A Framework for Reinventing the Energy Modelling-Policy Interface

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Standfirst

Energy modelling has a crucial underpinning role for policy making, but the modelling-policy interface currently faces several limitations. Therefore a reinvention of this energy modelling-policy interface is detailed to better provide timely, targeted, tested, transparent and iterated insights from such complex multidisciplinary tools.

Energy models provide the integrating framework that assists energy policy and industrial energy decision makers. By applying data to a coherent theoretical structure and using computer modelling software, they provide essential quantitative insights into alternative energy system design under conditions of pervasive uncertainty.

The underpinning policy role of energy modelling occurs through the most widely quoted international reviews[1], through the statutory policy assessment processes in major economies[2], and for energy balances and long term investment planning in less developed economies.[3]

Importance of energy modelling in the policy evidence base

There are a broad set of viewpoints on the overall role of modelling in the policy process. Social science commentators[4] classify at what stages in the policy process (advisory, discussion, participatory, mediation, strategic, analytical) modelling can contribute[5]. Other policy commentators focus on the experts themselves (including modellers), as well as on the importance of transparency and interdisciplinarity[6], and on the high level of complexity in policy insights that decision makers require[7].

Energy modellers' self-examination of the policy role of their tools is more circumspect. Some reviews of the typology of models suggest better links between them are needed.[8] Only a relatively small set of ex-post studies[9] attempt to assess the accuracy of prior modelling exercises. Those studies that actually examine the energy policy-modelling interface acknowledge the weak links between provision of insights and policy-maker needs, focusing on the imperfect process of policy making[10] or the specific policy requirements (and limited analytical capacity) of developing countries.[11]

Similar limitations in the successful engagement of models with policy makers are raised in related fields, notably water resources[12] and ecosystem management.[13] Looking beyond environmental issues, the modelling-policy reinvention improvements proposed here are consistent with recommendations in other policy fields such as public health.[14]

This Comment builds on past observations and proposes key elements for an ordered reinvention – through Enabling, Coordination, Review and Transparency – of the energy modelling-policy interface to provide timely, targeted, transparent and iterated insights.

Category	**Current Limitation**	**Proposed Improvement**
Enabling	Uneven path dependant development	Coupling to funding and policy cycles
Coordination	Incumbency advantage	Platform based expert user groups
Review	Modelling silos	Interdisciplinary external stakeholder review
Transparency	Lacking incentives for quality assurance, version control and documentation	Targeted resourcing for these model process tasks

Table 1: Key reinvention elements of the energy modelling-policy interface

Current practices

With a great deal of diligence, the majority of current energy modelling initiatives aim to provide the evidence base for public and private decision-making. However, patterns of developing, applying and communicating energy models have been incentivised and then become ingrained which may inhibit the resolution of key policy questions and controversies. We identify and discuss below four key limitations, summarised in Table 1.

First, energy models are generally developed in an uneven path-dependent process, with a mismatch between the long development cycles of models, and the short-term nature of the policy process, which is often focused on specific topical issues. “Archaeology” of model development[15] finds a tendency towards uneven balance in the detail of model elements, a lag in model documentation, review and testing, and a trend toward increasing complexity – very rarely is model detail removed in subsequent versions. This potential mismatch is exacerbated by the difficulty of modellers – especially those in academia or consulting whose model development is based on a series of projects – to engage in model exploration in areas outside the remit of current funding opportunities.

Second, established energy models enjoy considerable incumbency advantages. Models that are successful in high profile use can become long-lived and dominant in a “winner takes all” process – for example the NEMS[2] and the PRIMES[16] model have long been core tools for the USA and EU governments. Similarly, the core integrated assessment models (IAMs) in the IPCC’s 5th Assessment Report[17], derive from large and well-established institutional modelling teams. Such a winner-takes-all model development raises the entry bar for competing groups and also risks that the wrong modelling approach – but one that is tried and tested – is used for new policy questions.

Incumbent model advantage also spurs greater complexity, as these models need to include new features to retain their status as the leading tools. For example IAMs now need to include all greenhouse gases and emissions from land-use (even if these are only described in aggregate), while electricity dispatch models now need a very fine temporal scale even at the risk of high computational requirements. Model complexity further raises the barriers to reviewing and understanding models – well beyond the constraints of a typical journal paper.

Third, silos are built up around different modelling approaches. These silos of modellers – for example IAMs, energy system optimization models (ESOMs), systems dynamics, computable general equilibrium (CGEs), electricity dispatch, transport discrete choice, building stock, agent based models (ABMs) – form their own professional networks, attend specific conferences, publish in a core set of journals, and utilize different data banks (e.g. CGE modellers and the GTAP initiative[18]).

A real danger in silo model development is the lack of insights from outside a core modelling community, and particularly not from the wider set of modelling expertise in government, business and consulting. Modelling comparisons[19] are a hugely useful exercise that many modellers do, but they can lead to convergence as all teams are looking to be in the median of model outcomes, with those with outlier results dismissed too soon.[20]

Fourth, incentives for quality assurance, version control and documentation are lacking. Generally there is little funding, time or kudos for unglamorous model maintenance tasks. This is driven by intermittent funding streams (especially for model documentation and quality assurance), partly by the need for models to continually generate income and outputs (especially in non-academic settings), and partly due to turnover rates of highly trained researchers.[21]

Why do these four shortcomings in current practices matter? Policy makers continue to struggle to assess insights from competing models that give alternate findings, or respond when different commentators interpret results to support their arguments. These controversies will only increase as energy policy issues – such as decarbonisation – move from target setting to impacts on specific (incumbent) industries, social groups, and regions. Another key shortcoming is that most energy models generally remain some distance from the scientific standard of replicable and verifiable results. Lastly, energy models fall far short of best practice in software development, and are inconsistent with the open access movement from publically funded research.

Moving forward

The solution is not simply improved or better-linked models, nor is it solely improved communication of model outputs.[22] Instead we propose a structured reinvention of the energy modelling process for a truly iterative modelling-policy interface. Table 1 summarizes the limitations discussed above, and suggests improvements to each. Figure 1 then illustrates our idealised energy modelling-policy interface. The overall focus is on a tight coupling between model developers and funders, policy makers, other expert modellers, and broader stakeholders. These interactions form fully iterative feedback loops across development, calibration, testing, application and quality assurance. The four key elements to this modelling-policy reinvention can be categorised as: enabling (coupling model development to funding and policy cycles); coordination (an expert user group based on a modelling platform); review (interdisciplinary external review by wider stakeholders); and transparency (quality assurance, version control and documentation).

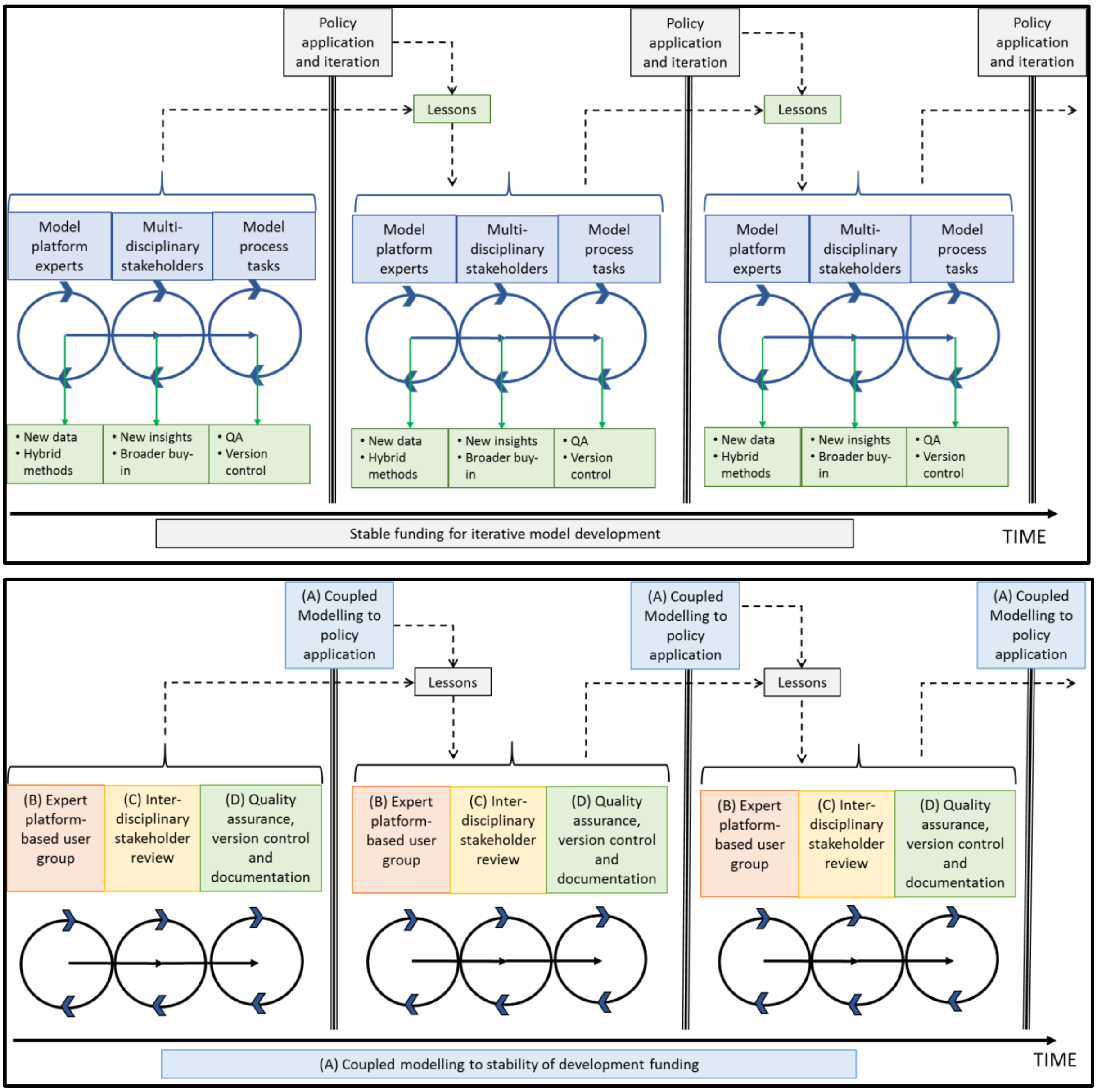

Figure 1: Idealised energy modelling-policy interface with full iterative feedbacks

Figure caption: A best-practice modelling policy interface would capture insights from (B) an expert user group based on a modelling platform; (C) interdisciplinary external review by wider stakeholders; (D) comprehensive quality assurance, version control and documentation, and feed these into future model improvements and application via (A) coupling model development to funding and policy cycles

Coupling model development to funding and policy cycles

This an enabling condition avoids an uneven path-dependent model development process. Coupling means firstly active and sustained cooperation between modellers and technically literate policy makers. This has been recognised in some countries already. For example in the UK there has been a decadal collaboration[23] between the Department of Energy and Climate Change (DECC) and the energy modelling team at University College London. DECC has prioritised development of in-house modelling expertise to enable stability of access to a set of models during a critical policy period (the setting and implementation of long-term climate mitigation targets), in an attempt to reduce short termism in model construction and development. Furthermore it gives technical policy makers a clear appreciation in the "art" of energy modelling – the human element in designing, formulating and interpreting the outputs of large complex models.

The second strand in this coupling process is to ensure policy engagement is recognised and rewarded by funders. In the UK, steps are being made in this direction with the explicit category of "impact" being given greater weight by the UK Research Councils in proposal peer review and by the Higher Education Funding Council for England (HEFCE) in the 7-yearly Research Excellence Framework (REF) process. In Portugal, successive policy contributions of energy modelling to national and EU legislative rounds was only made possible through the foresight of funding a standing team of independent modelling researchers.[24]

An expert user group based on a modelling platform

This coordination condition alleviates having a narrow field of modelling experts, tied to a single model, and overburdened with model tasks. Moving from single-institution and single-models to an expert user group on a broader modelling platform has a range of critical advantages. It spreads the load in the maintenance and updating of complex tools, and helps alleviate the practical difficulties of high turnover rates of technical modelling staff in academia (including PhD students) and in consulting. An expert user group can interject new software and new data into the model development process. Excitingly, policy makers can tap into a deeper institutional memory, and a more complete range of energy modelling expertise (including academia, national institutions, consultancies and individual firms' modelling teams).

A platform-based expert user group for energy models has traction across many types of models, with examples including globally led ESOMs (e.g., ETSAP-TIMES), USA-based IAMs (e.g., GCAM), accounting tools for developing countries (e.g. LEAP) and commercial electricity dispatch tools (e.g., Plexos).

Sustaining a platform-based expert modelling group can be problematic, given the imbalance of expertise between contributing teams, and the lack of managerial oversight across institutions. Collaboration downsides include the potential loss of upfront modelling intellectual property, the potential loss of (monopolistic) research income streams, the difficulties of sharing novel publications, and free-riding in the maintenance and documentation of models. Mechanisms to alleviate these issues include joint funding of a "gatekeeper", that is, a modeller tasked to manage model development, incentives to maintain only one core model version (e.g., DECC requires different practitioners to use the latest ESOM version for official UK policy projects), and visibility to peers and clients.

Interdisciplinary external review by wider stakeholders

This a review condition enables authoritative and truly multi-disciplinary energy modelling. A broad engagement is highly productive, merging modelling teams with strengths in cutting edge theoretical and analytical techniques, with stakeholders better versed on the realism of current policy implementation, market structures and societal responses (e.g., as highlighted in the conference reports of the wholeSEM (www.wholeSEM.ac.uk) interdisciplinary modelling initiatives). In a further example, stakeholder engagement helped the Irish ESOM team access expertise and data in broader agriculture and land-use emissions – a critical economic sector for Ireland.[24]

Such an engagement is typically coordinated via a dedicated online portal married to a systematic and ongoing series of stakeholder events. This ties in with efforts to develop open source energy models such as OSeMOSYS[25], and wider initiatives to spur transparency in energy models (e.g., http://openmod-initiative.org/) which are increasingly gathering pace. Ultimately, this can include the revamping, simplification and even termination of models that have become outdated.

Multidisciplinary critiques can break through methodological silos, and ensure model insights are what is needed for current and future decision making. An expert stakeholder group can also help government modellers maintain a consistent and rigorous framing as the political winds ebb and flow.

Quality assurance, version control and documentation

This transparency condition ensures that energy modelling meets the highest scientific and technical standards. Calls for improved quality assurance (QA), version control and documentation[26] have been made to ensure that energy modelling meets levels of transparency and replicability that other academic fields demand and which energy modelling has traditionally not met. Such a goal is a fundamental requirement.

The nature of many energy models; in terms of their analytical complexity, size of data-sets required, and the limited value in calibration to past trends for models that operate in exploratory mode over long horizons, make this a non-trivial task. But policy makers now demand high standards of QA; for example, the UK Government now has clear cross-departmental guidance[27] on the required QA processes for quantitative policy analysis. Energy modelling teams must be sufficiently resourced for these somewhat unglamorous model maintenance tasks, with decision makers and funders cognizant of minimum thresholds of rigour and transparency for models to be applied to policy questions.

In summary, this Comment has argued that aligning funding and policy cycles with energy model development, establishing a coordinated expert user group, ensuring model review by a broad range of stakeholders, and devoting efforts to quality assurance; can lessen the currently observed limitations in terms of path-dependent model development, incumbency advantages, a lack of interdisciplinarity, and only partial transparency. Such a reinvention of the modelling-policy interface (as in Figure 1) brings us full circle to collaborative iterations with policy makers, funders, expert modellers and wider stakeholders, to better provide timely, targeted, tested, transparent and iterated insights from such complex multidisciplinary tools.

References

1. IEA (2015). World Energy Outlook 2015, International Energy Agency, available at www.worldenergyoutlook.org
2. EIA (2015). Analysis of the Impacts of the Clean Power Plan, US Department of Energy, Energy Information Administration, available at: www.eia.gov/analysis/requests/powerplants/cleanplan
3. World Bank (2015). Climate Smart Planning Platform, available at: www.climatesmartplanning.org/tools
4. Mayer, I., et al. (2004). Perspectives on policy analyses: a framework for understanding and design. International Journal of Technology, Policy and Management 4(2): 169-190.

5. Yücel, G. and van Daalen, E. (2009). An Objective-Based Perspective on Assessment of Model-Supported Policy Processes, Journal of Artificial Societies and Social Simulation 12 (4) 3.
6. Spruijt, P., et al. (2014). Roles of scientists as policy advisers on complex issues: A literature review. Environmental Science & Policy 40: 16-25.
7. Stirling, A. (2010). Keep it complex. Nature 468(7327): 1029-1031.
8. Jebaraj, S. and Iniyan, S. (2006). A review of energy models. Renewable and Sustainable Energy Reviews 10(4): 281-311.
9. Pilavachi, P., et al. (2008). Ex-post evaluation of European energy models. Energy Policy 36(5): 1726-1735.
10. Mundaca, L., et al. (2010). Evaluating energy efficiency policies with energy-economy models. Annual Review of Environment and Resources 35: 305-344
11. Pandey, R. (2002). Energy policy modelling: agenda for developing countries. Energy Policy, 30(2), 97-106.
12. Borowski, I. and Hare, M. (2007). Exploring the gap between water managers and researchers: Difficulties of model-based tools to support practical water management. Water Resources Management 21(7): 1049-1074.
13. Hyder, K., et al. (2015). Making modelling count - increasing the contribution of shelf-seas community and ecosystem models to policy development and management. Marine Policy 61: 291-302.
14. Metcalf, C., et al. (2015). Six challenges in modelling for public health policy. Epidemics 10: 93-96.
15. Dodds, P., et al. (2014). Characterising the Evolution of Energy System Models Using Model Archaeology. Environmental Modeling & Assessment 20(2): 83-102.
16. NTUA (2015). Technical manual and selected applications of the PRIMES model, National Technical University of Athens, available at: http://www.e3mlab.ntua.gr/e3mlab
17. IPCC (2014). 5th Assessment Report on the Mitigation of Climate Change, Intergovernmental Panel on Climate Change, available at: www.mitigation.org
18. GTAP (2015), Global Trade Analysis Project, available at: www.gtap.agecon.purdue.edu/databases/default.asp
19. Edenhofer, O., et al. (2010). The economics of low stabilization: Model comparison of mitigation strategies and costs. The Energy Journal 31(Special issue 1): 11-49.
20. Socolow, R. (2011). High-consequence outcomes and internal disagreements: tell us more, please, Climatic Change (2011) 108: 775-790
21. Strachan, N. (2011). UK energy policy ambition and UK energy modelling—fit for purpose? Energy Policy 39(3): 1037-1040.
22. Upham, P. and Dendler, L. (2015). Scientists as policy actors: A study of the language of biofuel research. Environmental Science & Policy 47: 137-147.
23. Taylor, P. et al. (2014). Energy model, boundary object and societal lens: 35 years of the MARKAL model in the UK. Energy Research & Social Science 4: 32-41.
24. Chiodi, A., et al. (2015). in Informing Energy and Climate Policies Using Energy Systems Models (eds. Giannakidis G., et al). 15-41, Springer
25. Howells, M., et al. (2011). OSeMOSYS: The Open Source Energy Modeling System. Energy Policy 39(10): 5850-5870
26. DeCarolis, J., et al. (2012). The case for repeatable analysis with energy economy optimization models. Energy Economics 34(6): 1845-1853.
27. HMG (2015). The Aqua Book: Guidance on producing quality analysis for government, Her Majesty's Government, London. www.gov.uk/government/publications/the-aqua-book-guidance-on-producing-quality-analysis-for-government