Energy Modelling Across Scales

Stakeholder Workshop Summary

UKERC Meeting Report

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Introduction to UKERC

The UK Energy Research Centre (UKERC) carries out world-class, interdisciplinary research into sustainable future energy systems.

It is a focal point of UK energy research and a gateway between the UK and the international energy research communities.

Our whole systems research informs UK policy development and research strategy.

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Contents

Introduction

Place-based approaches to decarbonisation emphasise the value of local energy system modelling and scenario tools that can inform decision makers about options, strategies and trade-offs. Many local and regional governments are using such tools to help develop local energy planning and delivery programmes. In addition, electricity network companies prepare Distribution Future Energy Scenarios (DFES) based on disaggregation of national grid scenarios, and other national and regional models inform policymaking[1,2]. Energy system modelling tools have varying methodologies, scales and priorities, and alignment or integration between them is uncertain. There are also questions about how outputs feed into decision-making and any subsequent investments.

To explore some of these questions the UK Energy Research Centre (UKERC) organised a modelling workshop with cross-sector local, regional and national stakeholders on 6 July 2023. The workshop aimed to create dialogue between model developers and users at various scales. It explored practitioner responses to different energy system modelling tools, how energy modelling is used in decision-making, and how different scales of system modelling interact. This summary provides an overview of discussions and key emerging themes.

Session 1: Energy system modelling across scales

The net zero transition is increasing energy system complexity, including between vectors and at local and regional scales. This session reviewed a range of modelling tools designed to inform planning and decision-making at different spatial scales. Presentations were provided by UKERC modelling teams:

- UK TIMES – Oliver Broad, University College London
- CGEN regional transmission system modelling – Modassar Chaudry, Cardiff University
- StrathES last mile network modelling – Graeme Hawker, University of Strathclyde

UK TIMES: Oliver Broad introduced Whole Energy System Modelling (WESM). WESM adopts a system of systems approach to analyse interconnections and interdependencies between elements of the energy system and wider economic, technology, and environmental aspects. Simplifying these complex interconnections requires aggregation across sectors, time and regions.

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[1] See https://ukerc.ac.uk/publications/modelling-interactions-energy-systems/ for an overview of the modelling approaches applied by UKERC researchers, at the local and regional level.
[2] https://ukerc.ac.uk/publications/energy-modelling-decision-making/.

Models can generally be classed as bottom up or top down. Bottom-up models emphasise technological realism and interactions with the macroeconomic system. Top-down models integrate macroeconomic systems and micro-economic realism. As an example, for the residential sector, a bottom-up model would represent different types of heating technologies such as heat pumps, boilers, storage heaters and heat networks, using a range of fuels, each as individual technologies. A top-down model would typically represent the residential sector in an aggregated way that examines overall fuel consumption rather than individual technologies, with elasticities used to represent potential changes in fuel consumption over time. The principal advantages of a top-down model are broader boundaries, as they can cover the whole economy rather than just the energy sector, and speed of solution as they are smaller models.

UK TIMES is a bottom-up optimisation model. More specifically, the model is an integrated, long-term energy model (to 2050 and beyond) that represents the whole energy system, from resource extraction, through to primary and secondary fuel production (electricity, hydrogen, biofuels, etc.), and finally consumption in the residential, industrial, service, transport and agricultural sectors. Analysis is grouped into five years periods, commensurate with carbon budgets. Each period then has a representative year, and this is broken into 16 different time periods representing a combination of different seasons and different periods of the day. The technology explicitness of the model means the impact of various technologies, deployment rates and interactions between technologies can be understood in detail. This allows exploration of the future that doesn't overly rely on historical trends and thus allows high level planning for UK carbon budgets and decarbonisation pathways. WESMs have large data and computational requirements, and macroeconomic effects are often ignored. UK TIMES it is an aggregated single region model and is not suited to understanding deployment in a local area or integrating behavioural factors. UK TIMES can however be integrated with other qualitative and quantitative analysis tools to provide insights into specific policy questions. For example, in the Positive Low Energy Futures[3] project (Centre for Research on Energy Demand Solutions (CREDS) consortium) UK TIMES was integrated with other qualitative and quantitative approaches to provide a comprehensive assessment of the role of reducing energy demand in meeting the UK's net-zero climate target.

UK TIMES is administered by the UK Government and access is granted through agreement with the Department for Energy Security and Net Zero. The TIMES modelling framework that underpins the model is however open source[4], and work is progressing to make the model itself openly available. In parallel, an expert user group is convened by UCL and aims to connect and support the use of UK TIMES across stakeholders.

CGEN+ Energy Hubs: Modassar Chaudry introduced the CGEN optimisation model designed to integrate electricity, natural gas and hydrogen sources, and to provide

[3] https://low-energy.creds.ac.uk/ and https://low-energy.creds.ac.uk/3-our-approach/#3point3.

[4] See https://github.com/etsap-TIMES

detailed network modelling including the DC network and gas pressures[5]. CGEN is an operational framework which seeks to minimise total costs in the system. It provides a detailed representation of processes and assets, and realistic modelling of renewables, demand shifting and storage facilities.

The model adopts an ‘Energy Hub’ approach comprising inputs (energy vectors), transformations (e.g. converting electricity, heat pumps) and outputs. This allows operation at a range of spatial and temporal scales from regional to street-by-street scale. CGEN can also interact with other models (e.g. MARKAL/TIMES), or with sectors such as transport and water supply. The model was applied in the Oxford-Cambridge Arc to consider transport infrastructure developments (rail line and motorway), population scenarios and their impacts on the energy sector. Multi-vector supply options were analysed for the locality and then optimised to minimise national and regional costs. A dynamic front end was developed to display user configurable simulation outputs. This allowed users to make sense of interactions between complex data for various energy metrics (generation, margins, demand, loss of load, curtailments, demand-side management, costs etc.) and across geographic locations and temporal scales.

Benefits of the CGEN approach include a high level of technological detail which captures operational characteristics and allows integration of the transmission/distribution interface. It also has flexibility on temporal and spatial scales and allows for interaction between energy vectors. However, the model has large data and computational requirements, particularly if modelling at street by street level, and human behaviour tends to be characterised only by cost functions. It can model to a half hourly resolution and hence can incorporate some demand-side actions. It is not possible to model less than half hourly aspects of the energy system such as rapid frequency response. CGEN is a proprietary model, but another version (DAFNI[6]) is open source and is interlinked with transport and demand.

Last-mile network modelling: Graeme Hawker presented work at the University of Strathclyde on modelling last mile networks. This part of the energy system incorporates highly diverse assets, including buildings and occupant behaviour, as well as cables and pipes. Historically, last-mile scale has required relatively simple engineering analysis, but that is changing radically as the system becomes more complex and demand-focussed.

It is very hard to generalise about local networks, because there is a huge amount of variation based on location and when networks were built. Historically, DNOs have taken different approaches to upgrades, and records of networks built in the 1950’s and 60’s are often poor. DNOs are currently in a significant process of digitalising and improving data availability, which is raising questions about how to process a large volume of new network data. One approach to managing this complexity is to model representative parts of the network (such as rural, urban, suburban) across building archetypes. This allows analysis of specific questions, such as the likely

[5] See Chaudry, M. *et al.* (2022) ‘The implications of ambitious decarbonisation of heat and road transport for Britain’s net zero carbon energy systems’, *Applied Energy*, 305, https://doi.org/10.1016/j.apenergy.2021.117905
[6] https://www.dafni.ac.uk/insights/nismod-on-dafni/

level of disruption entailed in decarbonising heat, across specific locations and dwelling types.

An example analysis of a building simulation model was presented; this represented the social fabric of a house by simulating building occupants using appliances, resulting in patterns of energy services demand, and identifying technologies to meet demand and network impacts. This approach can be applied to a local area to identify decarbonisation options and interactions with other scales of system analysis. A place-based analysis can reveal how capacity, energy efficiency and levels of disruption vary considerably across building archetypes in an area. This scale of analysis can provide detailed insights, but incorporates high levels of uncertainty, some of which relate to national decision-making such as the future role of hydrogen for domestic heating. Behind the meter assets can be incorporated using inputs from other models. Careful consideration of which elements to couple is required, but a building fabric model, a behavioural model, and the localised network model can be included. The industrial and commercial sectors can be incorporated, but it is difficult to source representative datasets as data availability is poor and energy profiles of industrial clusters are very diverse.

Clarity on the modelling process across conceptualisation, design, parameterization and presentation can help to structure the use of modelling in analysis, decision-making and implementation. The concept of model 'usefulness'[7] across conceptualisation, quantification, comparison, contextualisation, certainty and application can be applied to analyse the role of modelling across different scales and circumstances. As energy system data become more widely available it is important to reflect on the drivers for modelling relative to the problems we are trying to solve.

Discussion

Local energy systems are developing in diverse ways, raising questions about the suitability of national-level governance for coping with emerging variety. Governance remains largely centralised and tends to frame decarbonisation as primarily a technology, rather than a social and political-economic, problem. Change is however increasingly happening at end-user level, indicating that optimisation should start from the demand-side. Previous studies, such as the Positive Low Energy Futures project, have demonstrated that it is possible to reduce energy demand radically through significant, and beneficial, social changes. Multiple recent smart, integrated local energy system (SLES) projects[8] have also demonstrated prospective whole system benefits, but it remains unclear whether, and how, the results will influence GB planning and decision-making. National policy prioritises technological solutions and is not yet engaging systematically with what are perceived as complex behavioural factors.

[7] See Hawker, GS & Bell, KRW. Making energy system models useful: Good practice in the modelling of multiple vectors. WIREs Energy Environ. 2020; 9: 363. https://doi.org/10.1002/wene.363
[8] Funded by Innovate UK (Prospering from the Energy Revolution), https://iuk.ktn-uk.org/programme/smart-local-energy-systems/

A patchwork of models across scales are currently fulfilling different purposes, but there is a perceived need for greater clarity about, and coordination of, interactions between approaches. The Regional System Planner role, under consideration by Ofgem[9], could play a significant role in structuring and systematising practices of regional modelling, decision-making and trade-offs between local, regional and whole system scales. Greater focus on learning from SLES innovations, and integration into whole system planning and decision-making, are also needed.

The Flexis project[10] in South Wales for example tested regional planning through considering the likely impacts of regeneration on the energy system. Analysis started from the demand-side and considered the impacts of different energy futures on housing, skills requirements and future jobs, to produce a comprehensive energy and economic plan for the region. This was complex to model and required commitment by regional leaders as well support from GB agencies and local Universities.

While GB energy system assets and innovation are diverse, there is a lack of diversity at the retail level; we all pay roughly the same energy prices. However, different regional opportunities suggest potential for future variation in costs between customer groups and locations. The implications of different regions experiencing higher or lower costs are under-represented in public debates about future energy policy and need wider discussion.

It is often unclear how modelling outputs can be used to support planning and decision-making locally. Community engagement in modelling and planning is resource intensive and is often not prioritised. However, it is becoming increasingly clear that a lack of engagement can result in low legitimacy and stalled delivery. Some DNOs and local authorities are engaging and collaborating with communities (such as DNO community energy engineers), but it is often difficult to understand requirements at a regional level and a consistent approach to engagement is lacking.

Session 2: Local modelling approaches in practice

Energy modelling in Greater Manchester: Rachel Berman and Sean Owen, Greater Manchester Combined Authority.

Presenters discussed the strategy for meeting the GMCA 2038 net zero target, which is guided by five year Environment Plans and carbon budgets. The combined authority plays an enabling and empowering role, setting the environment for local actors to deliver. There is extensive experience of energy modelling and local area energy planning (LAEP) starting from 2016 and progressing to the GM Local Energy Market trial[11] and production of a LAEP for each local authority area in Greater

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9 https://www.ofgem.gov.uk/publications/consultation-future-local-energy-institutions-and-governance
10 https://www.flexis.wales/
11 https://gmgreencity.com/projects-and-campaigns/local-energy-market/

Manchester (2022). This modelling can now be disaggregated via a data dashboard for each area, incorporating priority technologies and locations, with the aim of supporting detailed business case development. The first phase of LAEP indicated that results were often similar across local authority areas, indicating potential to adopt cheaper, faster modelling techniques with the main model used for validation and calibration.

There are significant challenges relating to heat decarbonisation and data access and quality. National data is often inaccessible or poor quality. There is also a significant lag on key datasets (18 months), making ongoing monitoring challenging. Skills and resource limitations make regular updates and live modelling difficult.

GMCA carbon budgets are very ambitious and national policy sets limits on what is possible locally. Greater Manchester are not currently on track to meet their carbon budgets and it is not clear how this slow delivery (in a region of significant size) feeds into other models at regional or national scales. There are also political challenges in delivering in many policy areas. There has been clear political commitment across districts and by the Mayor, and piloting LAEP in a single area was helpful in demonstrating its usefulness. However further political engagement is needed to ensure commitment to the delivery phase. Numerous competing priorities require the net zero team to make explicit the co-benefits for other priorities including housing, planning and health. The aim is to ensure every decision is prioritising decarbonisation. There are likely to be political tensions as decarbonisation progresses, however the combined authority's position has helped to secure commitment by providing support and analysis of the benefits of action.

The area-wide LAEP approach in GM has been supported by a significant wider research programme and data assets. The data and potential insights from LAEPs have significant value, however it is hard to use the Plans to make decisions (either at a council level or a household level) as some important information is missing or hidden. The modelling is beginning to provide the investable business case, but significant further development of individual projects is required with potential to package projects and work with delivery partners on portfolios. There is also more to do on citizen engagement. The GM LEM development incorporated a Citizens Panel and trialled community led energy planning (coordinated by Carbon Coop). Current research is examining consumer attitudes and barriers to behaviour change.

Energy Modelling to support the LAEP Programme for the West Midlands: Kate Ashworth, West Midlands Combined Authority.

Energy Capital acts as both the Energy Team within the West Midlands Combined Authority (WMCA) and as a public-private partnership which convenes the multiple partners making decisions on the energy system in the West Midlands. The regional voice in energy infrastructure is the 'missing middle' in net zero governance and Energy Capital aims to help to understand how this regional perspective can contribute to energy infrastructure development.

The West Midlands have developed a policy and evidence base since 2017 and in 2022 agreed a trailblazing Devolution Deal with government. This includes statutory responsibility for transport and a range of expectations on energy. Recent work is exploring how local energy planning and spatial planning could be meaningfully integrated and structured to inform national planning. The national policy landscape has moved towards recognising the need for a stronger regional voice in energy systems, with the ability to connect national scale and community level.

The Regional Energy System Operator (RESO) project, funded by Innovate UK (Prospering from the Energy Revolution), examined the role of local energy governance in Coventry, and developed proposals on the structures needed to establish and operate a regional system operator. RESO demonstrated the value of place-based approaches to decarbonisation and considered technical options, market design and governance. It concluded that development of RESOs would accelerate more cost-effective decarbonisation but would require a local data governance and whole-systems planning capability, as well as alignment of infrastructure and governance boundaries.

There are significant spatial challenges in modelling decarbonisation across the West Midlands because the geographies of energy, water and transport infrastructures differ. The resulting uncertainties need to be addressed and decision-making responsibilities allocated.

A data infrastructure platform for the West Midlands and a LAEP+ tool are under development to support optioneering and zoning and to allow 'what if' scenario development. This will provide each local authority with an energy baseline, including the National Grid DFES models, and the ability to model their own decarbonisation targets. Alignment between the ESO FES modelling, the NGED DFES modelling and the LAEP+ modelling is being explored through PRIDE (Planning Regional Infrastructure in a Digital Environment)[12]. To date this is indicating that a common approach across modelling teams would be beneficial to allow top-down strategic planning to be interoperable with bottom-up project delivery. A process of translating language and approaches across organisation is required, together with linking outcomes to local system optimisation

Local Area Energy Planning, David Lee, Energy Systems Catapult

The ESC has developed a Local Area Energy Planning (LAEP) roadmap. The process aims to provide local energy system modelling which supports the needs of local authorities, and numerous localities have developed, or are developing, LAEPs. Experiences of delivering plans across diverse areas is providing extensive learning about the benefits and challenges of local modelling and scenario preparation.

Whilst local data is critical to robust modelling, there is a need to triage data; scenario preparation is resource intensive and data priorities should focus on areas of highest impact. There are inevitably high levels of uncertainty in some areas of deployment and it is important to identify both short-term low regret priorities and longer-term decision points. LAEP should help to guide action through the production of priority zones for deployment across various timeframes. However local

[12] Supported by Ofgem Networks' Strategic Innovation Fund

engagement in the process is essential. Experience suggests this is most effective when initial strawman scenarios have been developed, but before detailed scenarios have been finalised. This provided sufficient detail for informed engagement, but allows local perspectives to shape final scenarios.

ESC guidance for LAEP needs to evolve as learning grows. Given that there is no GB-wide framework for local energy planning, it is currently difficult to ensure developments in modelling are consistently communicated to all actors. Guidance also needs to strike a balance between being prescriptive and allowing innovation. Current challenges for LAEP include processes to scale up LAEP findings to larger areas (region or DNO license area). This is challenging because there are limited structures to support coordination between areas. LAEP also needs to be configured to be useful to network operators. DNOs and local authorities work on different scales, with some DNOs operating across multiple local administrative boundaries. Network asset modelling is already robust so there is a need to focus on areas of added value and supporting interactions between DNO planning and local planning.

Incorporating consumer behaviour is complex and LAEPs are currently technology focussed. Behaviours also need to be understood over time, for example some data suggest gradual reductions in energy efficiency gains in the years following building retrofit. Additionally there is a need to understand local constraints on rates of change in more detail, including supply chains and skills. Accurate data for monitoring progress remains challenging. For example, EPCs are not necessarily a good representation of current building stock as properties with energy efficiency improvements are less likely to be rented or sold, and hence lack an updated EPC (unless they are in receipt of government grants or have undertaken significant renovations).

Discussion

There is considerable variation in local authority approaches and resources. A regional tier of coordination could help to minimise this variation. There is also a need to develop ways to support translation between models and interoperability across sectors. This would support a more comprehensive and common understanding of options at the regional level across electricity, gas, heat, transport, water. The results then need to feed into both national and local scales.

Overall, there is a need to synthesise the impressive work taking place at different scales. An architecture is needed to support base level standardisation across core models. Different approaches need to be able to fit together to enable analysis at different scales. Government already holds much of the data required for modelling so the focus should be on agreeing methodology. Other industries have already achieved this; in the 1990s for example the defence industry took ten years to unify around a single simulation model. Wales is currently developing a coordinated approach to LAEPs across the country. Welsh government support has been allocated to all local authorities to develop plans by March 2024. Technical modelling is being delivered by three organisations, with the ESC acting as technical advisor to ensure consistency. This will facilitate aggregation from the local authority to the regional level and then to the national level.

There is likely to be a delivery crunch in many areas with action on the ground not keeping up with targets derived from scenarios. We need to model this slow delivery and understand interactions with non-technical factors such as economic development, skills and politics. The aggregate impacts of multiple regions failing to meet decarbonisation trajectories should also be examined. Stakeholder engagement in LAEPs needs to include a range of communities and value the knowledge communities' hold about problems and solutions. Sufficient resources should be allocated to develop ongoing participation beyond one-off consultation. Infrastructure conditions behaviours and greater understanding of these dynamics could help to accelerate change. For example street scene and transport planning shapes walking and cycling behaviours, and lower temperature heating (heat pumps) may influence attitudes to thermal comfort.

Scenario exercise and discussion

In this exercise participants were presented with an example scenario for a local energy system with network constraints. In groups they explored how different actors, with different responsibilities, respond to the evolution of the energy system as they seek to decarbonise. What actions would they take and how would they coordinate? What insights does this provide for future model development, and how should decision-making and critical paths be represented in the modelling of energy systems? Participants were asked to fulfil the roles of: a local authority, a regional authority / devolved government, UK government / regulator, Distribution Network Operator, and a local resident / energy consumer.

Broad themes that emerged from the exercise included:

- There are difficulties in appropriately engaging with residents, understanding their concerns and how to communicate potential benefits.
- There is a difficulty for local actors in understanding how best to influence and incentivise behavioural change.
- The need for local and regional authorities to adequately resource and prepare for the significant amount of local strategy and planning decisions.
- The local impacts of higher-level regulatory change can be difficult to predict, and policy changes can be based on a simplified view of the energy systems in place around the UK.
- Supply chains in many areas of Net-Zero procurement are already tight, and this may place significant constraints on which options are actually available to decision-makers.
- Local and regional authorities often need to combine multiple different sources of funding, adding to the complexity of decision-making.
- There is a significant dependency on national-level decision-making to permit more granular and local assessment of options – such as around the future use of hydrogen in the residential sector and the implications for gas and electricity networks.

- For some technologies (such as heat networks) local authorities are expected to lead, design and incentivise investment; for others (such as EVs), they instead have to act in a reactive manner to ongoing uncoordinated decisions by consumers.
- Political tensions are present at all levels of governance, and lobbying interests exist to influence decision-making across all scales.
- The nature of local housing stock should have a strong influence on decision-making and needs to be factored into national strategy and modelling.
- Achieving buy-in to strategy is key, but can enable coordinated action – there is a broad desire to achieve change and this can be used if people believe in the overall plan and its outcomes.
- Consumers may be represented in energy decision-making by actors who have other motivations (such as private landlords or housing associations).

Emerging themes and final discussion

Decision-making under uncertainty. Inevitably there are going to be uncertainties in decarbonisation trajectories and the challenge for energy system modelling is how to best support decision-making at different scales, despite uncertainties. There is a risk that models and other decision support tools become barriers to action if the focus is on searching for the perfect model and data. Modelling needs to be mobilised to inform rapid action.

Integrating models across scales: there is a need to improve the integration of modelling approaches across scales. There is strong interaction between ESO Future Energy Scenarios (FES) and DNO Distribution Future Energy Scenarios (DFES) but interactions at a more local level are variable. Many local authorities lack resources or capacities to engage. There is a risk of individual LAEPs becoming siloed with limited incentives to manage interactions between plans in a region. Current structures do not support effective cross-scale governance and there is a need for regional coordination. Ongoing development of a Regional System Planner role could play an important role in structuring these interactions between agencies and scales.

Clarifying coordination across scales could help to develop trust between governance organisations at national, devolved, regional and local scales. Local delivery and long-term planning is also constrained by a lack of funding and short-term policy. It is currently unclear if specialist data science and modelling expertise is required in all localities or if this could be more effectively shared across regions or be supplied by a national hub. There is also a need to develop more collaboration in delivery through shared procurement models and delivery teams.

Communicating outputs and supporting multi-actor decision-making: The process of building models can help bring different decision makers together and provide detail on the specific decarbonisation challenges and benefits in a locality. Communicating this core evidence base is important to develop buy in from strategic decision-makers. However model outputs often still require translation to make them clear to politicians and investors, with additional resources required to develop subsequent business cases and financial strategies. Overall, the targeting of modelling analysis to decision making processes could be improved.

Standardisation and interoperability: It is difficult to compare modelling approaches due to the wide range of methods, data sources and outputs. Standardisation of models is complex as different models are designed to examine different questions, however there is a need to develop common approaches to data architecture, presentation of outputs and assumptions. A clear, common data architecture would clarify data flows and responsibilities and common terminologies would support comparison between approaches. Standardisation should also focus on the usability of model outputs, establish common processes for model users to feedback back into development (reflecting on the model-reality gap) and establish a framework for iteration and update.

There needs to be a balance between greater standardisation across models on the one hand and tailored and specialist knowledge on modelling inputs, outputs and processes on the other. There are risks that standardisation limits innovation in modelling or constrains the delivery options considered. The current diversity of approaches, however, particularly at the local level, creates challenges for actors at regional (DNO) or national scales in utilising model outputs in aggregate. The interactions between DNO and local modelling outputs are also currently unclear and should be formalised.

Incorporating behavioural factors: Individual decision-making will influence the speed and direction of decarbonisation, but modelling behavioural factors is an area of weakness for most models. There is a need for more focus on modelling approaches that better account for such factors, e.g. agent-based or system dynamics modelling. Local stakeholders could play an important role in developing new approaches to behavioural modelling.

Local authority capacity: technical modelling capacity and resources within local authorities are limited. Coordination structures should minimise additional inputs required at this level and consider how to develop added value for local, regional and national actors. Currently there is a risk that the diversity of local approaches limits the ability of actors at other scales (Ofgem and DNOs) to take account of local modelling and planning. Ultimately, Local Authorities need sufficient resources and capacity to use what they learn from modelled scenarios and to articulate their significance for local communities, businesses and public bodies.

Workshop attendees

Name	Organisation
Alex Dos Santos Aranda	National Grid (NGED)
Andrew Hunt	Oldham Council
Aneaka Kellay	Carbon Coop
Anna Livesey	Coventry Council
Bryn Pickering	Arup
Carolyn Howarth	Manchester City Council
David Lee	Energy Systems Catapult
David Parfitt	National Grid ESO
Ezgi Kelleher	Greater London Authority
Francisca Jalil-Vega	University College London
Gemma Delafield	Ceredigion Council
Graeme Hawker	UKERC
Huw Lewis	Welsh Government
Ivan Bolotkov	Electricity North West (ENWL)
Jack Flower	Arup
Jamie Gregory	Scottish Government
Jan Webb	UKERC
Jess Britton	UKERC
Júlia Fernandez Molina	UKERC
Kate Ashworth	West Midlands Combined Authority - Energy
Laurie Duncan	Birmingham University
Leonard Hofbauer	University College London
Lia Murphy	Ofgem
Modasser Chaudry	UKERC
Molly Atherton	Regen
Oliver Broad	UKERC
Owen Smith	University of Manchester
Peter Tayor	UKERC
Rachel Berman	Greater Manchester Combined Authority
Richard Bradley	Midlands Connect
Sean Owen	Greater Manchester Combined Authority
Sheridan Few	University of Leeds