UK ERC
UK Energy Research Centre

Energy Modelling in the UK

Briefing paper 3: Construction, maintenance and transparency

Pei-Hao Li and Neil Strachan

DOI: 10.5286/ukerc.edc.000949

Introduction

Energy models provide the underpinning evidence to support decision makers across policy, industry and civil society to understand strategies and trade-offs in the energy transition. But modelling exists in the "real" world where funding is limited, modellers' time is scarce, and decision makers often need insights delivered quickly. As a result, the construction of models can be an uneven development process with an incumbency advantage, and potential silos to new approaches.[1] The subsequent maintenance of models usually suffers from lack of incentives for quality assurance, version control and documentation. Maintaining models – and improving their transparency – is time-consuming, unglamorous, rarely prioritised by funders, and undervalued in terms of modeller's career progression.

Trust in energy models is essential to encourage both stakeholder participation and wider public engagement for the success of the energy transition. Model transparency is the key to gain public trust[2] as only transparent models can be reviewed and verified[3]. However, energy modellers – certainly in academia but perhaps even more so in Government and consulting – have often struggled to make their models open and accessible. Model transparency is defined by the UKERC Modelling Hub through three increasing levels:

- Open description models: Concise methodological summary, outline documentation and link to outputs and applications
- Open access models: A user group for access and shared responsibility for model development, plus full documentation and data sets
- Open source models: Fully accessible models available for any user to download and use

A better understanding of how energy models are constructed and then maintained can help the discussion of model transparency by identifying opportunities and obstacles. For instance, major funders for model developments can play a key role in transforming the landscape of model transparency by requiring teams to reveal more information of their models. While maintenance costs could be built into projects and hence could ascertain how much effort it takes to make a model open at different level of transparency.

To investigate these critical and interlinked issues of construction, maintenance and transparency, UKERC's Energy Modelling Hub coordinated a ground-breaking survey of all the energy models in the UK. This is advised by a Steering Group of key policy stakeholders.[4] As of 1st April 2021, there are 76 UK energy models reported into our database.[5] This is much more comprehensive than past reviews that relied only on models with accessible published information. But there will still be potential gaps and biases.

1 Strachan N, Fais B, Daly H. Reinventing the energy modelling–policy interface. Nature Energy 2016;1:16012. doi:10.1038/nenergy.2016.12.
2 Jan K. David Mackey and the clever climate calculator. Energy Strategy Reviews 2020;27:100429. doi:10.1016/j.esr.2019.100429.
3 Pfenninger S. Energy scientists must show their workings. Nature 2017;542:393–393. doi:10.1038/542393a.
4 UK Research and Innovation (UKRI), UK Government (BEIS), Scottish Government, Northern Ireland Government, Committee on Climate Change, Energy Systems Catapult, and the National Infrastructure Commission
5 The survey remains open for additional modelling entries, or for updates to existing model entries. Access here

This policy brief (#3) is the third of four from UKERC's Modelling Hub survey. The first brief on the UK energy modelling landscape, detailed the diversity of who hosts and runs models, their methodologies and coverage, and their major outputs. The second brief on the strengths and weaknesses of UK energy models highlighted the inevitable trade-offs in any one model, considering temporal and spatial disaggregation, the coverage of technologies and infrastructures, and the treatment of individual behaviour change and broader societal trends. In this third brief we focus on the findings from the survey that shed light on the construction, maintenance and transparency of UK energy models.

In considering the construction, maintenance and transparency of UK energy models we focus on three key areas:

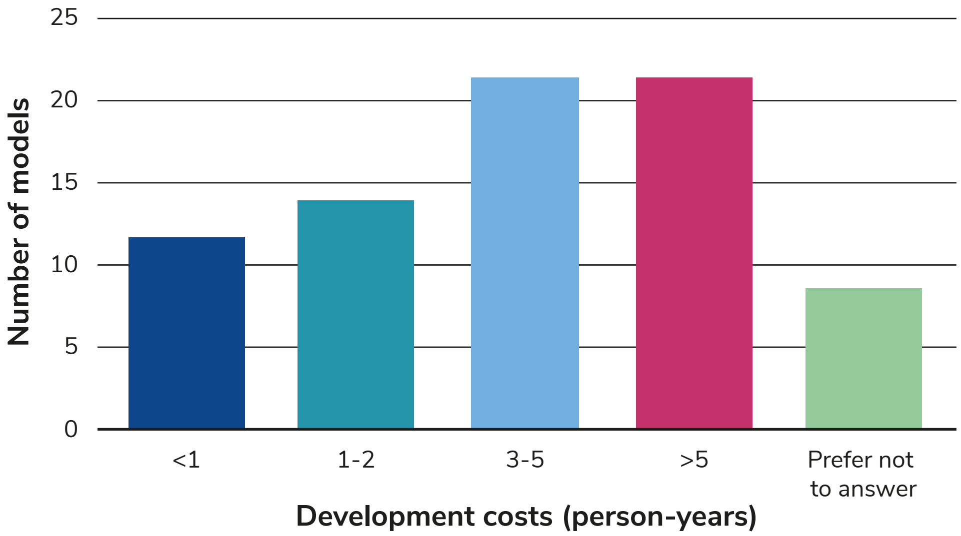
- How the models are constructed; in terms of costs, funding sources, and resulting impacts;
- How the models are maintained; in terms of costs, number of users, and the process of updating models;
- How the models are made open to stakeholders and other modellers; in terms of different transparency levels.

Construction of UK energy models

Firstly, this brief sheds a light on how modelling teams adapt to the "real world" of limited (and highly competitive) funding, when models take significant resources to build and where decision makers often need insights delivered quickly.

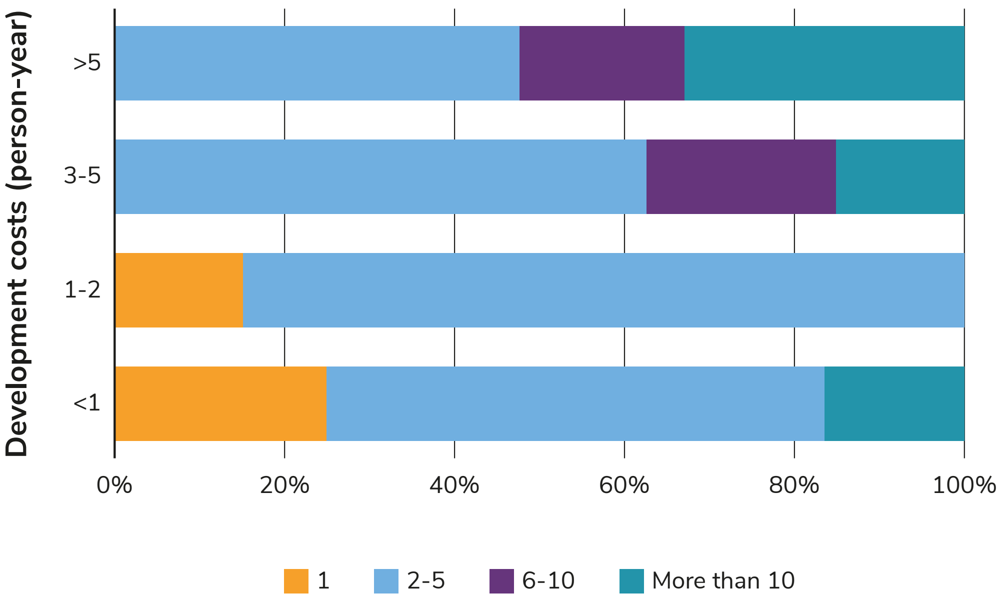
Evidently, energy models are costly to develop, as shown in figure 1. Most models (around 68%) need at least one person-year for development before the models can be functional enough to tackle challenging decision-making issues. In some cases (around 30% of energy models), more than five person-years are required. Given the modest size of UK model teams, the development of new models is a strategic decision.

Figure 1 Development costs of energy models



One way to spread the development costs of new models is to have a set of developers and then users of the model. Irrespective of the costs required for development, two to five modellers are the most likely to use energy models (around 55% of all cases). Intuitively, there are more model users as the development costs becomes higher, as illustrated in figure 2. Models with development costs higher than 5 person-years (around 52% of these models) commonly have more than 6 users. Model teams might intend to gain additional benefits from the investment in costly development by deploying more users to apply their models – notably this allows modellers with different skills and perspectives to contribute to the model.

Figure 2 Number of users for models with different development costs



More expensive models appear to have higher impacts in terms of the number of journal papers and the number of key reports to support policy-making, as shown in figure 3 and figure 4. Model teams are likely to have a clear purpose in the first place for models requiring higher development costs. These models are also more likely to incorporate expert modelling capability to deal with complicated research/policy issues using sufficient development resources. Consequently, the outputs from those models tend to be higher. Of course, a bigger user pool of those models (as shown in figure 2) could also help, while there may be an incumbency advantage of successful models being utilised more and more.

Figure 3 Number of key reports for models with different development costs

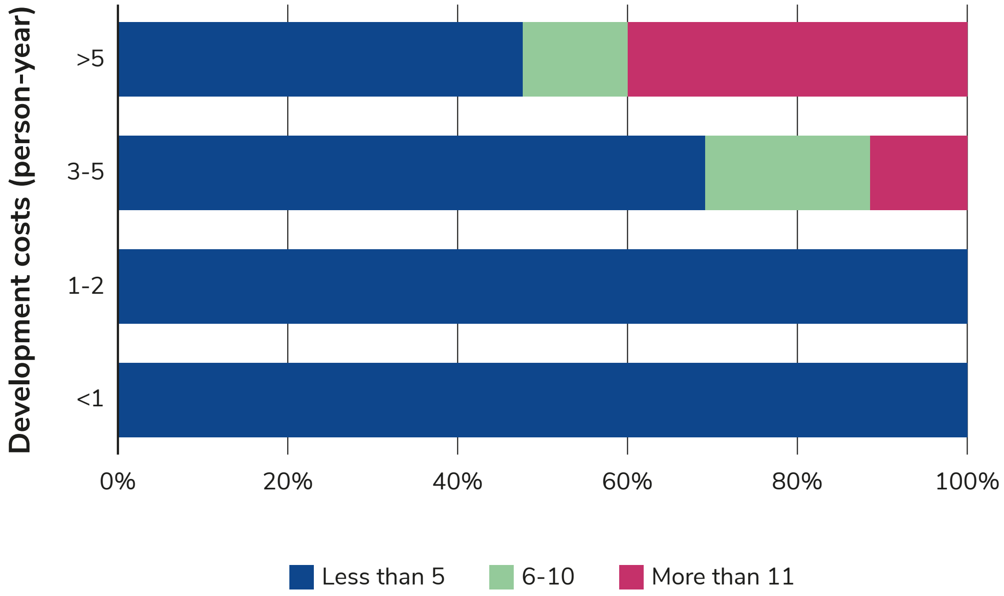
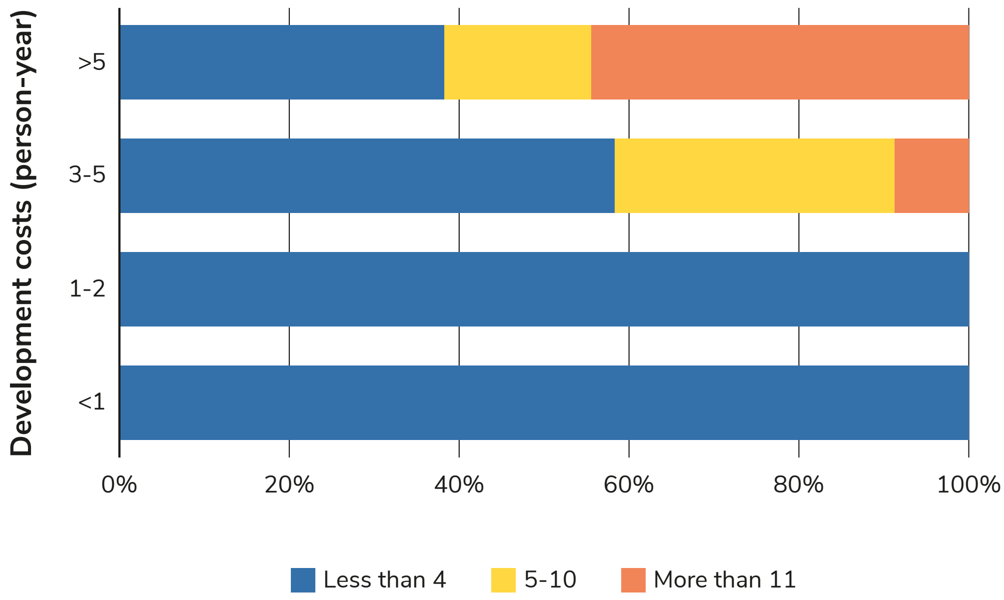
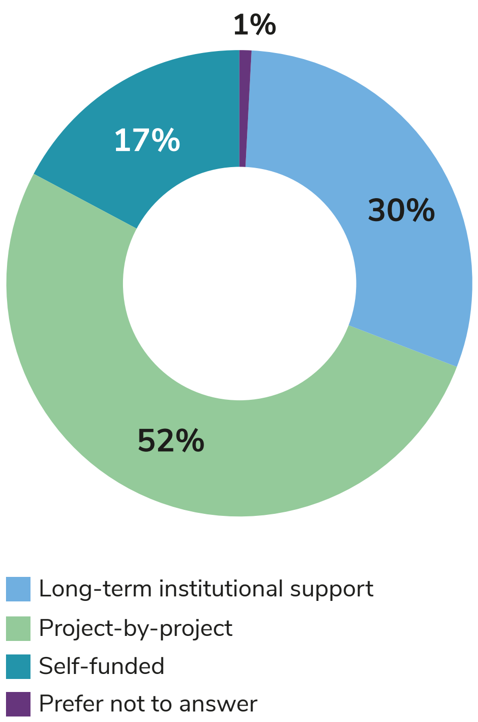


Figure 4 Number of journal papers for models with different development costs



The most common funding structure for the development of UK energy models is on a project-by-project basis (about 52% of the models). This can be a stressful process for modellers to continually seek new projects, but can mean the development of models align with the need to tackle the latest pressing issues (e.g. the move to net zero targets). A flexible and modular framework might help model teams more easily extend the capability of their models in this process. Around 30% of the models benefit from long-term institutional support to assist with institutional missions (e.g., regular forecasts or reports), while the capability of these models might be more specific than those constantly seeking funding from different sources for various applications.

Figure 5 Main type of funding for model development



For models seeking project-based support, UKRI (40%) and UK Government departments (25%) are the two major sources for model developments, as shown in Figure 6. UKRI supports model development in universities while UK Government departments only provide funding to the development of their own models (figure 7).

Consultancy and other organisations have a much tougher development path as they tend to self-fund the development of their models in the first place with only limited support from industry. This is then a bigger risk as they develop models with their own resources for the services they are going to provide. Following this investment, consultancies compete with other modelling organisations for projects from a range of funders to apply their models.

Figure 6 Primary funding source for model development

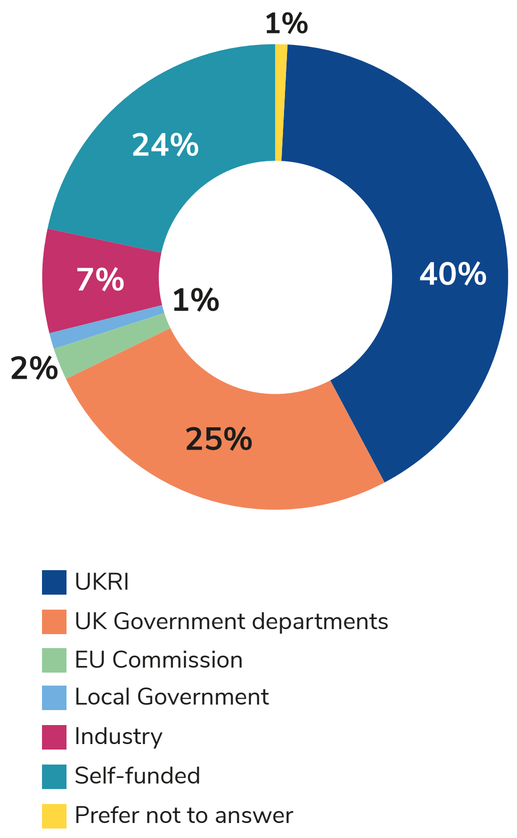
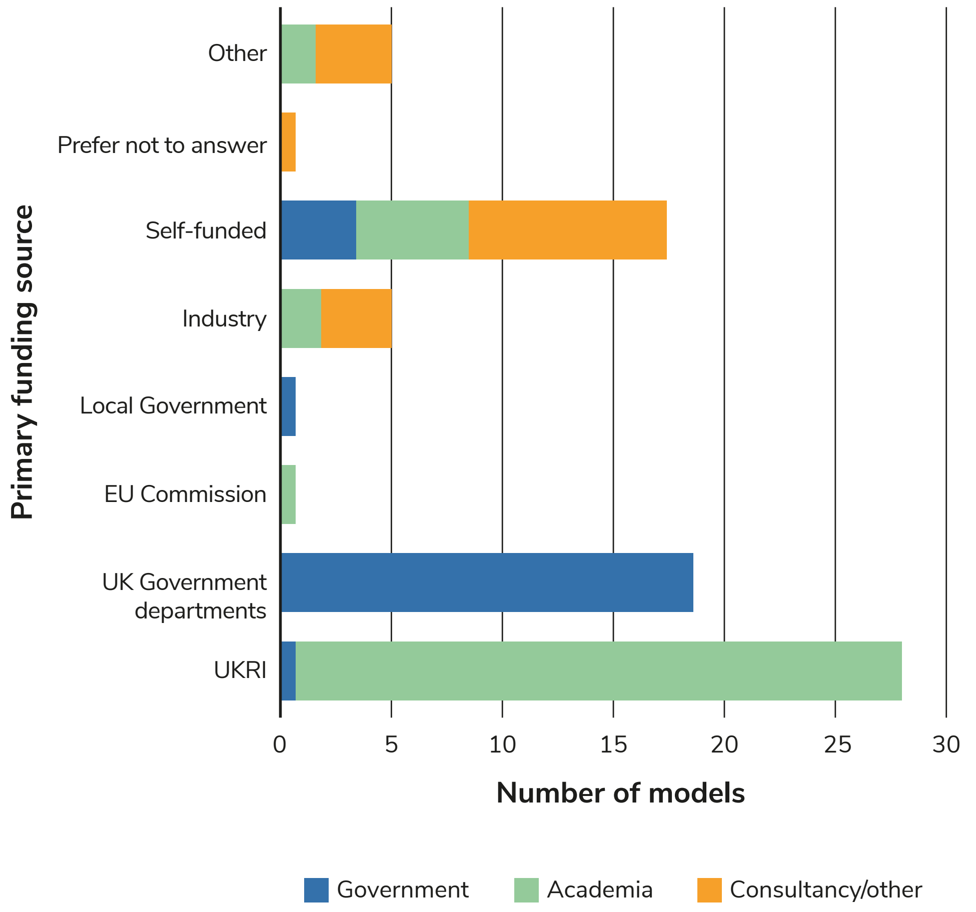


Figure 7 Model development funding sources by organisation type



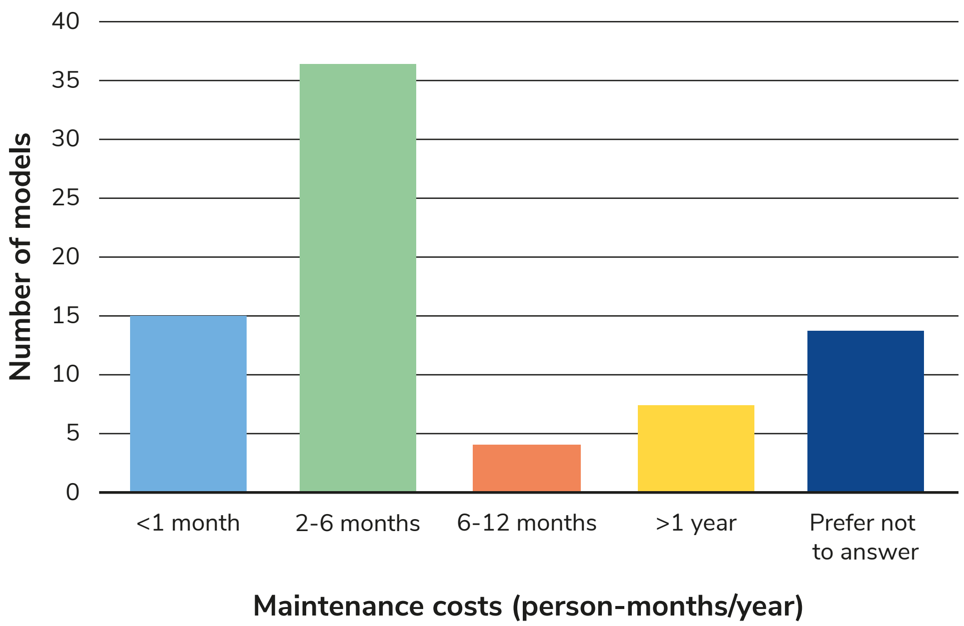
Maintenance of UK energy models

Maintenance of energy models is not a smooth or easy process. Maintaining models is time-consuming, unglamorous, rarely prioritised by funders, and undervalued in terms of modeller's career progression. But it is vital for quality assurance and transparency, while incorporating the most up-to-date data and scientific evidence is important for ensuring the continuing relevance of the model.

However, maintenance of energy models is not cheap. Most energy models (about 76%) require at least 2 person-months each year for maintenance, with 2 to 6 person-months being the most common maintenance effort (figure 8).

About 76% require at least 2 person-months each year for maintenance

Figure 8 Maintenance costs of energy models



Model maintenance costs have positive correlations with development costs and number of developers/users (figure 9 and figure 10). When model teams invest more in model developments, they are also likely to spend more resource to maintain their models to ensure the model is up-to-date for key research or policy applications. It is likely that these models are also larger and/or more complex, hence requiring more maintenance.

Around 50% of the models with development costs of more than five person-years need more than six person-months/year for maintenance. On the other hand, models with lower development costs (less than one person-year) are likely to only need less than one person-month/year to maintain the models (around 67% of those models). Of course, having a broader developer/user base allows maintenance effort to be shared out as shown in figure 10.

Figure 9 Maintenance costs for models with different development costs

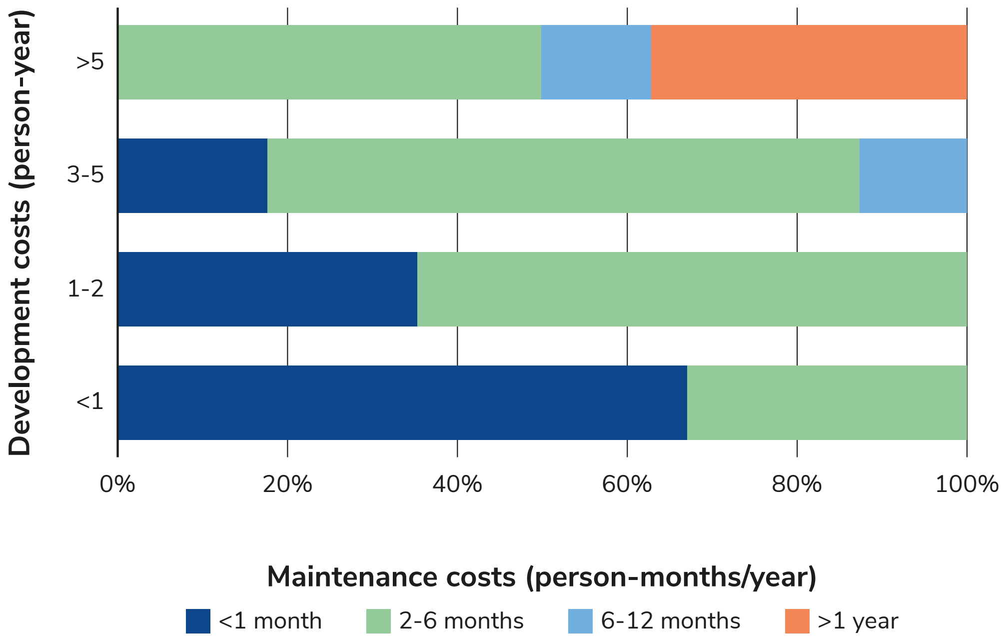
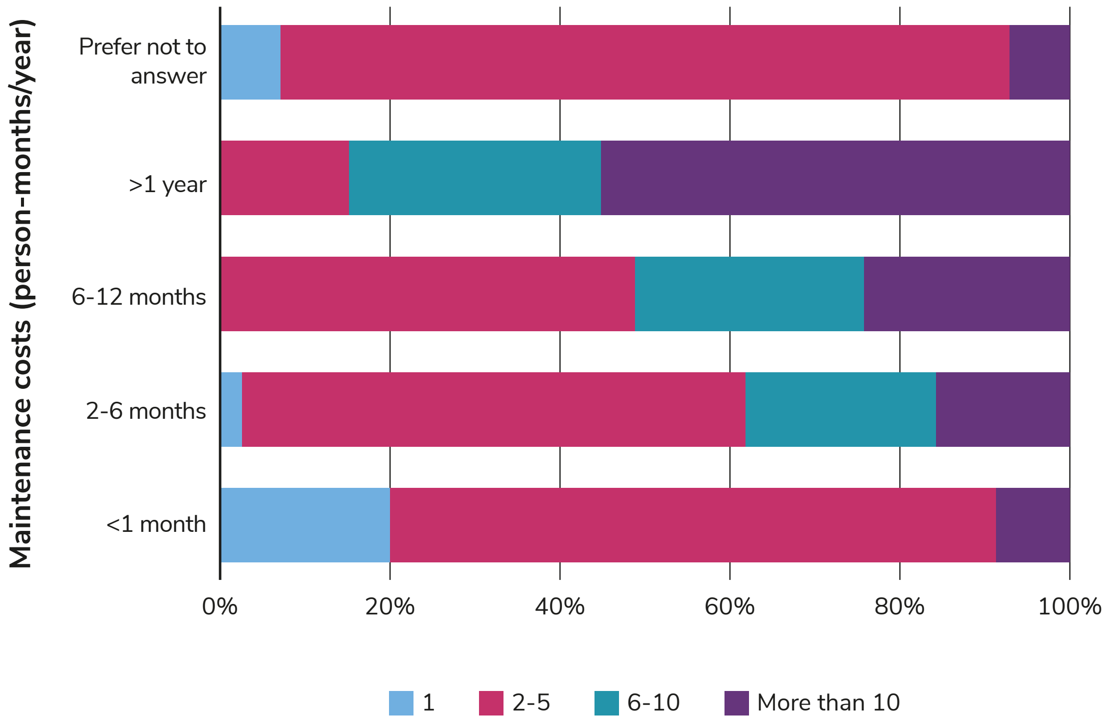


Figure 10 Number of users for models with different maintenance costs



Mirroring the findings on application of models with higher development costs (see figure 3 and figure 4), larger and more complex models that require higher maintenance costs generally have greater outputs (figure 11 and figure 12). Models requiring more than 1 person-year for maintenance are more likely to make higher impacts (83% have more than 10 key reports, and 50% have more than 10 journal papers). Meanwhile, models that are less frequently maintained generally have produced less than five academic outputs or reports to support policy-makings.

Figure 11 Number of key reports for models with different maintenance costs

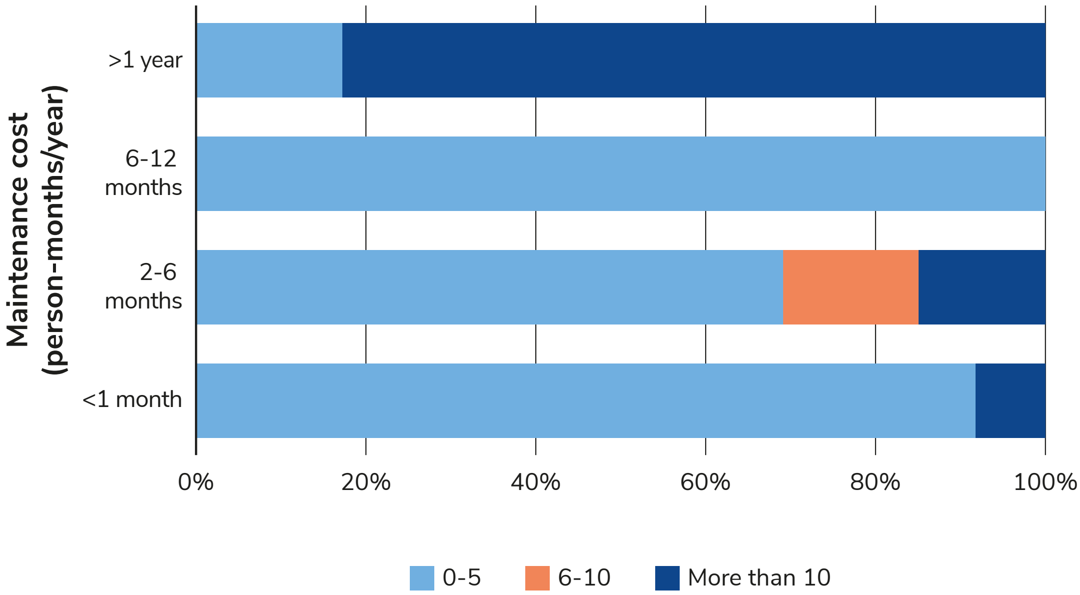
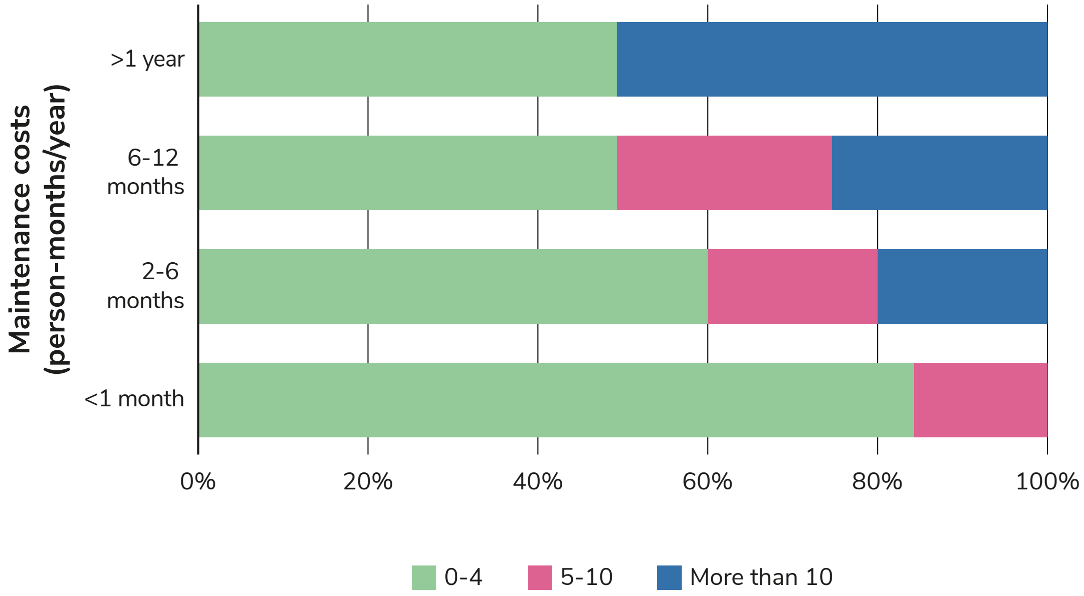
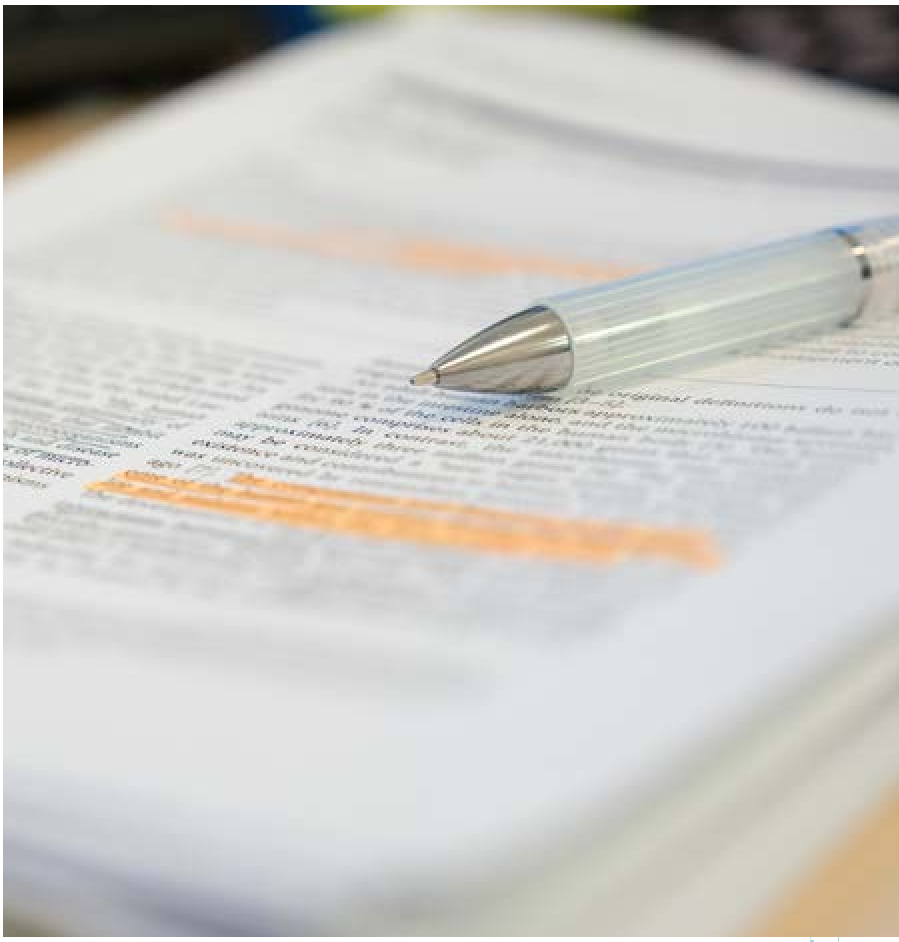


Figure 12 Number of journal papers for models with different maintenance costs

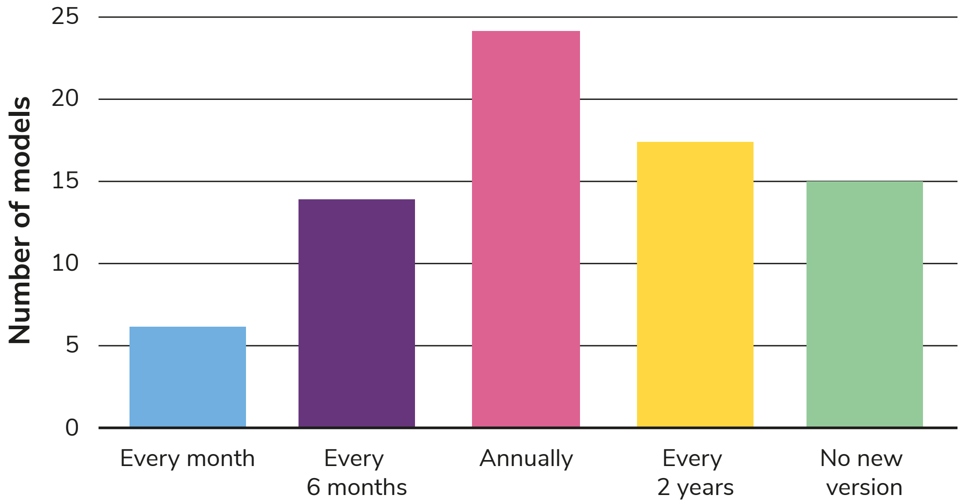


The most common update cycle of energy models (around 32%) is an annual update (figure 13). A few energy models have an extremely short update interval (one month), which could represent newly developed and hence still improving models, or models focused on issues with a rapid turnover of new data. There is no clear linear relationship between the update frequency and the outputs (key reports and journal papers), although annually updated models seem to have better performance in terms of key outputs. Hence the balance between model maintenance and application is a topic for further investigation.



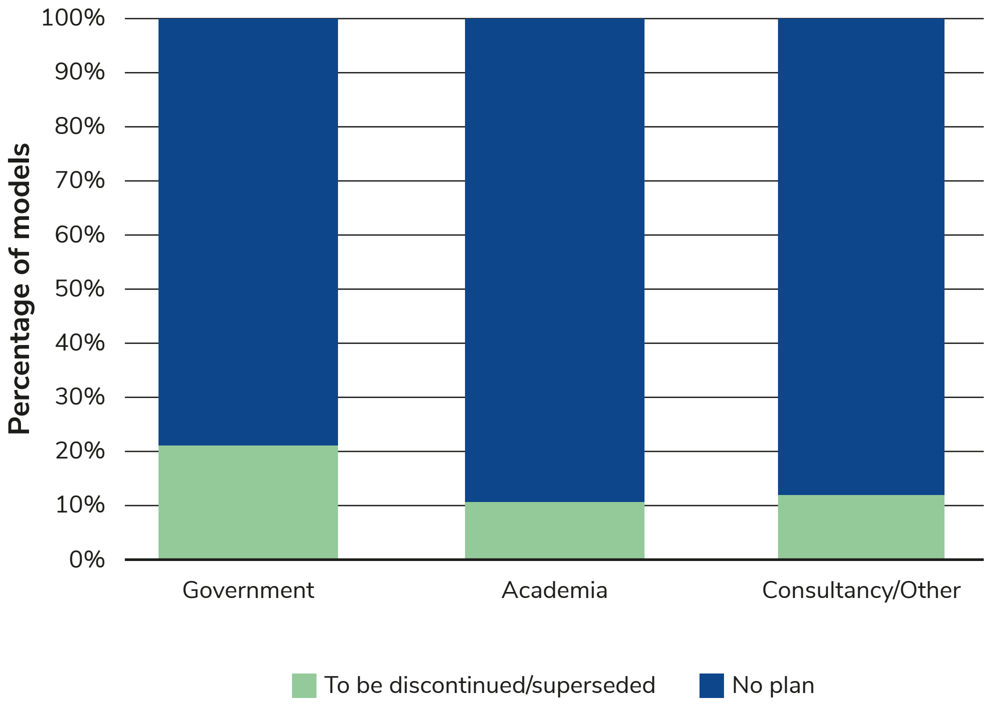
The most common update cycle is annual

Figure 13 Update frequency of energy models



Asking modellers if they will retire their tools is an interesting question as only about 14% of energy models are expected to be discontinued or superseded in the coming years (figure 14). It is entirely possible that this is linked to the difficulties in funding the development of new models. Among all host organisations, Government departments have highest share of models to be replaced (around 22%). This could be due to the gradual shift of policy directions/targets of these organisations, and the original design of those models might no longer fit for the new purposes, or it may be due to greater institutional support for new model development.

Figure 14 Discontinuity of energy models



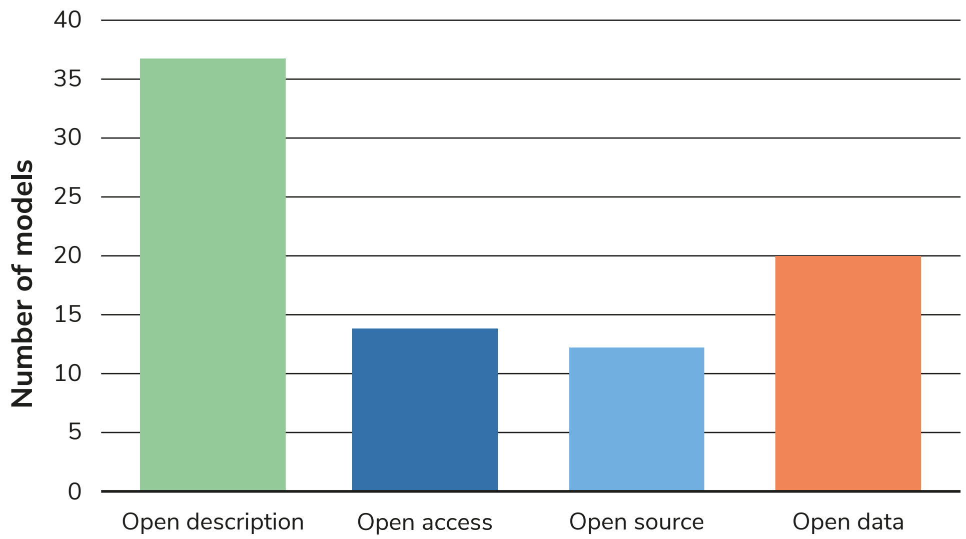
Transparency of UK energy models

This policy brief has argued transparency is essential for trust in energy models, to encourage both stakeholder participation and wider public engagement.

With the modelling community, transparency can enable review and validation of assumptions and modelling approaches, so that the credibility of energy models can be ensured more easily. Open access and open source models can even exploit the collective efforts from a large group of users to effectively extend the model capability to deal with more complicated and challenging policy issues. Hence, it is essential to improve the transparency of UK energy models.

However, the transparency status of energy models is currently far from this ideal. Almost half of energy models (about 49%) do not have any open information, including online documentation (open description). As for those more transparent models, model teams are only likely to provide online documentation to explain the functionality of their models (about 47%), but much less often open access (about 18%) or open source (about 16%) the models (figure 15). It should be noted that the levels of transparency status of models are not exclusive. Almost all open access and open source models provide online documentation (open description), while about 50% of open source models also have collaborative user groups (open access).

Figure 15 Transparency of energy models



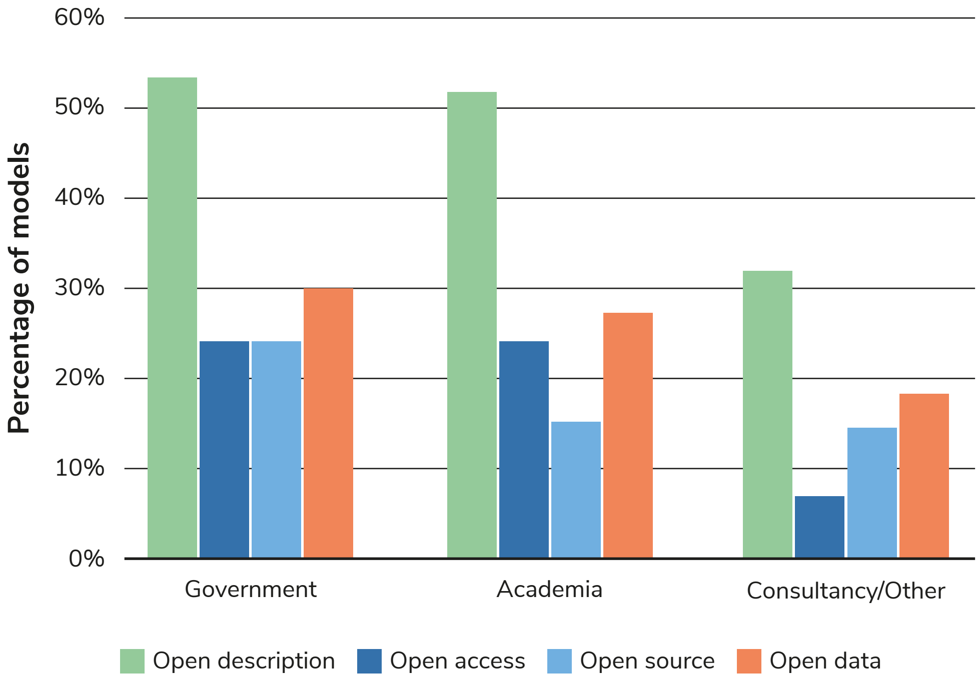
We can investigate the survey to understand why different model teams choose different transparency routes. Development costs have a modest influence on model transparency. Only when model teams invest extremely high costs (more than five person-years) in model development, are they more likely to provide online documentation (open description) of their models (76% of those models). Open access and open source models are also more common among those models (33% and 23% respectively).

Looking at organisation type, Government departments and academia score higher than other organisation types on all three transparency levels (figure 16). However, these transparency shares are still not a majority, which is odd given the debate in academic research on reproducibility and verification, and the drive in UK Government for quality analysis as detailed in the Aqua book.[6] Understandably, consultancy and other organisations are less likely to share information on their models, given how they need to retain a commercial advantage over their competitors.

Government departments' intention to earn public trust in policies made utilising their models might drive them to further reveal the details of those models. In the future, Government departments can lead the way to improve model transparency by asking their service providers from academia and consultancy firms to have improved model transparency. One element of this is the data part of energy models (shown in figure 16), which are only transparent in 27% of models, although Government is slightly ahead of other organisational types in this regard.

of models do not have any open information

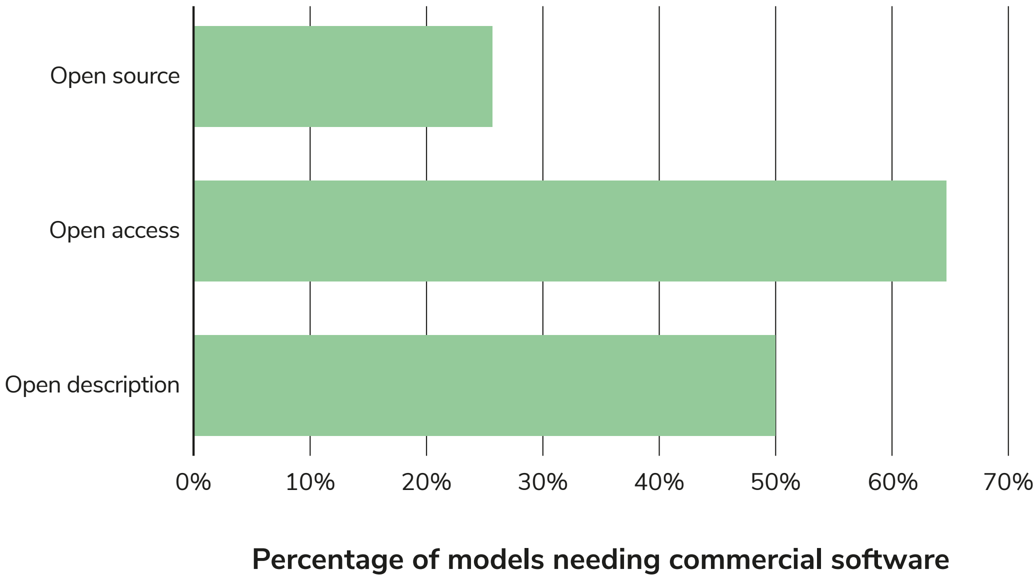
Figure 16 Transparency of models hosted by different organisations



[6] www.gov.uk/government/publications/the-aqua-book-guidance-on-producing-quality-analysis-for-government

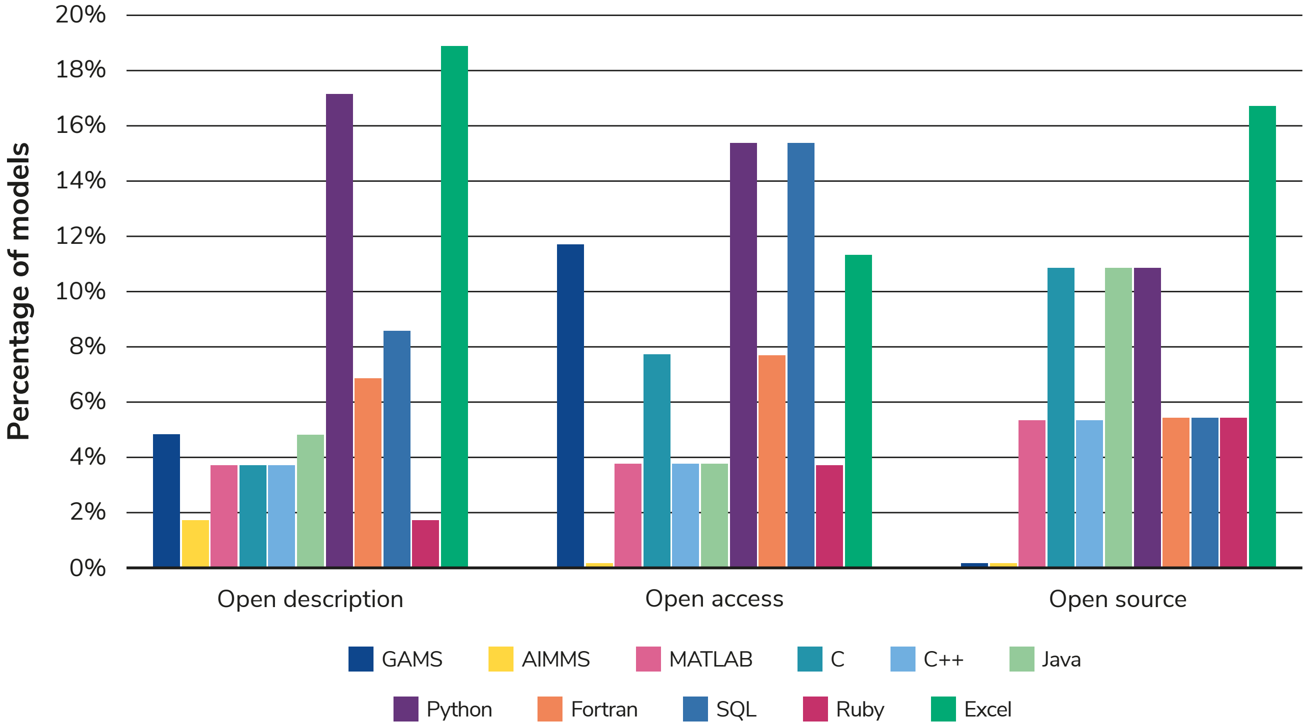
The requirement of commercial software (requiring costs to purchase and expertise in their application) can be a key barrier to adopt and share models and even to fully open source energy models. Only 25% of open source models need commercial software (mirroring their ethos for use by many), while over half of models with lower levels of transparency need commercial software (figure 17).

Figure 17 Requirement of commercial software for different model transparency levels



Finally, both Excel and Python are popular platforms for transparent models, accounting for 36% of open description models, 27% of open access models and 28% of open source models (Figure 18). The simple design (and widespread availability) of Excel might make the openness of models easier (using alternative open source spreadsheets can potentially further reduce the requirement of commercial software), with a high share of open source models (17%) are Excel-based. Python is an extremely popular programming language for open source software development; model developers might be naturally turn to Python for the development of their open course models. On the other hand, models based on GAMS and AIMMS (both are proprietary programming platforms) have not been found among open source models. Model development based on these platforms could be more expensive and hence deter model teams from sharing these costly assets to the public. Certainly, one way to improve model transparency is to encourage model teams to adopt open source programming platforms.

Figure 18 Development platform of transparent models



Summary

This policy brief has focussed on the construction, maintenance and transparency of UK energy models, focusing on three key areas:

- How the models are constructed; in terms of costs, funding sources, and resulting impacts;
- How the models are maintained; in terms of costs, number of users, and the updating process;
- How the models are made open in terms of different transparency levels.

So how do modelling teams adapt to the "real world" of limited (and highly competitive) development funding? The survey illustrated how successful energy models cost a lot to develop, with one way to mitigate this being to spread the costs over many developers. The most common funding mechanism was on a project-by-project basis which can be a stressful process, but could perhaps make models modular and more flexible in their design. Government and academia have access to public funds to bid for, while consultancies are in the hardest position often having to self-fund development to then allow them to bid for model application projects.

The subsequent maintenance of models – and improving their transparency – is time-consuming and unglamorous. It is perhaps the "hidden effort" of energy modelling.

Again, the better funded and more successful models (in terms of outputs) can spread these updating, calibration and documentation tasks among a set of modelling contributors. In terms of how often to update models, there is a balance between up-to-date data and methodologies and applications of existing tools to recoup development efforts.

Transparency (and hence trust) in energy models is essential to encourage both stakeholder participation and wider public engagement. There are different routes (open documentation, open access or fully open source) for model transparency and teams must choose the most appropriate and productive approach. However currently around half of all UK energy models do not follow any of these transparency options. Government and academia are somewhat better than consultancies in terms of transparency, which is logical in terms of the greater commercial pressure consultancy teams operate under. Finally Excel and Python appear as leading candidates for open models of varying levels of complexity.

The final policy brief (of four) on the UKERC modelling survey will distil insights from the whole series of outputs and will focus on applications of UK energy models to decision making in Government and industry.

Authors

Pei-Hao Li, University College London
Neil Strachan, University College London

Reference

This report should be referenced as: Li, P. and Strachan, N. 2021. Energy Modelling in the UK: Construction, maintenance and transparency. UK Energy Research Centre, London.

DOI: 10.5286/ukerc.edc.000949

About UKERC

The UK Energy Research Centre (UKERC) carries out world-class, interdisciplinary research into sustainable future energy systems.Our whole systems research informs UK policy development and research strategy. UKERC is funded by the UK Research and Innovation, Energy Programme.

Contact

T: +44 (0)20 3108 7564
Email: UKERC@ucl.ac.uk
Website: www.ukerc.ac.uk
: @UKERCHQ
: www.linkedin.com/company/uk-energy-research-centre

UKERC is committed to making all of its publications accessible, with all new PDFs published from March 2021 meeting accessibility standards. We're always looking to improve the accessibility of our publications. If you find any problems or would like further assistance please contact UKERC@ucl.ac.uk

UK Energy Research Centre,
Central House, BSEER,
14 Upper Woburn Place,
London, WC1H 0NN