EPSRC National Centre for Energy Systems Integration

Socio Technical

Community Energy Modelling

CESI Flex Fund Project FF4-001

Workshop outputs

Authors:

Dr Paraskevi Vatougiou, Heriot-Watt University

Dr David Jenkins, Heriot-Watt University

Claire Copeland, University of Sussex

Dr Andrew Peacock, Heriot-Watt University

Dr Peter McCallum, Heriot-Watt University

Contents

1 Introduction

The journey of an energy modeller can often have minimal interaction with the buildings/communities that are actually being studied for that modelling. Regional specifics of household and building characteristics, and geography-related challenges and opportunities to low-carbon retrofit at scale, can therefore be difficult to characterise within modelling studies.

The work of this CESI Flex Fund aims to address this through a period of engagement and elicitation with a range of stakeholders with detailed understanding of how future scenarios may be implemented at community scale, and how this may vary with different communities. The first part of this project involved a series of semi-structured interviews with different stakeholders from industry, policy and academia. These interviews, already reported on, were used to structure and design the second stage of the work; the workshop described below. In particular, the interviews allowed us to identify key themes to structure the workshop exercise around: i) Occupants and inequality, ii) Buildings, iii) Energy System, iv) Governance, and v) Practical obstacles. The workshop then brought focus group-style sessions together to discuss how these five themes need to evolve to meet the challenge of creating low (and zero) carbon communities.

The description of the day, the workshop exercise, and the results of discussions are overview below. All feedback obtained represents the views of the attendees, not of the authors of this report.

2 Workshop

The workshop was organized by Heriot-Watt and Sussex Universities as part of the UK Centre of Energy System Integration (CESI) (CESI FF4-001) and constituted a half-day interactive online event aiming to investigate barriers to modelling low-carbon communities. More specifically, the workshop was run to discuss various considerations/issues that are poorly represented in energy models but might be suitable to be targeted for model improvements. These considerations, in particular, emerged from the collected material of 10 semi-structured interviews with a range of stakeholders and interested parties, conducted prior to the organisation of the workshop. 32 people in total attended the workshop; these were selected with the consideration to have a balanced representation of people within academia, industry and local authorities/councils.

Before the actual workshop (consisting of two individual activities described below), three presentations were made to introduce attendees to the purpose of the project and the workshop itself. Firstly, an overview of CESI, and this specific CESI Flex Fund, was provided to note progress so far. Then, the content of the interviews were presented in a short summary highlighting the main findings, which were then used to define the main themes and sub-topics for the workshop. Finally, a description of the ParaDwell thermal stock model was provided; this is developed by the Urban Energy Research Group (UERG) and used within the context of CESI and other projects (such as ReFLEX Orkney[1]) to estimate thermal demand at the stock-level. Workshop findings are intended to be used to inform the way communities are modelled within ParaDwell. Specifically, the last section of this report attempts to investigate how and whether workshop outputs can be accommodated in ParaDwell to better understand specific parameters that are either direct inputs to the model or can assist on the definition of future scenarios for specific communities.

Following these presentations, attendees were introduced to the workshop activities and were then assigned to five separate breakout groups (five to six people per group), each representing a particular theme with several underlying sub-topics to discuss (themes and sub-topics are presented in *Table 1*). The

[1] ReFLEX Orkney project: https://www.reflexorkney.co.uk/

workshop comprised of two individual activities: a scoring exercise (~20 minutes) and a broader discussion with open-ended questions (~55 minutes).

Based on their modelling experience (either using a model and/or being a recipient of information from a model), each breakout group was asked to identify whether a specific issue (as described by the sub-topics) is important for a range of different actors. To aid this discussion, as an initial activity, the participants of each group were asked to assign a score from 1 (least important) to 5 (most important) for each different sub-topic reflecting its level of importance for i) modellers, ii) local authorities/housing associations and iii) industries/technology developers/service providers. For the purposes of the second activity, participants were asked to discuss how the different sub-topics can be characterised or described within a model that requires inputs to be quantified in quite discrete ways. The discussions were driven by the following questions:

- what data do you need to quantify the issue?
- who has this data/info?
- what is the uncertainty/reliability of this data?

A facilitator was present in each group to keep timings (ensuring that equal time is given for each topic to be discussed) and the minutes of the discussions. The facilitators were recording group conversations in customised tables using an online collaborative platform. The main outcomes of each breakout group were presented at the end of the workshop to all attendees. After the workshop, attendees were provided with a link to access to the tables online in order to add any points missing from the discussions.

3 Themes

Table 1 presents the workshop themes with their underlying sub-topics (with the five breakout groups being assigned a single theme each). The scores (1 to 5) refer to level of importance of each sub-topic for three different actors as identified by each breakout group. For some of the sub-topics, additional comments were made by the participants to justify the score given and/or provide further factors that should be considered to decide whether each issue is important to the different actors. These are presented in the following sections.

Table 1: Workshop themes and sub-topics. Level of importance of each sub-topic to different actors (outcomes of Activity 1)

Theme	Sub-topic (issues)	Modeller	LAs/Housing associations	Industry
1. Occupants and inequality	**1.1** Accounting for fuel poor households	3	4-5	1-2
	1.2 Reflecting heating requirements of vulnerable households (e.g. poor health and socio-economic conditions)	3	4-5	2-3
	1.3 Impact of capital availability and willingness on the uptake of energy efficiency measures	3-4	4-5	5
	1.4 Impact of retrofit measures on overheating	5	4-5	3-4
2. Buildings	**2.1** Impact of housing market regulations and property value on the uptake of energy efficiency improvements	5	5	5
	2.2 Impact of tenure on retrofit decisions	4	5	5
	2.3 Impact of house condition on suitability of specific heating technology installation	5	5	3

3. Energy systems	**3.1** Addressing issues around the best use of renewables (e.g. producing hydrogen vs running heat pumps)	5	4	3
	3.2 Interaction of consumers with time-of-use tariffs and acceptability of smart home heating controls (e.g. noting a desire of demand flexibility)	5	3	4
	3.3 Impact of heat pump size selection and large-scale adoption on the electricity grid alongside widespread EV adoption	5	4	4
4. Governance	**4.1** Impact of different funding streams on technology take-up over time	5	5	5
	4.2 Importance of local aesthetic and effect on decisions for deep retrofit	3	5	2-3
	4.3 Influence of local planning regulations on community-specific energy models	4-5	5	4-5/3
	4.4 "Solving" competing visions of decarbonised heat (e.g. Hydrogen vs Heat pumps)	5	4-5	5
5. Practical obstacles	**5.1** Central and local government future policy on the route to decarbonisation	3	4	3-4
	5.2 Informing policy on how to prioritise retrofit actions and plan technology roll-out over a continuous timescale (e.g. with 10, 20, 30 year targets)	5	4	4-5

Sections 3.1-3.5 mainly focus on presenting workshop findings per theme for the second activity (including some of the comments made in the context of the first activity). It should be noted that the opinions expressed below relate to the responses of the workshop participants, not the authors.

3.1 Occupants and inequality

Accounting for fuel poor households

High-resolution **income and energy cost data** is needed to characterise fuel poverty, and now energy efficiency performance in homes due to the recent change of definition to Low Income and Low Energy Efficiency (LILEE)[2]. Generally, there is detailed information available, but energy efficiency performance certification is problematic and currently under review by UK government. However, fuel poverty is usually described as a binary phenomenon (fuel poor or non-fuel poor) and numbers of those impacted will change with changes in definition. A more representative picture of the extent of fuel poverty would require linkages to other data; this includes **area-level data**, **capital availability**, **employment** and **dwelling type**. This information can be accessed through online public data sets or local councils. The binary nature of fuel poverty combined with the fact that its definition can change very rapidly by the Government means that any household has the potential to move in and out of fuel poverty at any time. Reliability issues also emerge from the uncertainties associated with how data is collected, how often it is updated, and what percentage of this data is inferred rather than actually collected.

Reflecting heating requirements of vulnerable households (e.g. poor health and socio-economic conditions)

The level of importance of this issue for **modellers** depends on the model requirements (technical vs service models). If the model is developed for the private sector (industry), it could potentially be working with fuel poverty as a factor, but this is not usually the main aspect. **For local authorities**

[2] https://www.gov.uk/government/collections/fuel-poverty-statistics

working with fuel poor areas, this is a high priority issue; level of importance is 5 in this case. Local authorities are generally interested in carbon reduction measures. However, although the transition to low carbon is a priority, tackling fuel poverty is also important and should not be overlooked. Even if a specific local authority works for an affluent area, there might still be vulnerable people that should not be left behind. If heat pumps are to be one of the future heating systems, vulnerable households and their ability to adapt their heating requirements is of high importance for **industry** and, especially, service providers. Taking agile tariffs as an example, little effort has been made so far for this particular group of consumers and vulnerable households seem to be a low priority.

- **Heating demand and socio-economic data**

Heating demand data might not be representative or appropriate to understand households with health and wellbeing issues. Socio-economic data could be used instead. This include information accessed through UK census, which could be suitable for identifying indicators flagging up who might be vulnerable. For example, a dwelling's age of construction combined with fuel used and income might be a good indicator for identifying vulnerable households.

- **Definition**

An official and widely accepted definition of energy vulnerability has yet to be established, particularly in a way that is accepted by all parts of the UK. This might be helpful in the quantification of this complex and multi-faceted issue.

Impact of capital availability and willingness on the uptake of energy efficiency measures

This particular factor combined with household preferences for heating technologies is important for **modellers** when defining scenarios, but these issues are not always captured comprehensively in energy models.

- **Heating technology preferences**
  The information for understanding heating technology preferences is usually based on national-scale surveys lacking spatial resolution, so it is difficult to scale the data to local authority and community level.
- **Financial data**
  The Organisation for Economic Co-operation and Development (OECD) database includes data on household disposable income at the national-level. Using this, disposable income can be inferred at higher spatial resolution using other indicators. It might be worth looking for rebound issues especially for the post-Covid period. To quantify/describe capital availability, it might be useful to carry out surveys focusing on households' willingness to invest on different options. This would give an idea on the available interventions and reward. Also, data on saving rates is useful.
- **Funding and incentive schemes**
  Understanding the different funding and incentive schemes provided by both central government and local authorities is important. In this context, using the different incentives and predicting the likelihood of uptake might be helpful to get an insight for this issue. However, the quantification of this data in models is difficult.
- **Conservation areas**
  Other hurdles such as differences in conservation areas might have an important role on the uptake of energy efficiency measures.

Impact of retrofit measures on overheating

Quantitative as well as qualitative data is needed to account for the impact of retrofit measures on overheating risk. Weather data, information on the dwelling's construction, and heating system should be taken into consideration before applying retrofit improvements. It was argued that overheating issues should be avoided if insulation is installed correctly. A good model of the dwelling's pre-retrofit condition is significant for limiting overheating risks after retrofit applications.

Modern thermostat controls will stop heating when the set-point is reached. However, over-insulation could result in overheating during winter heating months especially, for example, if reflecting trends for wood burning stove in addition to insulation and underfloor heating.

It is important to protect consumers (home-owners) in case of overheating issues caused by retrofit applications (especially if these are serious). The discussion focused on whether there is a way to claim this to the company and get compensated.

Both climatic conditions and retrofit installations can result in overheating during summer months; this is especially important for residential buildings, which do not usually have air-conditioning. "Predicting" overheating risks with dynamic simulations might be possible, but good weather data is needed. Generally, detailed building models are required in order to identify overheating risks resulting from the application of retrofit improvements.

3.2 Buildings

Impact of housing market regulations and property value on the uptake of energy efficiency improvements

- **Property values**
  Data on property values can be accessed through estate agents and surveyors, the Valuation Office Agency (VOA), and HM Land Registry. This should be held both locally and nationally at a granular level. Generally, data in this area is considered to be reliable.
  The impact of energy efficiency improvements on property values can be evaluated using information from organisations such as the Royal Institution of Chartered Surveyors (RICS), UK Green Building Council (UKGBC), Green Finance Institute, Nationwide Building Society and Green Mortgages as well as from academic literature. It was argued that this type of data is usually associated with many confounding variables (e.g. labelling, technology type) limiting its reliability.
- **Regulatory impact**
  Based on recent BEIS consultation, the government's preferred policy scenario recommends the introduction of a minimum threshold of EPC C to new tenancies from 2025 and to all tenancies from 2028, this setting the stage for what might happen in the owner-occupied sector. However, there are many issues around EPC ratings. Highly regulated rental economies outside the UK have shown significant impact on energy efficiency figures. New directives around existing homes and EPC ratings might be introduced through the European Green Deal.

Impact of tenure on retrofit decisions

- **Property ownership data**
  This data is held by local councils, housing communities and local government. This includes reasonably reliable information, but some issues around sub-lettings might reduce data reliability.

- **Holiday lettings data**
  Information relating to holiday lettings can be only accessed through informal economy, which obviously raises significant reliability issues.

- **Socio-demographic data**
  Considering wider socio-demographic types/groups (including tenure) and, then, designing retrofit measures that are tailored to these discrete types were identified as being important (e.g. Ofgem energy consumer archetypes). In addition, the stage of an individual's life is a factor that can have a significant impact on decision-making. However, the uncertainty associated with predicting behaviour (from a retrofit perspective) based on socio-demographics might be significant. Generally, socio-demographic data is piecemeal, community-led, and access requires local engagement. Integrating this detailed information into a model is difficult and replication to other areas is another issue for consideration.

Impact of house condition on suitability of specific heating technology installation

- **Building fabric condition/efficiency**
  Fabric condition is considered to be a critical factor for the effective operation of heat pumps. Information to understand the constraints of heat-pump operation relating to poor building fabric efficiency can be derived from multiple sources such as manufacturer data, academic modelling, pilot activities, and user surveys. Data for the fabric condition of the building itself can be accessed through EPCs and National Housing condition surveys, as well as local authorities and councils. The information included in these sources is associated with varying levels of reliability.
- **Heating technology and building fabric mapping**
  Data for mapping existing heating technologies with building fabric efficiency can be accessed through academic modelling projects, Renewable Heat Incentive (RHI) and local authorities. Local authorities, in particular, know the stock and the specific constraints around retrofit measures, which can be extended to technology installations. Again, the information included in these sources is characterised by varying levels of reliability. Useful information can be also gained from a range of available tools and, particularly, models designed to be used by local authorities.
  Interesting comments were made at this point about data localisation. It was generally argued that data for quantifying and describing the above issues needs to be local in order to effectively reflect building stock and household characteristics. One challenge noted was related to formulating methodologies addressing this requirement for localisation. Localised data can be accessed through local councils. In the North-East of England and Orkney Islands Council, this is on-going. It would be interesting to understand whether a local template or methodology might be possible for ensuring that data collection practices meet the needs of the modelling/policy community.
- **Demand/heat mapping**
  Mapping technology and retrofit measures to capacity demand in the grid was raised as an issue. There is not always a clear modelling pathway to bring together these factors.
- **Supply-side assessments at the building-scale**

Another issue that was raised during the discussion is whether low quality and not historically important buildings should be replaced with new housing rather than being retrofitted. In this case, some capital investment saves on operational costs of the energy system and home-owner. It would be useful to find relevant studies in the literature (if any) focusing on the compromises involved in such a project and on whether there are any tipping points from an economic and environmental perspective. If there is strong evidence that replacing low quality buildings with new is a worthwhile consideration/plan, then this would be of high importance for all the three key actors (modellers, local authorities/housing associations, industry) to consider in their work.

3.3 Energy systems

Addressing issues around the best use of renewables (e.g. producing hydrogen vs running heat pumps)

- **Costs, including life cycle analysis.**
  Regarding hydrogen networks, minimal data is available at this stage associated with very limited reliability. On the other hand, some heat pump data emerges from data services such as the UK Data Service (UKDS) and UK Energy Research Centre (UKERC) mainly covering technology trials. However, scaling of this data is currently unknown as only a small number of related data sets are currently available.
- **Weather data**
  Generally, participants argued that this is a well-researched, more robust and familiar area than others. Weather data can be collected through open-access services and APIs such as the Met Office, Climacell Dark Sky and Wunderground. It is essential for users to consider the purpose for which weather data will be used, thus selecting appropriate weather data matching the particular aims of the model. Traditional models usually use Design Summer Year (DSY) and Test Reference Year (TRY) data. Another consideration for modellers is the utilisation of weather data based on probabilistic rather than deterministic weather forecast approaches.
- **Generation data**
  Related data can be accessed through load forecasting services such as DEXTER and RenewableUK. For hydrogen, in particular, generation data can be found in Bloomberg; this includes figures relating to generation and transmission of hydrogen at the international level. However, the representation of these figures in energy models is difficult considering the large uncertainties around the technology mix in the future and demand for each technology; these are linked to uncertainties around learning rates and future costs of low carbon technologies that can decrease rapidly. Also, another source of uncertainty is associated with hydrogen import potential from other regions (e.g. Africa) and associated transport costs.
- **Demand data**
  It was highlighted that accurate demand data is of great importance for modellers to understand costs for a specific technology. This information can be accessed through Distribution Network Operators (DNOs) and smart meter data.
- **Data on existing infrastructure and storage requirements**
  Again, related information can be accessed through DNOs, TNOs (Transmission Network Operators) and National Grid ESO (Electricity System Operator). Although information provided by network operators is reasonably accurate, access permission is not always certain. In addition to that, access to data from privately owned plants is considered to be a far more significant challenge.

Interaction of consumers with time-of-use tariffs and acceptability of smart home heating controls (e.g. noting a desire of demand flexibility)

- **Demand response data**
  Data to explore the behavioural response of consumers to Time-of-Use (ToU) tariffs offered on an

opt-in basis (e.g. heating shut-off) can be accessed through DNOs and energy/flexibility service providers. Although this type of data is considered to be accurate, access is not certain due to the highly sensitive nature of the information included.

- **Data on patterns of household activity, appliances and EVs**
  This information can be inferred from Time Use Surveys (TUS) and smart meter data. As TUS are usually running at a self-reporting basis, consistency and accuracy should be evaluated. The discussion then focused on the need for more frequent TUS as low frequency means the data quickly becomes outdated. It was generally argued that fast-changing behaviours relating to disruptive technology is difficult to be captured and represented through the utilisation of TUS. On the other hand, smart meter data can potentially be processed to investigate household patterns, but this type of modelling would introduce uncertainty.
- **Time-of-Use (ToU) energy tariffs**
  This information can be accessed through flexibility service providers. A good example is the Agile ToU tariff provided by Octopus Energy. Data of electricity rates is available at half-hourly intervals from 2017 to present and for different regions across the UK; this data can be accessed online via an open-access API. Data is considered to be accurate flagging up no reliability issues. It was mentioned that also other service providers offer flexibility schemes, but data is not as forthcoming.
- **Behind-the-meter (BMT) battery storage data**
  This data can be accessed from several projects on technology market trials such as Cornwall LEM project. Modelling is required coupled with the consideration of a large number of external parameters, including costs related to self-consumption value and the value of various flexibility services.

Impact of heat pump size selection and large-scale adoption on the electricity grid alongside widespread EV adoption

- **Peak demand data (including EVs and heat pumps)**
  Peak demand data can be accessed through DNOs and energy/flexibility service providers. Generally, this data is reasonably accurate. However, as mentioned above, due to its sensitive nature, access is not always certain.
- **Data on household patterns**
  TUS and smart meter data can provide useful insights on how people adopt smart technologies with this relating to changes in their daily patterns and peak demands. The uncertainty and reliability issues associated with TUS and smart meter data were mentioned in the previous section.
- **Household economics**
  This includes data derived from ToU tariffs (e.g. Agile), BTM battery economics supplemented by cost data for CapEx (capital expenditure) and other information on available grants, credit availability, etc. However, uncertainty might be significant for some sectors as market and finance data is fast-changing for energy and is strongly linked to policy, change in Government, available budgets, etc. Certainty on cost data relating to each technology group should improve over time, especially when policy intervention is removed.
- **Population density and travelling patterns**
  Regarding the widespread adoption of EVs, on-street parking (city/rural/suburb) is significant, and

this considerably links to population density. In addition to that, average travel distances and commuter patterns is another factor of interest. The required data to describe this issue can be accessed through Census and/or inferred from EPC data, GIS data (Ordnance Survey) and AddressBase (OS). Census is 10-year frequency, and this means that it can be outdated. Also, rates of housebuilding can be very location specific, and they do strongly depend on the type of the location (urban, suburb or rural). Ordnance Survey data is considered to be accurate especially regarding population density (accuracy limitations might appear at far more granular scale).

3.4 Governance

Impact of different funding streams on technology take-up over time

- **Distinction between upfront and on-going funding streams**
  For the different technologies available, there is a need to understand how much funding is coming upfront and how much is coming on an ongoing basis. For the level of upfront-cost funding, performance and compliance requirements are essential, while for the level of ongoing payment funding, smart meter as well as measurement and verification plans are needed. Data for available funding streams can be accessed through central and local government. Also, bodies offering funding and/or managing underlying standards and verification plans such as SAP and Microgeneration Certification Scheme (MIS) have this data. There are many grey areas for early adopters that need to be defined with these being technology -or even product-specific.
- **Funding limitations**
  It is important to understand the particular limitations on the number of funding streams that any investor can utilise and, also, on the eligibility criteria for any investor to access the different funding streams. Again, bodies offering competitive steams could hold this information. Uncertainties can be significant due to lobbying issues affecting policy and available funding that might be fast-changing over time.

Importance of local aesthetic and effect on decisions for deep retrofit

- Restrictions can be forced by local authorities (historical buildings, conservation areas) or by home-owners themselves (e.g. aesthetic issues with heat pumps). Related information is held by local authorities and data can also be accessed through EPCs. Generally, this issue is difficult to be quantified and considered in models in a direct fashion.
- Aesthetic restrictions can be very location-specific with the different local authorities adopting different retrofit approaches. There might be significant diversity in decision-making about whether aesthetic value should be compromised for thermal performance with this resulting in deep retrofit applications to be accepted in one local authority, while refused in another.

Influence of local planning regulations on community-specific energy models

- **Regulation content**
  As also mentioned above, there might be significant differences in regulations between the different local authorities with this increasing the need for developing LA-specific models. Information on this can be accessed through local and central government as well as organisations such as Community Energy Scotland. There might be a significant level of uncertainty associated with how the different actors involved interpret regulations, with this being very difficult to be quantified/described in models. Also, the duration of local planning regulations introduce another

source of uncertainty. Retrofit decisions being made by central government are implemented by local authorities with the latter often experiencing limited resources.

"Solving" competing visions of decarbonised heat (e.g. Hydrogen vs Heat pumps)

- **Technology characteristics**
  Detailed technical information for new technologies is a very important factor from a modeller perspective. This data can be accessed through manufacturers' data sheets and technology trials such as the Energy Saving Trust's field trial study (for heat pumps). The discussion focused on reliability issues around manufacturers' published data. Often, data reliability is considered to be limited due to commercial factors, resulting in simplified data being published. Performance data is provided for ideal conditions and, thus, system characteristics used in models do not reflect reality with this significantly impacting model outputs. There is a varying level of reliability for data derived from field trials (metadata) with reliability issues emerging due to installation errors and poor quality monitoring or data collection practices.
- **Financial data**
  Both capital and fuel costs are needed to compare the different technologies. This type of data can be accessed through organisations such as the International Renewable Energy Agency (IRENA) providing technology costs and future projections and Lazard's providing insightful analysis on Levelised Cost of Storage (LCOS) and Levelised Cost of Energy (LCOE). Another factor to assess for this particular issue is technology-specific funding provided by government to encourage deployment (e.g. RHI data).
- **Information about the wider energy system**
  It is very important for modellers to access and use data covering the varying nature of carbon intensity and electricity prices. This information can be derived from the National Grid, DNOs and energy suppliers and organisations such as Elexon. The level of uncertainty associated with this type of data might be significant particularly regarding price forecasts provided in the horizon of 10, 20, 30 years. Generally, this type of data is sensitive to changes over time arising uncertainty, which should be taken into consideration in models.
- **Thermal comfort**
  Information is needed to understand thermal comfort requirements (and technology acceptability from people). This can be accessed through internal temperature monitoring data, which could be building specific (offices vs residential) or inferred from local community demographics, UK TUS, ONS UK General Household Survey, and Scottish General Household Survey.

3.5 Practical obstacles

Central and local government future policy on the route to decarbonisation

- **Fuel poverty data**
  Information on fuel poverty is needed to better understand implications of policy on this particular group (fuel poor). The discussion focused on the impact that the different fuel poverty definitions have on these figures and on the fact that newer definitions might make fuel poverty quantification too complex. It was pointed out that it is difficult to source all data required to quantify fuel poverty. However, some data can be derived from private households, Home Analytics (HA) datasets, or equivalents. Income data is important, but this is not the sole issue. Billing information can be accessed through notable community energy projects, but data security issues can impede

targeting. Smart meter data is also useful, but similar access issues emerge. It would be very difficult to define data reliability. However, data landscape is much more diverse and granular data does exist.

- **Evidence from existing projects**
  Transparent data on existing projects is necessary including the flagging of negative (or problematic) results, what went wrong, and what were/are the consequences. There are multiple research projects in both industry and academia and useful information can be derived from case studies. However, there are barriers to getting access to data relating to activities that were unsuccessful, resulting in those same mistakes being made again by different parties. Reliability issues exist due to bias of researchers to present positive rather than negative outcomes.
- **National and local data**
  Distinctions need to be made between national and local-level data. There is also a need to get better data from DNOs to better understand issues around grid reinforcement, EV roll out, etc. Detailed sub-station monitoring is important to quantify problems occurring within case-study areas. This is key to demonstration projects that are testing technologies popular in current policy pathways.

Informing policy on how to prioritise retrofit actions and plan technology roll-out over a continuous timescale

- **Net-zero standard**
  Definitions of net-zero are not entirely static, with different qualifications added depending on the application of this standard or the timing of the target (e.g. "Allowable Solutions" once used with zero-carbon homes standard). This can alter strategies and responses to net-zero, as different definitions can stimulate (or dampen) interest in different technologies. Whilst some flexibility in such definitions are not entirely unexpected (or, necessarily, a negative result when considering how energy landscapes change over periods of years/decades), long-term planning for responding to targets (and definitions) requires some degree of certainty and consistency. This is even more problematic if it is felt that definitions change due to political convenience, rather than being informed by research.
- **Data on fuel-switching**
  More data is needed to understand fuel-switching and technology-shifting trends (e.g. are HPs replacing electric resistive heating or fossil fuel based heating). This type of data can be accessed through local authorities and local councils. Further information around success rates and unintended consequences would be useful. Again, quantifying this information is difficult and might require a stage of expert elicitations.
- **Lobbying**
  Finally, the discussion focused on whether policy targets are informed by good modelling or good lobbying (e.g. technology providers/sectors being particularly successful at promoting their own technologies). Furthermore, it was questioned whether there is a definable causation between a policy target being introduced and, subsequently, a tangible action happening "on the ground"; and whether these can be tracked in a robust and useful way. This, in part, links to earlier points relating to the transparency of research and demonstration outputs. Research, be it academic or industry-based, requires a narrator and all such communication has an inherent bias, particularly when the stakes are so high.

4 Community model - ParaDwell

The workshop groups produced wide-ranging outputs that extend beyond the focus of this CESI Flex Fund project, but these are presented here for relevance to research with different scopes. Part of the stimulus of this work was to understand how quantitative building energy models could reflect local issues and characteristics in a more tailored way. Based on the above feedback, *Figure 1* illustrates the relationship between the impact of each sub-topic on modelling output and its ability to be quantified in a robust way within the context of energy modelling. Both the relative impact and ability to quantify are evaluated using a scale of -5 to +5 corresponding to unimportant/important impact and straightforward/difficult (to quantify), respectively. Although the scoring of these are issues are somewhat subjective, they are informed from the detailed discussions and feedback of this workshop and *Table 2* includes a number of brief comments justifying the associated scores for each of the 16 sub-topics.

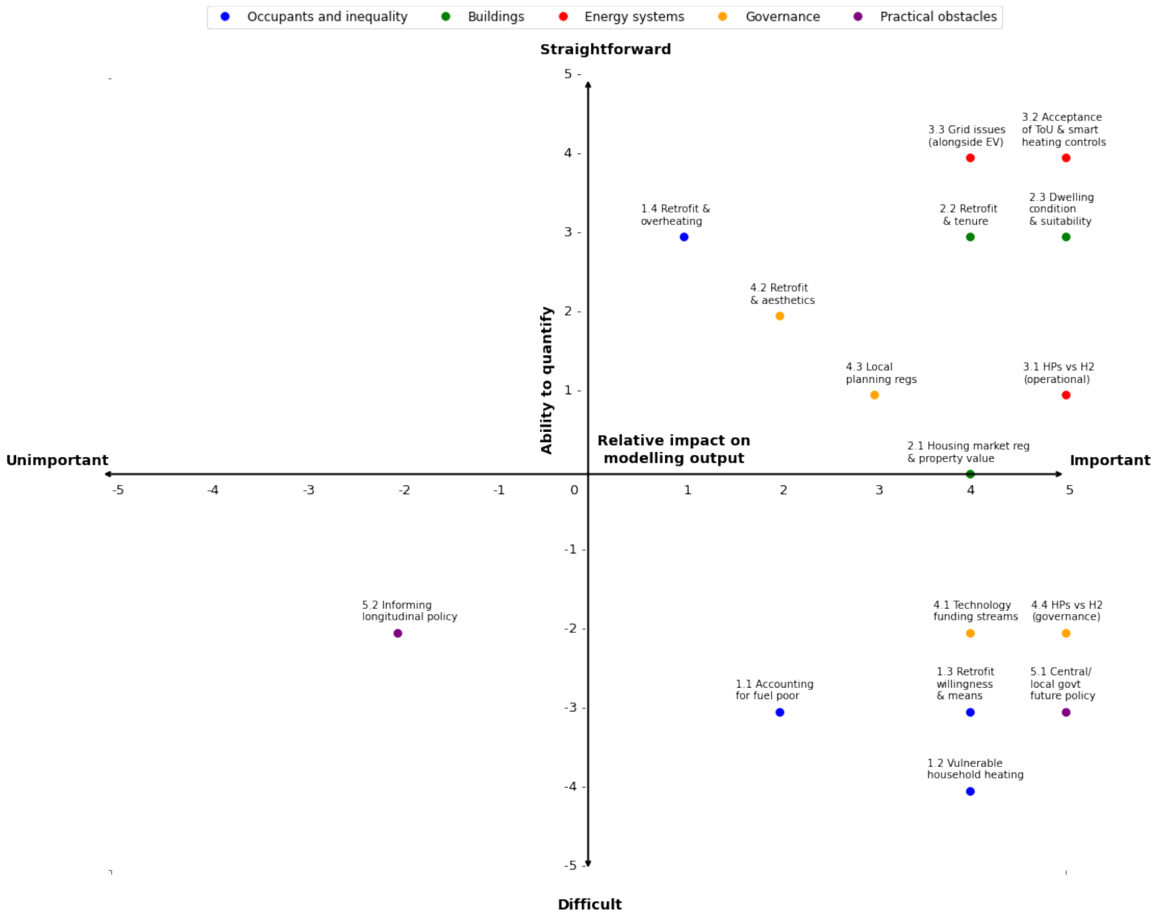

Figure 1: Relative impact of each sub-topic on modelling output against data availability to be quantified in energy modelling

Table 2: Justification of scoring applied to chosen sub-topics

Consideration	Relative impact on modelling output	Ability to quantify
1.1 Accounting for fuel poor households	On its own, not impacting energy output, but would impact future retrofit scenarios (e.g. decarbonisation of fuel poor households is to be prioritised)	Difficult to get household specific data - tends to be generic and usually provided at local level (data-zone level for Scotland)
1.2 Reflecting heating requirements of vulnerable households (e.g. poor health and socio-economic conditions)	Considerable if linked to heating profiles	Difficult to get household specific data - tends to be generic
1.3 Impact of capital availability and willingness on the uptake of energy efficient measures	Future scenario retrofit inputs could be largely different	Would require regional and accessible retrofit data - but also projections of future uptake
1.4 Impact of retrofit measures on overheating	Indirect impacts exist	Almost straightforward to be modelled (e.g. EnergyPlus) and quantified using established overheating criteria
2.1 Impact of housing market regulations and property value on the uptake of energy efficiency improvements	Significant considering EPC rating thresholds imposed, which will, in turn, influence retrofit uptake	Property value data is associated with varying levels of reliability
2.2 Impact of tenure on retrofit decisions	Can significantly impact retrofit scenarios	Straightforward to obtain tenure data at the individual-dwelling level (EPC), but impact on retrofit decisions would require access to retrofit data
2.3 Impact of house condition on suitability of specific heating technology installations	Can significantly impact retrofit scenarios	Almost straightforward to access house condition data through EPCs (or equivalent), but how this is linked to technology suitability would require technology-specific data
3.1 Addressing issues around the best use of renewables (e.g. producing hydrogen vs running heat pumps)	Scenarios about fuel-switching would considerably affect modelling output	Would require future projections, which exist, but they are associated with high uncertainty
3.2 Interaction of consumers with time-of-use tariffs and acceptability of smart home heating controls (e.g. noting a desire of demand flexibility)	Important, linked to heating profiles	Straightforward, high resolution data at the dwelling-level exist and is publicly accessible through extensive technology trials across the UK
3.3 Impact of heat-pump size selection and large-scale adoption on the electricity grid alongside widespread EV adoption	Important if linked to heating profiles and demand response	Straightforward, high resolution data for peak demand exists and is accessible
4.1 Impact of different funding streams on technology take-up over time	Can significantly impact scenarios for technology-shifting	Difficult to quantify, fast-changing policy over time
4.2 Importance of local aesthetic and effect on decisions for deep retrofit	Generally, varying level of importance. Can be significant for conservation areas	Relatively straightforward to access regulation for listed buildings and conservation areas, but aesthetic issues imposed by home-owners are difficult to be quantified
4.3 Influence of local planning regulations on community-specific energy models	Important, can impact future retrofit scenarios	Interpretation of regulation relatively difficult to be quantified within energy models
4.4 "Solving" competing visions of decarbonised heat (e.g. Hydrogen vs Heat pumps)	Scenarios about fuel-switching would considerably affect modelling output	Difficult to quantify the impact of governance-related factors (such as lobbying) driving fuel-switching trends
5.1 Central and local government future policy on the route to decarbonisation	Important for future retrofit scenarios	Would require local-level information and a stage of expert elicitation
5.2 Informing policy on how to prioritise retrofit actions and plan technology roll-out over a continuous timescale (e.g. with 10, 20, 30 year targets)	Questionable whether modelling influences policy in reality	Would require expert elicitation to understand fuel-switching and technology-shifting trends

5 Summary

This workshop has endeavoured to bring together a wide range of factors that influence the construction of community energy models and, more generally, assumptions on planning for a low-carbon future. As with any workshop or focus group, the presented results are a product of a relatively small group of attendees and, therefore, it cannot be guaranteed that the list of factors presented here are exhaustive. However, this CESI Flex Fund – collating responses from both an interview stage and workshop exercise – has highlighted tangible issues (and, potentially, barriers) to forming useful and actionable models for future low-carbon communities. With urban/community energy modelling currently being an active and fertile research area, and particular attention being focussed on policy initiatives to enact genuine and scalable change in our building stock, the issues discussed in this report are proposed as being of significant importance to energy modeller as we move towards more challenging carbon targets.