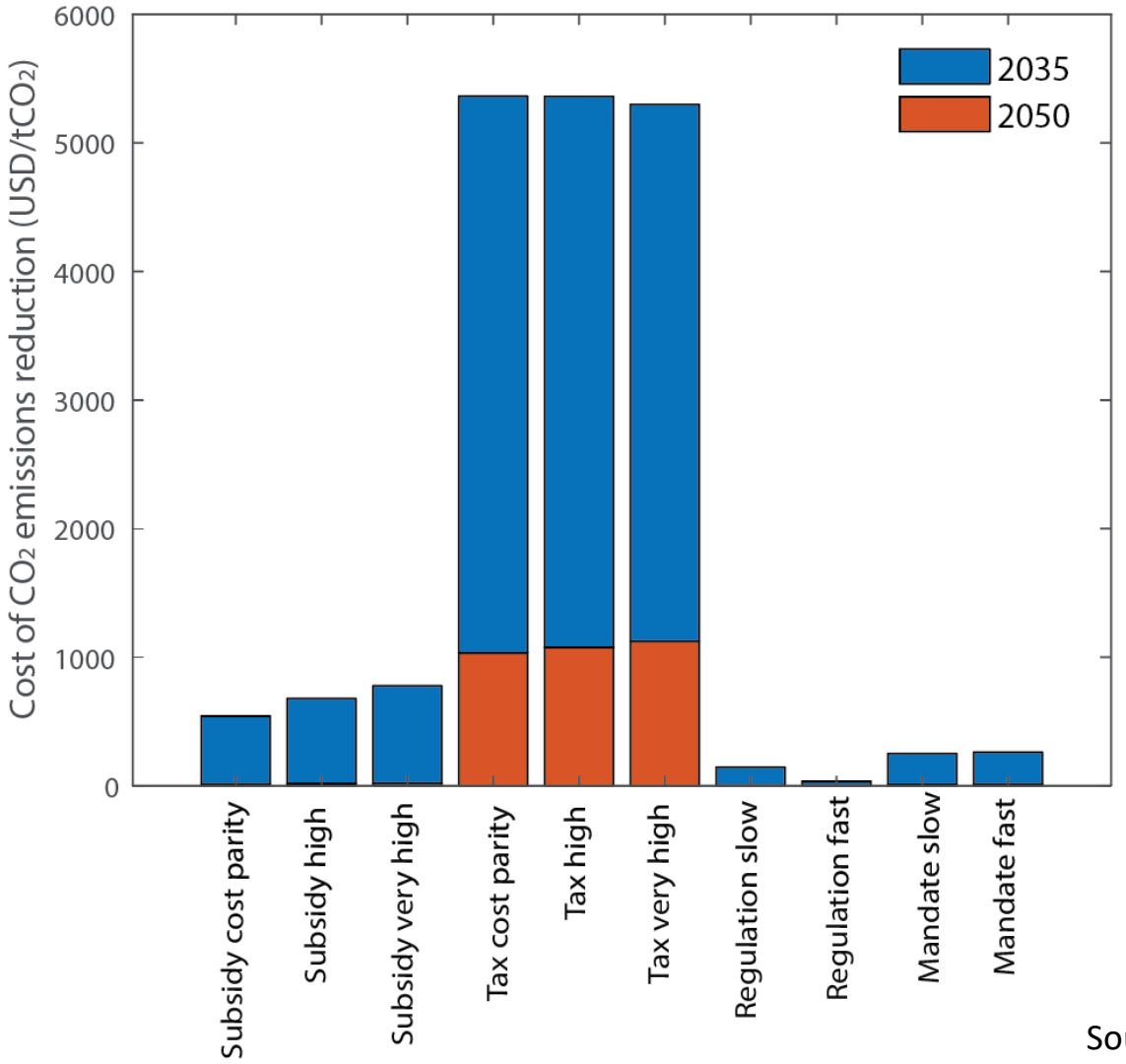


Figure 4: Maps showing the cheapest energy source in the 70 E3ME regions, in 2023, 2027 and 2030. The biggest shift occurs between 2020 and 2025, which sees wind and coal give way to solar PV as the cheapest source of electricity.

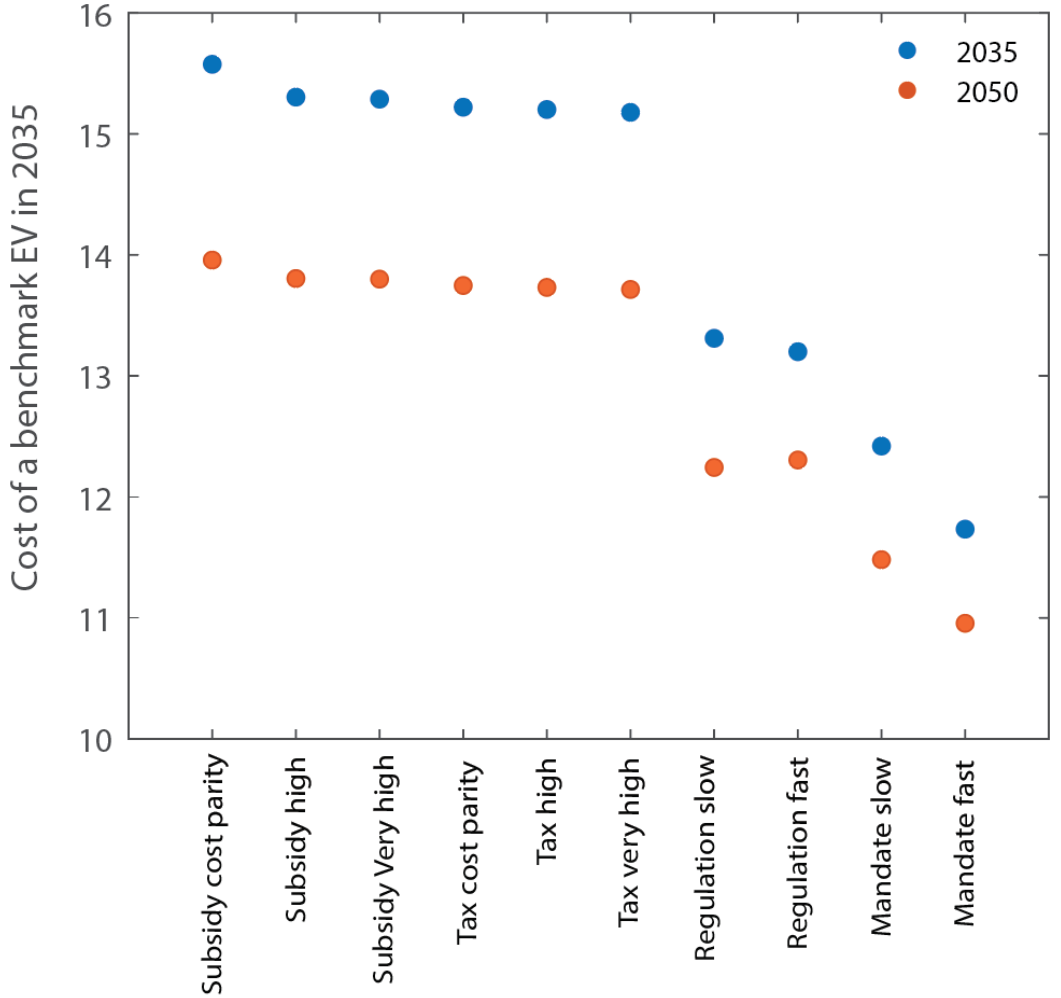
POLICY CHOICE

Policy options to deploy electric vehicles in India

Cost per tonne of emissions reduction



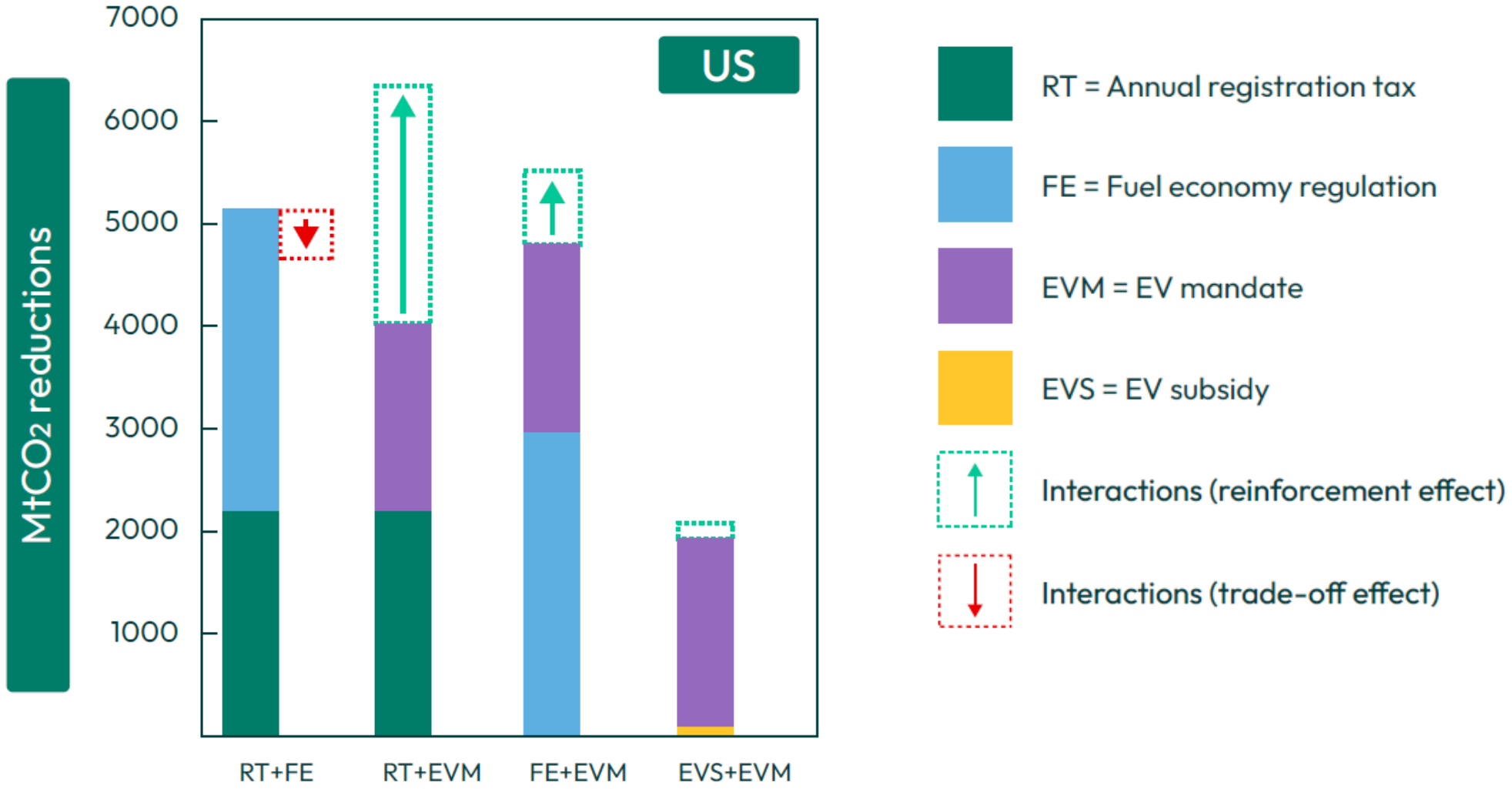
Cost of benchmark electric vehicle in 2035



Source: Lam & Mercure

POLICY COMBINATIONS

Emissions reductions from policy combinations in road transport (using the FTT model)

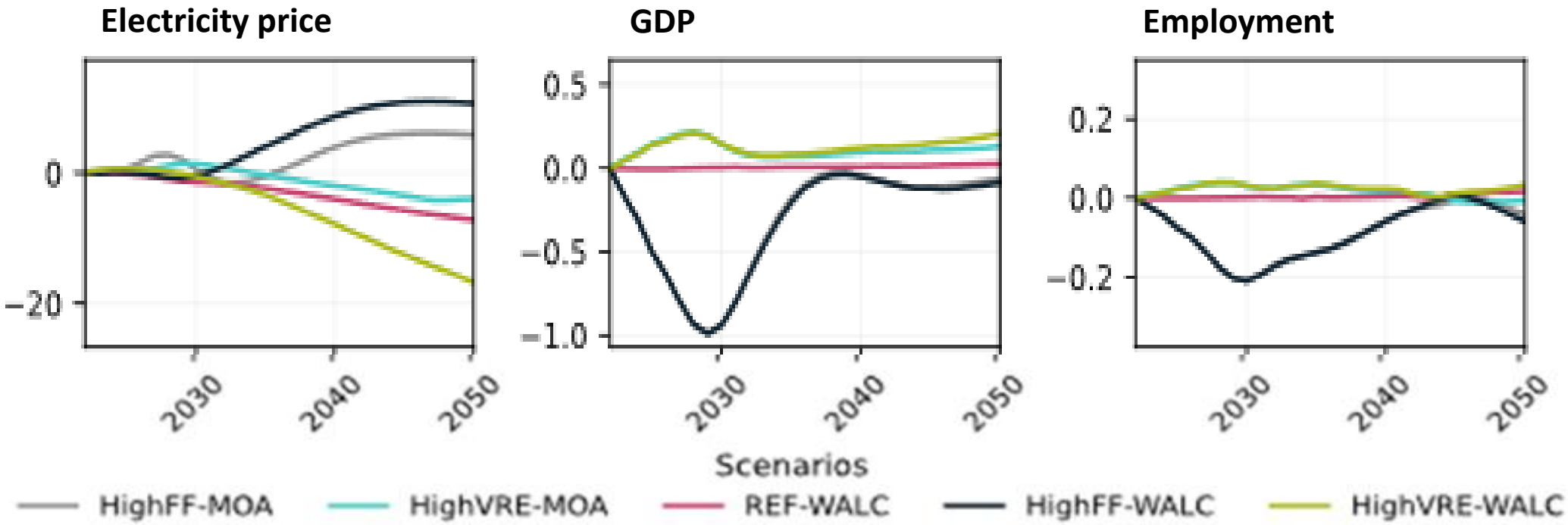


Source: Lam & Mercure, using the FTT model

MARKET DESIGN

China

% difference from Reference-MOA scenario

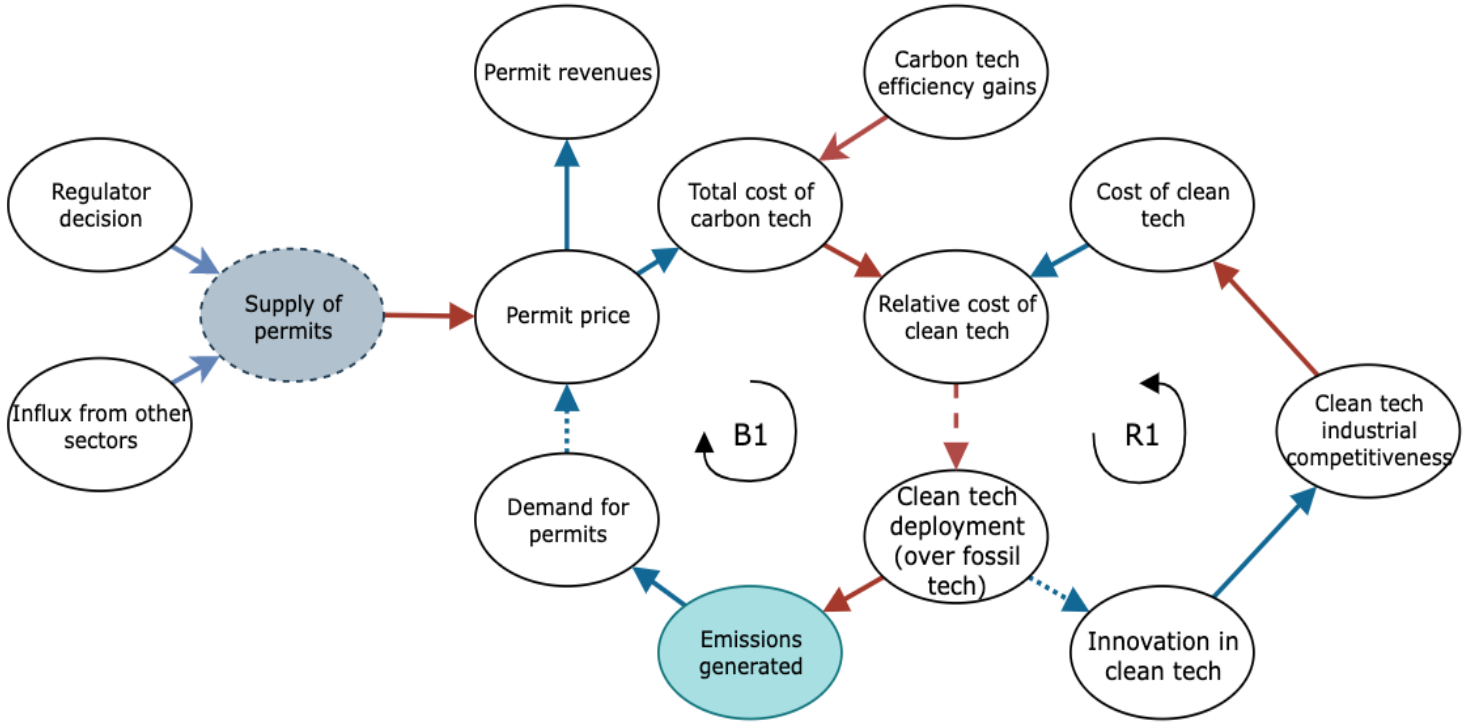


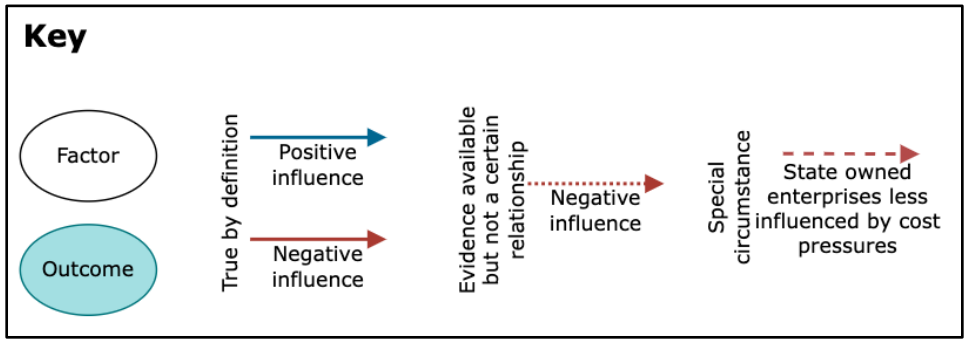
Solar Coal Onshore wind

High FF = high fossil fuel scenario
High VRE = high variable renewable energy scenario
MOA = price formed by merit order approach & marginal supply cost
WALC = price formed by weighted average levelized cost of generation

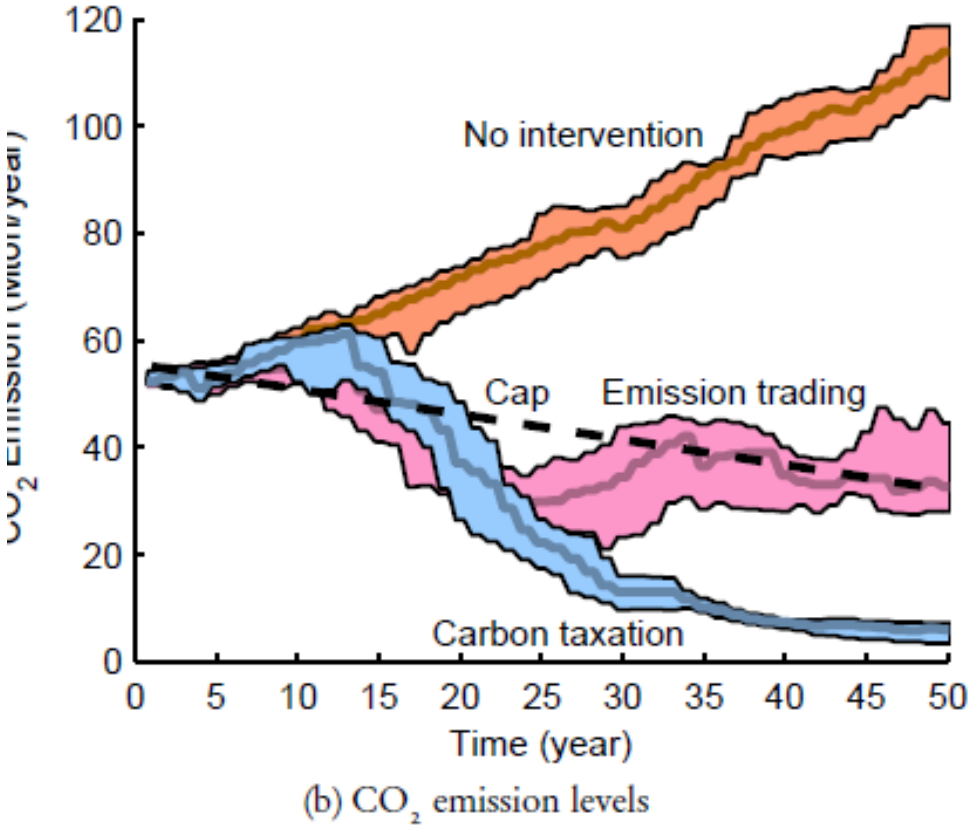
Source: Vercoulen et al, using the E3ME-FTT model combination

POLICY DESIGN





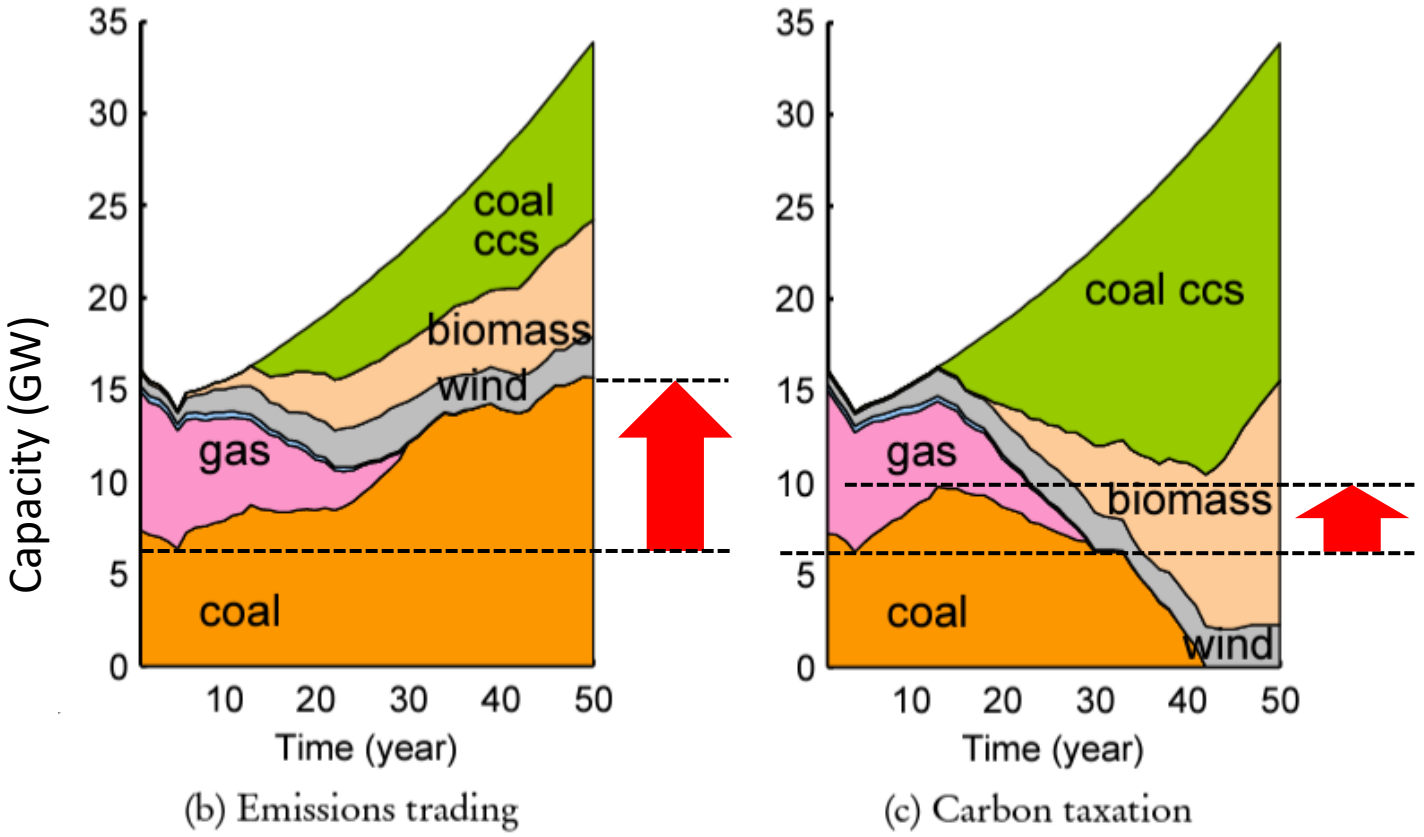
Comparison of carbon tax and ETS with same average carbon price, using an agent-based model



(b) CO_2 emission levels

Source: Chappin (2010): http://chappin.com/ChappinEJL-PhDthesis.pdf

Least cost marginal emissions reduction = maximum wasted investment



Evolution of the generation technology mix (averaged across model runs)

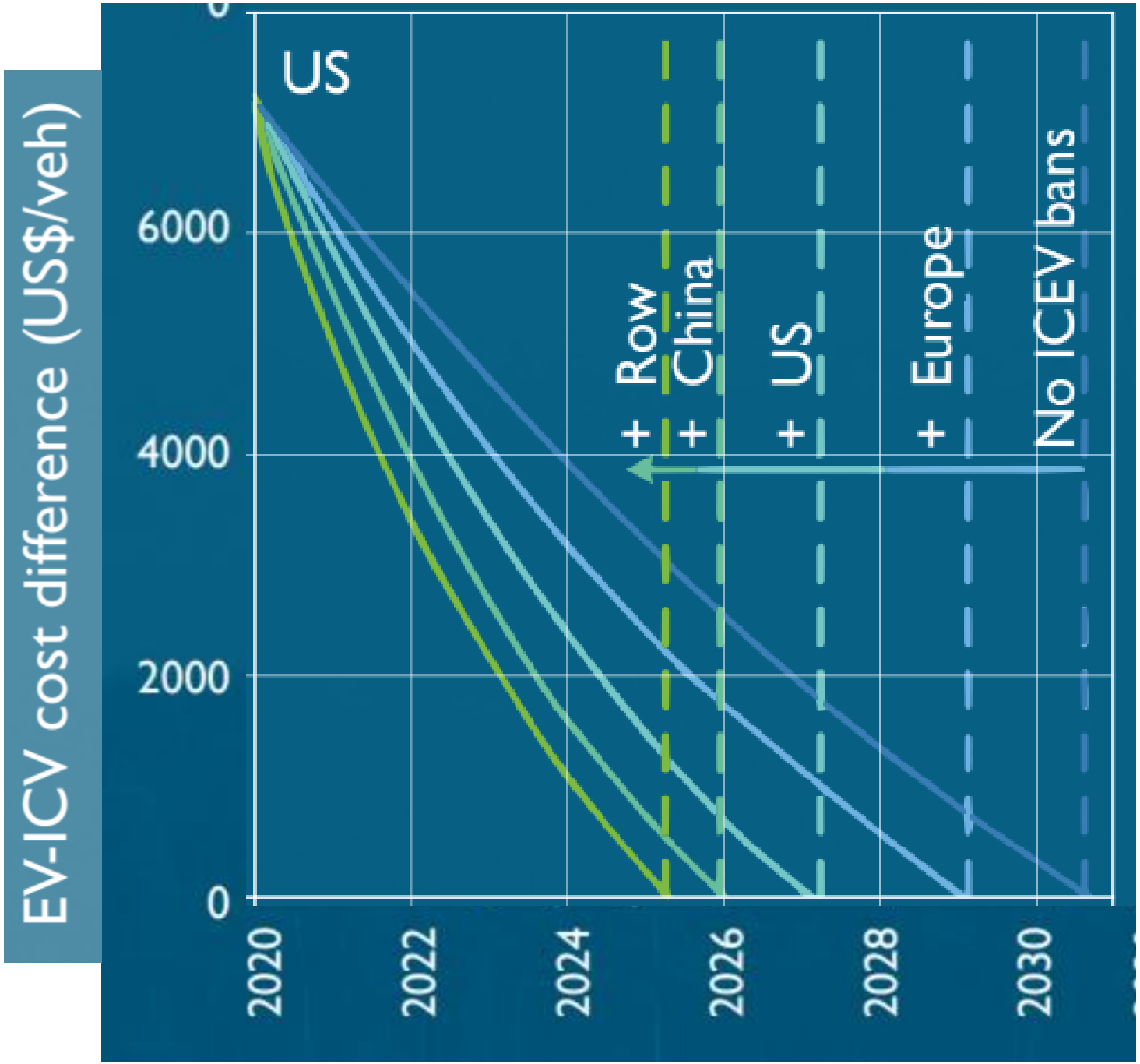
= potentially wasted investment in new power generation assets that need to be replaced before the end of the transition

Source: Chappin (2010): http://chappin.com/ChappinEJL-PhDthesis.pdf

DIPLOMACY

Three regulators can bring forward the electric vehicle tipping point by 5 years

Source: Lam & Mercure, *'Evidence for a global electric vehicle tipping point'* (2022)



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