Economic modelling fit for the demands of energy decision makers

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Summary

Decision-makers need sector-specific, policy-focused, dynamic economic models with rich representations of technological progress. These allow them to understand how the energy transition is likely to unfold with different policies and what its impacts might be. A new generation of models are emerging to meet these demands, but more action is needed.

Main text

Over the last fifteen years there has been an important but underappreciated change in the needs of decision makers working on the energy transition. In public policy, this shift has been from wanting to understand whether and how much to act on climate change and debating carbon pricing, towards needing to understand how to implement effective, sector-focused and economically-beneficial energy transition policies[1,2]. As energy and climate have become recognised as issues relevant across all parts of government, international networks have been created to build capacity (e.g. the Coalition of Finance Ministers for Climate Action, the NDC Partnership, and many others).

In industry, the same shift has been occurring, from businesses considering climate change as

an issue of corporate social responsibility (at best), to firms understanding the need to make strategic decisions to position their business for success as the energy transition reshapes global markets and supply chains[3]. Similarly, investors have gone from ignoring the potential of the energy transition in the early 2000s, to needing to understand their exposure to climate and transition risks[4].

Economic modelling is not keeping up with these shifting needs. Large policy developments, such as the Inflation Reduction Act in the US, are moving beyond the advice of narrowly conceived cost-benefit analysis. Without the economic analytical capacity to match, we risk undermining this increased policy and industrial ambition, instead of using it to achieve rapid structural change in the energy system.

Models fit for shifting decision needs

The most high-profile climate-energy-economy models over the last twenty years - the integrated assessment models (IAMs) used by the IPCC - are excellent tools for exploring aspirational pathways that meet energy and climate targets. They have been instrumental in meeting the earlier needs of decision makers to make the case for climate action. Since they are often relatively aggregated optimisation models, especially in their representation of economic systems, they are much less well-suited to current needs. In all but a few cases, optimisation models struggle to help decision makers understand the likely efficacy and impact of a proposed policy, and aggregated models cannot represent sectors or energy policies in great detail[5]. Different models are needed for assessing the likely effectiveness and multidimensional impacts (positive or negative) of specific energy policies and instruments beyond carbon pricing.

In the last five years, a new cohort of models have emerged that are better suited to meet these needs. These models, taken as a whole, incorporate greater regional, sectoral, technology, and policy instrument granularity, though no model does this all at once. They include, but are not limited to, macroeconomic disequilibrium models such as E3ME-FTT and its technology dynamics and finance extensions[6], new IAMs[7], empirically grounded technology cost forecasts[8], and data-driven agent-based models (ABMs) of the labour market[9] or the broader economy[10].

These models typically leave behind the constraints of optimisation, equilibrium, and aggregation, but retain a pragmatic hold on their role in policy. These are not models designed by academics for academics, but rather models designed at the science-policy interface, for use in real decisions. The demand for these models is clearly coming from decision makers[11] and their adoption is growing fast (for example, in the World Bank, Bank of England, and European Commission).

There is still much to be done to advance both greater adoption and influence of these models, as well as their methodological improvement. But the direction of travel is clear. Policymakers need climate-energy-economy modelling which can represent multiple economic sectors and their interaction, as well as diverse individual policies and their implementation in detail, not through just one parameter of carbon price. They need models which represent technological progress in empirically validated ways, for different technologies, components, and contexts. And lastly, they need models that can simulate the economy as dynamic and evolving, capture irreversible

transformational change, and which better explain the connection between low-carbon technological progress and economic transformation and growth.

Some of these capabilities are better served than others and few models meet them all. Some optimisation and IPCC models meet one or two of these capabilities, most notably models with a well developed energy system component which can have high policy detail. Since no one model or approach can suit all policy needs, methodological diversity, comparison and combination, and variety of use for different purposes is critical.

Moving forward

Decision makers working on the energy transition are increasingly moving ahead of standard economic analysis. In examples such as the Energiewende in Germany, solar support in China, LED lighting and electric buses in India, offshore wind policy in the UK, and the Inflation Reduction Act in the US, learning from experience and intuition has trumped earlier economic advice that didn't capture longer-term strategic (and ultimately economic) considerations. Standard economic analysis assumes, and works best where, policy impact is marginal. That is, when it does not transform the markets and sectors it affects, or the wider economy. In the context of energy policy and the transition, where transformational change is being sought to address the climate crisis, this assumption of marginal change does not hold.

It is vital that modellers, and research more broadly, responds. We need to improve the new cohort of models so that they catch up with, and inform, these types of decisions. Without modelling fit for these decisions, policy will go ahead anyway, but it will be less well designed and targeted. Policy interactions and novel types of policy instruments, where we don't have past experience, will also not be able to be assessed. This is a race against time, as the energy transition unfolds and climate targets become ever more pressing. In this context, the development of this new cohort of models and their successors will involve a range of activities by modellers, funders, governments, and international organisations. These include embedding models in the policy process, investment, new data collection, going beyond cost-benefit analysis, and doing this all in a rapid and targeted way.

Capturing learning and socialising models

As use of these models expands, we need to learn more from their use, continuously improve their usability, and articulate their theory of change and value better. We also need to to socialise models (i.e. help decision makers understand their pros and cons, core functionality, and most important assumptions). Only with this learning and socialisation, will we successfully incorporate them into decision making.

This is easy to say, but hard to do. It will involve deep collaboration between modellers and decision makers to design models to address specific policy questions, and to update or replace them when the questions change. It will require the involvement of more science-policy specialists, acting as the 'cartilage in the joint' between modelling and energy policy. The equivalent developments with traditional IAMs happened organically and before developments in reflexive understanding of how models and evidence are used in the policy process. We need to

learn from past experiences and build reflection and learning into this new cohort of models.

Investing in modelling teams

Modelling communities need to maintain the capacity to deliver on decision makers' needs rapidly. This costs money. Funding has thus far been patched together (often in university contexts) from a variety of sources including internal university resources, research councils, philanthropists, private actors, and consultancy. Funding has not tended to be stable or large-scale, meaning that capacity issues can and do arise. Teams need to be large enough such that their capacity does not become the block on the use of models. This does not mean just a few very large teams. An ecosystem with variety in team sizes needs to be created; multiple models (and thus multiple teams) should be developed rather than putting all our eggs in one or two baskets. Teams should be geographically dispersed, not all in Europe and North America. Investments in teams should be tied to policy cycles with use of models baked into funding plans[12].

Collecting data

Data to underpin and validate disaggregated models is often a blocker to their use, especially in developing countries. There is a very real risk of this reinforcing inequalities and justice issues around energy policy. Investment is needed in data collection and sharing to fix this. Here, we are referring to data on financial, technological, and adoption aspects of the transition, along with greater granularity by region and population segments, among other dimensions. The shifts in the use of data in macroeconomics more broadly have been rapid in recent years, and further investment will build directly on this, going deeper in terms of geographical coverage and disaggregation. These types of data will have much value beyond the immediate modelling uses envisaged here. This means investment in data should be a pooled effort, organised around a wide selection of analytical and administrative needs, so long as this does not slow progress.

Moving beyond narrow cost-benefit analysis

This is not just about individual models. The ill-fitting nature of cost-benefit analysis for energy and climate-related investment decisions is increasingly clear. When applied narrowly, cost-benefit analysis overestimates the costs, and underestimates the benefits of climate action[13]. We need broader and dynamically-literate alternatives since the energy transition will have such wide-reaching impacts on the economy.

Developing these involves learning from the successes of the past where decisions went against standard economic advice. For example, through the 2000s, and as late as 2014, most economic assessments suggested policy support for solar PV was a waste of public money based on cost. However, unusual environmental politics in Germany (which had developed over previous decades as a result of oil shocks, acid rain, and Chernobyl) meant that early investment in solar was made on political and strategic grounds, despite the economic advice[14]. This then laid the ground for the Energiewende in 2010. These developments also had knock-on effects in China, where investments in solar production were made based on this foreign demand, despite a lack of domestic solar PV use in China at the time[14]. These dynamic chains of impact cannot be

captured by standard cost-benefit analysis.

Alternative decision-making frameworks are here already, but in various stages of development and use. Arguably most developed is the European Commission's large investments in multidimensional policy appraisal, which feeds into action such as the European Green Deal. At the other end of the spectrum, Risk-Opportunity Analysis[15], a generalisation of cost-benefit analysis appropriate for situations of uncertainty, heterogeneous interests, and non-marginal change, has also emerged. However, it requires further development, and most importantly needs to be deployed repeatedly in practice with learning built-in.

Supporting rapid development for near term targets

Historically, model development has been a time consuming process. However, decision makers, the energy transition, and the climate, can't wait fifteen years for this new cohort of models to be fully established, endlessly tested, socialised, and backed by large well-funded teams.

This means we need to ramp up efforts for new models in parallel to existing analysis with established models, and not see it as an either-or competition between the two. Time is of the essence, so we must be selective, picking the most compelling places and topics to focus this new modelling on. That is, on the big emitters, big industrial sectors, the most complex and interrelated policy areas, such as steel, hydrogen, transport, and agriculture. Established modelling communities in the Global North must partner with analysts in countries such as China, India, Brazil, and Indonesia. Efforts must be more targeted, reflecting not only the nature of the models and decision makers' needs, but also the need to develop new capabilities in the presence of path dependencies in existing modelling infrastructures.

This call for increased effort in new economic modelling, data collection, and decision frameworks might feel far removed from real action. However, we believe it is one of the best ways to influence the energy transition and global emissions. Just as a change in policy can influence many investments, a change in economic thinking and analysis can influence many policies. Decision makers are demanding better tools for the decisions they are making right now. It is up to modelling communities, funders, and policy makers working in these spaces to respond and deliver.

Competing interests

The authors declare no competing interests.

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