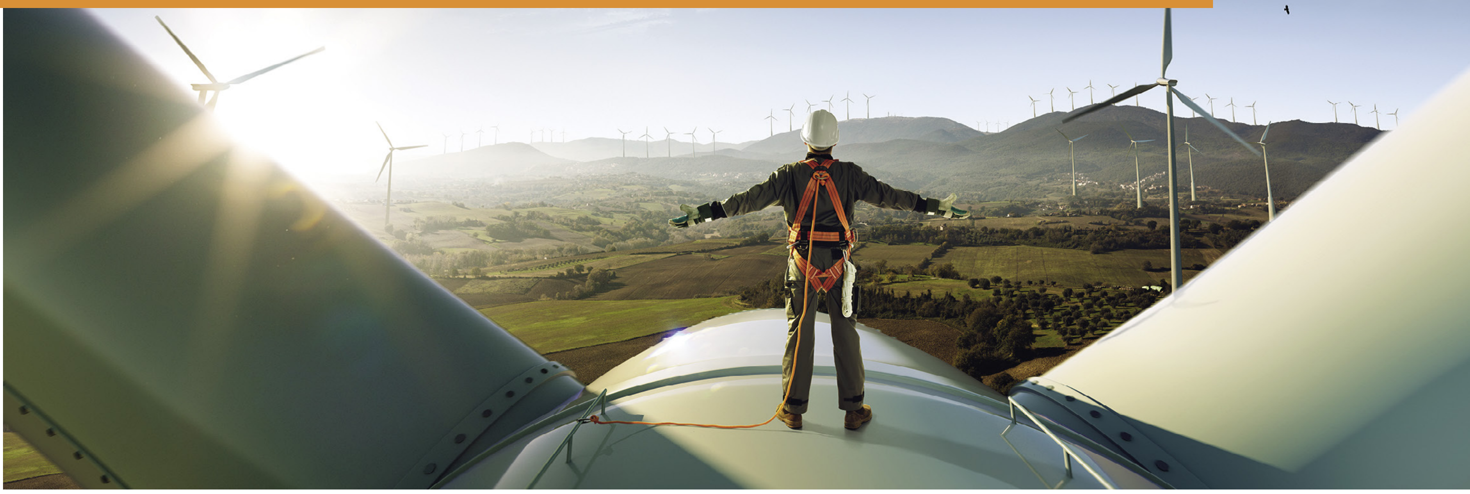
RESEARCH BRIEFING

Institute for New Economic Thinking
at the Oxford Martin School

OXFORD MARTIN SCHOOL

UNIVERSITY OF OXFORD

A fast clean energy transition would save trillions



Key messages

- A rapid transition to a fully decarbonised energy system by 2050 would save at least $12 trillion in global energy costs compared to continuing with our current fossil fuel-based energy system.
- The faster we decarbonise, the larger the savings will be and the sooner they will be realised.
- Old energy models repeatedly and badly underestimated the speed of clean energy cost declines. Using more empirically robust foundations, this work shows a decisive clean energy transition would be an economic boon, slashing energy costs and raising GDP.
- These cost savings will only be realised, however, if governments, investors, and businesses take actions to rapidly deploy clean energy technologies at scale.

The clean energy revolution has been gathering speed for some time now. Whereas fossil fuel prices have remained roughly constant for over a century, solar has fallen in cost by a factor of 5,000 since the photovoltaic cell was first commercialized in 1958. Other key technologies such as wind, batteries, and electrolysers have experienced similarly exponential cost drops. Solar and onshore wind are now the cheapest electricity generation options in a significant majority of countries.[1]

1 IEA (2022), Renewables 2022, IEA, Paris, and IRENA (2022), Renewable power generation costs in 2022, International Renewable Energy Agency, Abu Dhabi.

A new, empirically proven forecasting method shows that clean energy costs will very likely continue to fall and the more widely used these technologies become, the faster this will occur. As a result, decarbonising the energy system by around 2050 would save at least $12 trillion in global energy system costs.

A new approach is needed

Standard integrated assessment models ('IAMs'), such as those used to inform the UN Intergovernmental Panel on Climate Change ('IPCC') and policymakers worldwide, have consistently and significantly overestimated the future costs of key clean energy technologies. For example, the average value of IAM projected solar PV cost reductions for 2010-2020 in rapid decarbonization scenarios was 2.6% per year; the actual drop was almost 6-times faster at 15% per year.

Our methodology uses historical data to forecast the most probable future paths of technology costs, and careful out-of-sample back-testing shows that these forecasts are highly accurate.

Specifically, the method properly captures the dynamic "learning effect" whereby as the cumulative production of clean energy technologies grows, their costs decline.

Though researchers have long been familiar with such technology learning effects, arbitrary floor costs included in previous energy models prevented their full impacts from being incorporated into forecasts, resulting in analyses that repeatedly and significantly underestimated the speed of clean energy cost declines.

Three scenarios for meeting global energy needs until 2070

a. Fast transition: Renewables grow slightly slower than their current exponential growth rates for a decade, after which deployment slows to grow at 2% per year. This would likely meet the 1.5° Paris Agreement limit if non-energy sources of emissions (e.g., agriculture, cement) are also addressed. With the right policy choices, such a rapid transition is technically achievable.

b. Slow transition: Fossil fuels are phased out at a slower rate than in the rapid transition.

Figure 1: The Levelised Cost of Electricity (LCOE) is the discounted lifetime cost of building and operating an energy generation asset, expressed as a cost per unit of electricity generated

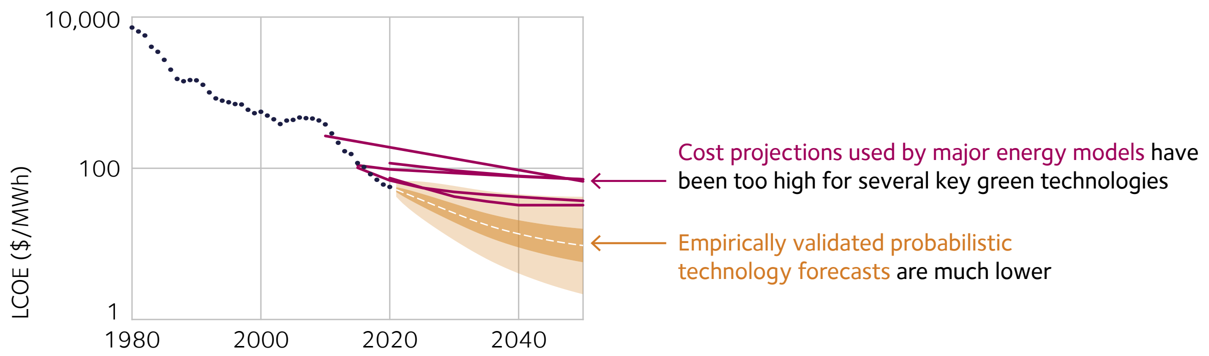
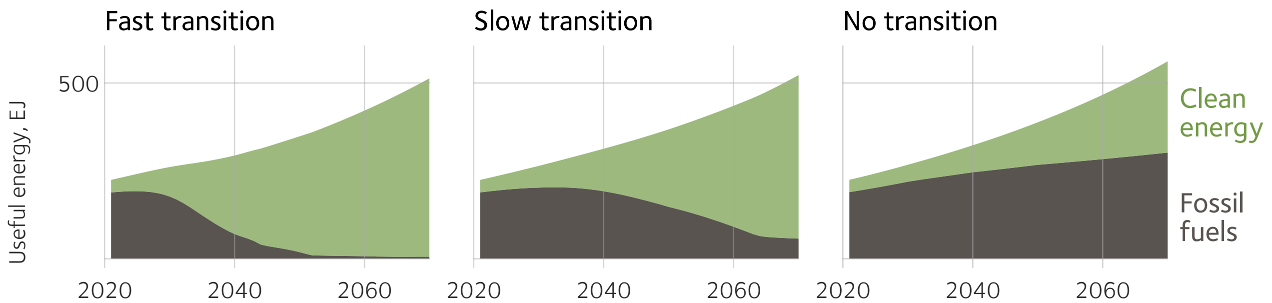


Figure 2: Transition scenarios



c. No transition: The energy system remains similar to its current form for several decades. This is similar to the reference or 'no policy' scenario used by many IAMs.

Key results

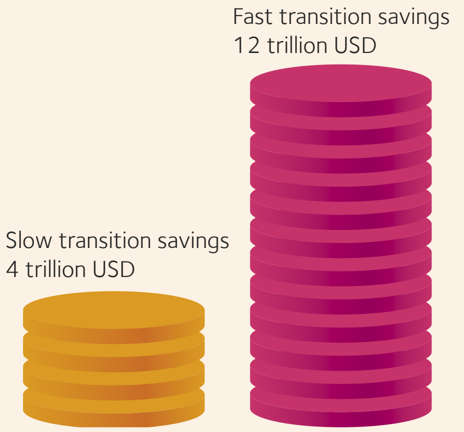


Figure 3a.

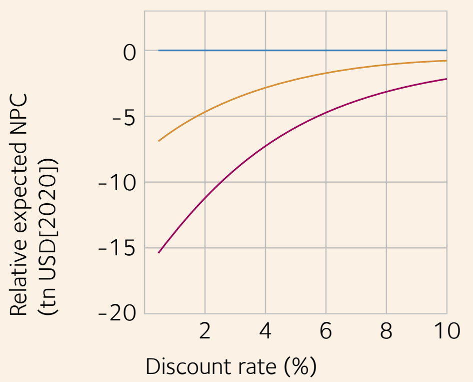


Figure 3b.

- **The fast transition generates an expected net present saving of roughly $12 trillion** compared to no transition, using the Stern Review's recommended 1.4% social discount rate (Figure 3a).[2]
- The fast transition is expected to **raise future GDP** since total energy system expenditures are reduced compared to no transition, as the associated green infrastructure costs are more than offset by fast-forwarding to lower renewable energy costs.
- The fast transition is forecast to be **cheaper at all reasonable discount rates** (Figure 3b).
- A fast transition is expected to **save $8 trillion more than a slow transition** because the savings from clean energy technologies are realised much sooner (Figure 3a).

A conservative estimate: This analysis uses consistently pessimistic assumptions regarding the costs, performance and requirements of clean energy technologies, and consistently optimistic assumptions for fossil fuels. Because we restricted our modelling to technologies whose costs could be firmly grounded in historical data, the results do not factor in promising innovations which will likely further reduce clean energy costs, such as heat pumps and demand-side management of power grids. As a result, we think it likely that the savings actually achieved by a fast transition would exceed the estimates presented here.

Enough storage to comfortably tackle intermittency: The Fast Transition scenario allocates enough storage capacity – using batteries and power-to-X fuels (e.g., green hydrogen) – to run the entire global energy system for a month without any sun or wind. This is now economically feasible because, like other key clean technologies, both batteries and electrolysers have seen large cost reductions – reductions that our forecasts show are likely to continue.

Minimal asset stranding: With the right policies in place, a fast clean energy transition can be achieved with very little need to decommission fossil fuel infrastructure before the end of its useful life. In an average year, energy demand grows by around 2% and 2%-4% of large energy infrastructure capacity needs replacing.

2 Stern, N. (2007). The Economics of Climate Change: the Stern Review (Cambridge University Press).

This means that key clean technologies can replace virtually the entire existing energy system in around 20 years provided all new energy infrastructure built going forward is clean. The remaining 5% of the energy system can be decarbonised over the following three decades with very few fossil fuel assets left 'stranded' by the transition.

Enormous wider benefits: The net savings offered by a fast transition make it economically worthwhile even in the absence of global warming. Factoring in the climate crisis, its benefits become overwhelming. By preventing the worst of climate breakdown, it would save millions of lives and an estimated $88-775 trillion in avoided damages.[3] In addition, a clean energy system will improve energy security, reduce air pollution, and decrease the volatility of energy prices. For developing countries dependent on fossil fuel imports with volatile prices, lower cost, secure, predictable energy will reduce both energy poverty and macroeconomic uncertainty.

3 At a discount rate of 1.4%. A recent study found climate change would cause 83 million excess deaths by 2100 without decarbonisation: Bressler, R.D. The mortality cost of carbon. Nat Commun 12, 4467 (2021).

Summary

- As clean energy deployment grows, the "learning effect" drives their costs down; the faster we drive this technological revolution, the sooner we will unlock large savings.
- Our empirically proven methods show the immense benefits of a clean energy economy. Previous models significantly underestimated clean energy cost declines, providing poor guidance to policymakers and the private sector, and creating a mistaken belief that a shift to clean energy would have negative economic impacts.
- Achieving a fast clean energy transition will require strong national and international policies for building infrastructure, skills, and mobilizing investment. But these policies will pay for themselves over and over in terms of the social, economic, and environmental gains they would bring.

Read the full research: Empirically grounded technology forecasts and the energy transition. Rupert Way, Matthew C. Ives, Penny Mealy, J. Doyne Farmer. 2022. *Joule*, 6 (9): 2057-2082. doi: 10.1016/j.joule.2022.08.009

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