RCUK Centre for Energy Epidemiology

Department of *Science, Technology, Engineering and Public Policy*
UCL STEaPP

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UK Energy Lab:
Feasibility Study Final Report

August 2014

Annex A – The Benefits Case

Authors
David Shipworth
Adam Cooper

With input from
Alun Humphrey
Tadj Oreszczyn
Philip Steadman
Michelle Shipworth
Anni Oskala

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1. Aim

The aim of this workstream is to establish the policy evaluation, research and cost-benefit case for the establishment the 'UK Energy Lab' - a repeat-wave nationally representative socio-technical survey for understanding energy use in homes and workplaces across the UK. The UK Energy Lab as a whole has the aims of helping to inform and evaluate national energy policy, and to provide a platform for energy innovation and wider research.

This workstream has drawn on the work of the other elements, and has been combined with input from meetings with stakeholders on their needs for new data in this space. It identifies the perceived gaps as viewed by academic and policy audiences and to what extent can a longitudinal panel address those gaps. A key consideration has been the role of the UKEL in supporting broader energy policy and energy research landscape objectives.

2. Objectives

The work undertaken in this workstream of the overall project aimed to achieve 5 objectives:

1. To review recent energy landscape policy documents to determine the relative prioritisation given to data-collection in the national energy research landscape.
2. To conduct a gap analysis on the existing major surveys bearing on energy use in the home and workplace to identify where a major new national survey should lie, and which other surveys it could complement.
3. To conduct workshops with key policy and academic stakeholders in order to identify the primary policy evaluation and research objectives that the UK Energy Lab should address.
4. To engage with key funding bodies to determine the feasibility of securing sufficient funds to establish and conduct the first one or more waves of, such a repeat-wave/longitudinal study.
5. To identify likely key components in such a survey including: a social survey component; a physical survey component; and deployment of environmental monitoring equipment.

3. Work undertaken

The work has proceeded through four broad stages.

1. A review of recent energy landscape policy documents including:
   - Skea, J.; Hannon, M. & Rhodes, A. (2013) 'Investing in a brighter energy future: Energy research and Training Prospectus', RCUK Energy Programme Energy Strategy Fellowship, http://www3.imperial.ac.uk/rcukenergystrategy, November 2013.
   - IEA, Tracking Clean Energy Progress 2013: IEA Input to the Clean Energy Ministerial, http://www.iea.org/publications/TCEP_web.pdf.
   - DECC (2012) 'DECC science and innovation strategy 2012', DECC, April 2012.
   - DECC (2014) 'Developing DECC's Evidence Base', DECC, January 2014.
   - Low Carbon Innovation Coordination Group (LCICG) (2012) 'Technology Innovation Needs Assessment (TINA) - Domestic Buildings Summary Report' November 2012.
   - Low Carbon Innovation Coordination Group (LCICG) (2012) 'Technology Innovation Needs Assessment (TINA) - Non-Domestic Buildings Summary Report' November 2012.

2. The conduct of a series of workshops for policymakers and the academic community.
   - A workshop with DECC (mainly the Energy Efficiency Deployment Office, EEDO) representatives on 21 March at DECC.
   - A workshop with academic stakeholders on the 5th of June at UCL.
   - A workshop with academic stakeholders on the 17th of June at Loughborough University.
   - A poster presentation and discussion at the End Use Energy Demand Gala event in Lancaster on the 3rd of June.
   - Individual discussions with academics were conducted throughout the lifetime of the project.

3. Taking presentations on the case for the UK Energy Lab to potential funding bodies' key decision makers and key decision-making fora.
   - A paper was presented to the Low Carbon Innovation and Coordination Group (LCICG) on the 1st of April 2014.
   - A submission to the Department of Business, Innovation and Skills Science Capital consultation on the 2nd of July.

4. Establishment of the primary components necessary to include within the UK Energy Lab.
   - This is covered in the Methods and Design section of the report.

This work has been synthesized into Section 3 of the Synthesis report and is expanded below where the four key arguments from the perspectives of the energy policy and research landscapes are developed more fully.

4. Energy policy and energy research landscape arguments

a. Reasons to have a UK Energy Lab

Effective management of a rapid decarbonisation transition

The UK's ambitious carbon reduction plans see energy use in homes almost fully decarbonised by around 2040. This will require unprecedented rates of change how we supply and use energy in homes (~30% of final energy demand). However, we currently have no mechanism to monitor, understand, or manage such changes in home energy demand over time. We have no means to measure emerging trends in energy use, how cohorts use energy differently, how demographic changes impact on energy, or how people and buildings interact to create energy demand. Unless we measure, we can't manage this national scale wholesale energy transition effectively.

The transition to a largely decarbonised stock of homes will require rapid changes in the physical form and fabric of dwellings, the technologies used to generate energy (and both national and local scales), and the way people use these dwellings and technologies to create comfort in their homes. Failure to understand the integration between fabric, technology, and occupant behaviour, will lead to solutions which significantly under-perform against their potential, and against policy expectations.

To put the speed of this transition in context, it is a period equivalent to one generation, around two boiler replacements, approximately four times the average time a household stays in a dwelling (~7 years), or 5 fixed-term parliaments. To effect change at this rate requires ways of measuring and monitoring energy that can track the rate at which different groups (cohorts) change energy demand, explain how they differ, why they differ, and provide insights into how we may accelerate positive changes and counteract negative ones.

Longitudinal designs are much more sensitive to change – since they track change at an individual as well as group level. This means you can start to see developments (both emerging risks and opportunities) much sooner than with cross-sectional. The individual level data also then enables you to take a much more nuanced understanding of the different kinds of groups depending on their current state and how that relates to previous states, giving a much clearer sense of possible customer journeys and therefore what kinds of policy drivers are much more likely to work given the naturally occurring changes.

Cross sectional designs at a national level can provide a 'clean' picture of the overall system – a snapshot – at specific points in time. This is clean in the sense that because participants have not been involved in the study before they are providing data and are therefore less prone to panel conditioning. The UK Energy Lab intends to address panel conditioning through recruitment of panel top-up participants in each wave in order to check unconditioned (cross-sectional) participants' responses against potentially conditioned panel members' responses. In summary, a

predominantly longitudinal design allows us to build powerful explanatory models of how and why energy use changes over time.

Minimising overall energy system infrastructure deployment financial costs and political risks

The costs of retrofitting and upgrading buildings, installing distributed generation systems, and smart-energy control systems to decarbonise the residential sector is in the hundreds of billions. The provision of detailed, disaggregated, data for better targeting the upgrading the energy system, from building retrofit, to installation of distributed generation at the home or district scale, to smart-energy infrastructure is therefore of paramount importance in minimising the overall financial costs and political risks of meeting the decarbonisation targets. This requires understanding how to match the physical form and fabric of dwellings, to technically appropriate heating systems, and to consumer segments that will accept and use these systems appropriately. This is an intrinsically socio-technical issue, as we know that prior experience of heating and control technologies influences acceptability of new systems, and that, for example, the efficiency of heat pumps is influenced by the thermal time-constant of the dwelling.

These effects make both the matching, and the sequencing of interventions critical to efficiency and acceptability of large-scale energy system programmes. While these interactions are known from case studies, they have never been quantified at the National scale in ways that would allow development of National scale programmes, or in ways that would allow for the identification of target market segments from available data. The need for understanding sequential effects necessitates the longitudinal nature of a UK Energy Lab, while the need to understand social as well as technical feasibility and their interactions necessitates the socio-technical nature of a UK Energy Lab.

Driving much better value out of existing investment in energy research

UK public sector R&D expenditure on energy research has risen sharply in the last decade with current spending around £300 million per annum. This expenditure has gone into a large range of initiatives across organisations including DECC, RCUK, TSB, ETI, Ofgem, Carbon Trust and others. These recent initiatives can be categorised broadly along the following lines:

- **Whole energy systems modelling initiatives**, such as the RCUK funded Supergen-HubNet, WholeSEM, and Infrastructure Transitions Research consortia, that focus on building fundamental modelling and simulation capacity for smart grids, whole energy systems, and infrastructure transitions at points 1 & 2 on the TRL Scale.
- **Whole energy systems research and development initiatives**, such as the ETI Smart Systems and Heat Programme, the TSB Energy Systems Catapult, and the TSB Energy Systems Innovation Platform, that focus on whole energy systems product and technology development and commercialisation along points 3 to 6 on the ‘technology readiness level’ scale.

- **Big data initiatives** such as the TSB Future Cities Catapult and the Digital Economy Catapult that look to collate, analyse and exploit existing and emerging data streams.
- **Smart-grid initiatives** such as Ofgem Low Carbon Network Fund Tier I & II projects, and forthcoming RIIO projects, that support innovation in the UK's energy transport infrastructure.
- **Other energy research initiates** such as the TSB/RCUK/DECC Energy Catalyst; UKERC Phase III; BuildTEDDI; and individual RCUK projects that range in aims from research synthesis into policy, through to specific technical development challenges.

Collectively, these initiatives vary in their aims, but none of these initiatives provides, or plans to provide, a fundamental overview of energy demand in homes at the national scale, or its social, physical and environmental drivers and their rates of change. Each of these initiatives however, will be significantly enhanced through having access to such data. Whole energy systems modelling initiatives take as inputs baseline data on energy demand, and to date have had little and often poor quality data on disaggregated rates of change in energy demand with which to ground and calibrate their models. Similarly, whole energy systems research and development initiatives currently lack the detailed disaggregated data on energy demand, broken down across dwelling type, technology type, and socio-demographic segments, that would allow them to correctly target interventions to market sectors in ways that are both technically and socially acceptable.

Big data initiatives are currently reliant upon sources of administrative data, or modelled data, of unknown accuracy and precision. Recent discoveries of systemic biases in modelled data, such as the systemic mis-estimation of the U-values of solid wall properties, has drawn particular attention to this issue and its impact upon policy formation. The broader research initiatives and those directed towards smart grid research are carried out through a range of projects targeting individual technologies or specific market sectors, and these require the ability to contextualise their findings against a high resolution disaggregated picture of energy demand at the national scale. The creation of a UK Energy Lab would provide harmonised methods of measurement, and the statistical backcloth against which such studies can be positioned, and from which the required high quality national scale data can be provided.

Creating a focal point for understanding energy

The workshops held across government departments and the academic community identified the common need for high quality, disaggregated, socio-technical data on energy demand. The government driver was the need for strategic oversight of how energy is used across all major household and dwelling combinations differentiated by energy end use in the home. The academic driver was the need for a 'statistical backcloth' into which smaller scale studies could be attached in order to contextualise these studies against the national picture. There was common concern that this data be provided to national statistical standards, in a timely manner, and to known degrees of accuracy and precision that took into account instrument

accuracy as well as sampling errors. All parties wanted the capacity to disaggregate the data by household characteristics, dwelling characteristics, heating system technology characteristics, geographic region, and have disaggregated end use energy demand data within the home. Government sought the capacity to differentiate between such sectors to within a few per cent, whereas academics sought a resolution of ideally one per cent.

Current sources of data on energy use in homes (The EHS & EFUS; the NEED; The National Household Model; The Cambridge Housing Model) do not provide the understanding of change over time, the statistical capacity to disaggregate confounding effects, nor the comprehensive coverage necessary to serve government needs of policy development and evaluation, or academic needs for explanatory statistics of energy demand covering human, physical and environmental factors. The research design for a UK Energy Lab would address this by linking social, behavioural, physiological, psychological and health data about the occupants (social/human data), with physical surveys of the dwellings' form, fabric and technologies (building data), with monitoring of environmental conditions in the dwelling (environmental data), and high quality energy data from smart-meters disaggregated into end uses (energy data). This would provide the data needed for significantly improving national housing stock modelling initiatives such as the National household model, the Cambridge Housing Model, as well as underpinning better whole energy systems modelling initiatives such as Markal/UK Times/ESME and the work of the WholeSEM consortium. This would strengthen the UK's capacity in decarbonisation scenario planning thus supporting energy policy strategy.

In addition to these key energy policy and energy research landscape arguments, the range of additional specific arguments for a facility like the UK Energy-Lab are outlined below. These are repeated from the Synthesis report Section 3 above to make this Annex a self-contained exposition of the benefits case.

5. Key stakeholder functions

In addressing these arguments, a UK Energy Lab would be able to deliver the following key functions to different stakeholders.

a. The policy community

- A strategic oversight of how energy is used across all major household and dwelling combinations resulting in a significantly better understanding of energy use and drivers than at present, and greatly enhanced empirical, disaggregated, end use energy demand trend data.
- An 'observatory' capacity, highlighting emerging trends in energy demand that will enable more rapid identification of emerging opportunities and risks associated with energy demand from this key sector.
- A policy evaluation capacity, to assess how national and regional energy demand reduction policies and programmes are working on the ground. Providing earlier, more disaggregated, and more comprehensive information on whether policies are working as intended. This will reduce the need to commission policy-specific evaluations in many instances.
- An omnibus capacity, to add specific, policy related questions in individual or a short series of survey waves. This could both reduce the costs of doing independent surveys, and add enormous value through leveraging the existing knowledge about participants in a UK Energy Lab.
- An 'innovation lab' capacity, allowing direct testing of policies and technologies in a linked, but quarantined, representative sample of homes. This would remove the need to commission many small detailed technical studies independently as is currently the case. This would result in much better pre-intervention data, much better data on the performance of the technologies in-situ, and much easier and quicker deployment into the field testing environment, keeping it relevant to policy timescales.
- Providing an authoritative reference source of data for adjudicating disputes on the major issues and opportunities affecting UK energy demand in homes, and an authoritative source of evidence for convincing stakeholders of the need for specific policies or standards.
- Understanding the wider, non-energy, costs and benefits of different approaches to distributed energy generation and energy efficiency, for example on physical and mental health, workplace productivity, education outcomes, and others. This will support contextualising residential energy policy within wider policy priorities, assisting in understanding where synergies could lie between the goals of policies in different spheres. For example, identifying, understanding and tracking the fuel poor in order to understand the wider implications of fuel poverty that may fall across the remit of other government departments.

b. The research community

In fulfilling the primary criteria outlined in Section 4 above, a UK Energy Lab will be able to deliver the following key functions to the research community.

- A 'statistical backcloth' - providing national data for contextualising other studies.
- Benchmark methods - establishing harmonised methods of measurement.
- Uncertainty quantification - determining uncertainty as a function of measurement method and providing measurement models for use by the academic and professional communities.
- An omnibus capacity, to add specific research questions in individual or a short series of survey waves.
- A catalytic capacity, by providing a focal point for the end use energy demand in homes community through engaging in the governance processes of, inputting into the design of new instruments for, and participating in the analysis of the findings from, the Energy Lab.
- Providing the opportunity to exploit learning from natural experiments (energy price rises, extreme weather events, international energy events, etc.) and deliberate experiments (through the innovation lab capacity), at sufficient scale, and with sufficient understanding of the uncertainties, to differentiate between the impact of such events and noise in the data.

6. Adding wider value

a. Nationally

- Allowing energy field-work and trials funded through RCUK, Ofgem, TSB, ETI, Carbon Trust and others to use rigorously developed and tested standardised methods, to harmonise with UK Energy Lab, to quantify uncertainty, and to contextualise their findings against National data.
- Improving our socio-technical understanding of energy use in homes, with the consequence that other, more targeted studies can be executed to higher standards through drawing on better instruments, and contextualising against better data, in order to deliver more robust findings for policy, industry and academia.
- Reducing trial costs through providing an 'innovation-lab' facility with homes of known National representativeness from known socio-technical market segments.
- Reducing energy surveying costs through provision of an omnibus survey leveraging all the data collected from UKEL participants.
- Increasing business development and growth advantages through identifying technology spaces into which they can innovate.
- Reducing the cost of policies and programmes through better targeting of energy efficiency expenditure.

b. Internationally

- Demonstrating how Advanced Metering can be used to enhance data on energy use in homes with applicability across the EU through the Energy Efficiency Directive.
- Developing new methods of measurement and analysis of energy use in homes with applicability across government and industry globally.
- Being done in accordance with the new EU Energy Statistics Regulations providing learning benefits across EU in the implementation of these.
- Developing and disseminating best practice in energy demand measurement, analysis and reporting.

7. Questions a UK Energy Lab could answer significantly better than existing data or methods

A UK Energy Lab will potentially allow us to answer the following sorts of questions. These questions have been developed from the consultations with the energy policy and energy research communities and contain an extended list of questions outlined in Section 3 of the Synthesis report. It should be noted that which questions are ultimately answerable by a facility like Energy Lab would depend on a range of factors including the interest of the funding bodies and the final choices of survey questions and monitoring technologies deployed.

Energy landscape questions:

- How do people use energy in their homes?
- How and why is home energy use changing over time?
- Are we making progress in reducing energy demand, and if so what is driving it?

Deep explanatory questions

- How do households and dwellings influence each other to determine energy demand?
- We can only explain around half the observed variance in home energy consumption, what factors do we need to explain the other half?
- When energy demand changes, how much is due to planned events and how much is beyond our control?
- What do people do when they get too hot or cold at home?
- How does energy demand change when you have a baby?
- How does energy demand change when the kids leave home?
- How do life stages and life histories influence home energy use?
- How much of take-back is due to building physics and how much is due to occupant behaviour?
- What educational/life-historical factors lead to lower energy use in homes?
- How do occupants' previous heating technology histories impact on their use of their current heating system or acceptability of new heating systems?

Policy relevant questions:

- Which households will respond positively to Time of Use energy tariffs?
- Is better to retrofit a smaller number of homes to a higher standard, or a larger number to a lower standard?
- Why does energy use increase after retrofit in some homes and not in others?
- Is air conditioning use going to increase as we drive up building regulations?
- Can we measure changes in energy use accurately enough to measure the effect of a policy with a 1% impact?
- Are SAP and EPC surveys sufficiently accurate and precise for the uses to which they are current put?
- How does energy use change as people move in and out of fuel poverty?

- Are building regulations delivering the expected energy savings?
- What is the impact on energy use behaviours of occupants or dwellings moving in and out of the private rented sector?
- Can inferences from smart meter data help us determine how to best retrofit a home?
- How does infirmity impact on our capacity to manage different heating systems?
- Are energy savings from interventions maintained when different occupants move into the dwelling?

Energy and environmental health questions:

- Does how we heat homes effect occupants' metabolism?
- Does the pattern or level of heating impact on physical and mental health?
- What effect does invalidity and/or disability have on home energy use?
- Are certain retrofit or new construction strategies healthier for occupants than others?

Energy futures questions:

- How do generations, or cohorts differ in the their energy consumption pathways over time? Will tomorrow's retirees differ in their energy consumption from todays?
- What are the implications of the average seven year residency period of UK households in dwellings on the efficacy of retrofit measures?
- What is the extent and impact on energy use in homes from social trends like the collaborative economy or working from home?
- How far into the future can we predict demand based on current trends?
- How does energy demand differ by type of home, how are these segments going to evolve into the future?

Methodological questions:

- Where can investments in developing new methods deliver greatest impact in increasing our understanding of energy use in homes?
- How can we measure 'practices' in ways that explain variation in energy use?
- How can we improve the accuracy of SAP/EPC surveys?

In conclusion, the size, structure, and content of the proposed UK Energy Lab is driven out of addressing needs that are not satisfied by existing data sources. This has led to the proposal for a new UK energy survey that is: focused on homes; national in scale; primarily longitudinal; intrinsically socio-technical; covers social/human, building, environmental and energy data types; and able to resolve effects to within a few per cent between policy and academically relevant segments of the population.

In order to address the need for an inherently socio-technical approach, the survey would focus analytically on the social functions of energy demand in homes, e.g. comfort, cleanliness, cooking, entertainment, information seeking, etc., as a way of structuring demand into socially meaningful activities and providing a conceptual

architecture for bringing the human, physical, environmental and energy data together.

In order to address the need to quantify uncertainty, and to maximise the efficacy of the research design, it is recommended that a UK Energy Lab adopt a hierarchical (or 'concentric ring') structure across three levels. This is addressed in Section 4 of the Synthesis report and in **Annex C** on Methods and Design. This structure supports efficient quantification of uncertainty in the data collected across the whole sample, through monitoring smaller numbers of homes more intensively, and making well calibrated and tested statistical models that leverage the power of smart meter data to infer information of known accuracy in the larger sample. This will make the survey more cost effective, adaptable, and to allow us to quantify uncertainty in our data and others' data. It would also be designed in concordance with the new EU Energy Statistics Regulations and to comply UK National Statistics standards.
We believe that this structure will allow us to create powerful market-segmentation models, addressing interaction and sequencing effects, telling us how to target interventions that are both socially relevant and technically efficient.

8. Review of key energy landscape documents

Major recent reviews of the energy research landscape in the UK have consistently identified lack of data on the energy use, and the drivers of energy use, in homes and workplaces as being a strategic weakness in our understanding of energy demand.

Skea *et al* (2013) in their in their energy research and training prospectus 'Investing in a brighter energy future' make four specific recommendations that bear directly on the case for establishment of UK Energy Lab. These are:

> *"No.7. In developing their Strategic Plans, the research councils should plan beyond the time horizons associated with budgetary cycles to enable long-term investments in infrastructure, surveys, trials and experiments to be exploited fully. Strategies should take account of long-term energy policy goals and associated uncertainties. Long-term plans should be flexible, should not be seen as establishing firm budgetary commitments and should be reviewed at regular intervals."*
>
> *"No. 8. The research councils should be prepared to make selective longer-term research investments of 10 years or longer, subject to rigorous stage-gating procedures, where there is clear evidence that scientific benefits cannot be realised on shorter timescales. Examples include field trials for crops, cohort studies in the social sciences and the evaluation of the impacts of policy interventions."*
>
> *"No. 20. The RCUK Energy Programme should continue to support ambitious interdisciplinary research initiatives."*
>
> *"No. 21. The research councils, especially the Economic and Social Research Council (ESRC) and potentially the Arts and Humanities Research Council (AHRC), should consider how disciplines which have not traditionally contributed to energy research could be engaged. Putting in place a process for mapping out potential contributions would be a good starting point." (p.v-vi)*

They also make three further specific recommendations relating to the need to establish improve data collection through field trials:

> *"There is a widespread understanding that high quality research which builds on what went before is underpinned by effective data collection, curation and sharing. Two themes emerged from our workshops, the first relating to perceived gaps in data collection and curation, the second to data curation and sharing. The biggest data gaps were considered to be in the area of energy consumption, echoing generic conclusions reached by the IEA.39" (p.37)*
>
> *"The importance of supporting field trials and environmental monitoring emerged in several area of energy research [including] energy efficiency interventions. In most of these areas, long-term monitoring (10 years or*

> *more) might be needed to gain an adequate understanding of outcomes." (p.39)*
>
> *"…During our consultations, we identified two ways in which scientific benefits … could result from the adoption of longer term perspectives. These are: a) the adoption of research strategies that extend beyond the budgetary cycles associated with CSR periods; and b) field trials and experiments where the full consequences cannot be assessed within, say, a five year period." (p.39)*

In addition to this, both the Low Carbon Innovation Coordination Group's (LCICG) Technology Innovation Needs Assessments (TINA) for Domestic Buildings and Non-Domestic Buildings identified improved data on energy use in operational buildings as being the primary case for UK public sector intervention. The 'Domestic' TINA notes in its 'Key Findings':

> *"Innovation in the domestic buildings sector represents a significant opportunity to help meet the UK's greenhouse gas emissions targets as well as providing value through avoided energy costs, amounting to savings of 73MtCO2 and c. £16bn by 2050. Innovation could also help create export opportunities that could contribute an estimated £1.7bn to GDP to 2050. Public sector support will be required to unlock this value, as there are significant market barriers across the sector to overcome."*

Under *The case for UK public sector intervention*: two of its four points relate to the need for data:

> *"1. Market barriers exist across the buildings value chain, stifling innovation and progress in improving the energy efficiency of domestic buildings. These include a lack of high-quality data, split incentives between various actors, and regulatory uncertainty....*
>
> *4. Gathering data on actual building performance in-use is vital and should be encouraged to understand the value of energy savings, as well as to innovate and implement measures effectively. Split incentives between different actors in the value chain currently prevents this from happening."*

The Non-Domestic TINA report similarly notes under its Key Findings that:

> *"Innovation in the non-domestic buildings sector represents a significant opportunity to help meet the UK's GHG emissions targets, as well as providing value through avoided energy costs, amounting to savings of 86MtCO2 and c. £13bn by 2050. Innovation could help create export opportunities that could contribute an estimated £1.7bn to GDP to 2050. Public sector support will be required to unlock this value, as there are significant market failures across the sector to overcome."*

Under *The case for UK public sector intervention*: one of its four points relates again to the need for data:

> *"Gathering data on actual building performance is vital to understand the value of energy savings, to implement measures effectively and to overcome split responsibility between different actors in the value chain."*

Similarly, DECC's 2014 'Developing DECC's Evidence Base' cites the central role of data: "Given the scale and complexity of the challenges, cost-effective access to an extensive, relevant and robust evidence base is crucial."(P.4) This is particularly important for the construction and calibration of robust models of energy demand in buildings. As this Evidence Base review recognises, there is a critical lack of data on energy use in homes and workplaces. Further to this, both DECC and academic analysis shows that we can only explain around half the observed variation in energy use in buildings using existing datasets such as NEED, or research data sets such as the EHS/EFUS. This leaves us with a real weakness in being able to target interventions accurately based on socio-demographic, occupant behavioural, building-demographic, and technical system data.

9. Summary of the Policy consultation

A Policy workshop was held on 21 March 2014 at DECC and a paper was presented to the Low Carbon Innovation and Coordination Group (LCICG) on the 1st of April 2014. The broad aims of the events were to gain feedback on the policy drivers for, and structure and high level content of any new survey in this field.

Participants (attendees and invitees) included

- Jon Saltmarsh (Science and Innovation);
- Sam Jenkins (Fuel Poverty & Smart Meters);
- Samuel Thomas (DECC);
- Sarah Meagher (Energy Efficiency Deployment Office);
- Stephen Oxley (Energy Efficiency Deployment Office);
- Daniel Alford (Energy Efficiency Deployment Office);
- Beth Moon (Energy Efficiency Deployment Office);
- Michael Harrison (Smart Meters Programme Delivery);
- Ian Ellerington (Science and Innovation);
- Ian Llewellyn (Science and Innovation);
- David Johnson (Green Deal);
- Jon Warren (Science and Innovation);
- Mark Ewins (Fuel Poverty & Smart Meters);
- Andrew Culling (Energy Efficiency Deployment Office);
- Katherine Macdivitt (Heat & Industry);
- Marianne Law (Heat & Industry);
- Matthew Baumann (Economics);
- Alexander Boss (Science and Innovation);
- Mary Gregory (Statistics)
- Julian Prime (Statistics)

Amongst the policy officials and analysts attending there was unanimous agreement for the need for better data in this field. At the broadest level, this need was summarised by the question “Which energy efficiency measures perform well and why?”, and the need for a mechanism that would allow the findings from a range of smaller scale studies to be scaled up and contextualised into the national picture. When asked to prioritise the various components proposed for the UK Energy Lab there was a clear consensus that the emphasis needed to be on establishing high quality, nationally representative, end-use energy demand data at a sufficiently disaggregated level. The level of disaggregation should enable policies to be developed or evaluated that could be applied to building types or social segments at the national scale. Ideally, energy end use would be at the level of social purposes (heating, hot water, lighting etc). This was primarily driven by the need to be able to provide DECC with a strategic capacity to understand how energy demand was changing within buildings at the national scale. Also thought essential was the ability to be able to understand the human, physical, and environmental drivers of energy demand. Proposed components of the UK Energy Lab that were thought desirable, but less essential, include the provision of an Innovation Lab facility, and an Omnibus

capacity. Opinions on the importance of these varied between delegates, with those in charge of delivering technical programs of change rating the provision Innovation Lab function more highly. While the importance of understanding the Non-Domestic building stock at the national scale was recognised, it was also felt that the logistics involved in trying to construct such survey outweigh the potential benefits at the present. It was also noted that the BEES surveys had recently been commissioned and would provide additional data in this regard. It was recommended that the importance of the non-domestic stock be downgraded in the further design of the survey.

Questions regarding the nature of the data to be provided from a UK Energy Lab were discussed at some length. In terms of precision, it was felt that a minimum accuracy of 3 to 4% for distinguishing the impact of programmes between regions, socio-demographic, or building demographic segments was an appropriate balance between the levels of accuracy required for practical policies, and the costs associated with achieving higher levels of precision. With regard to the time frames within which data were provided it was felt that these will vary from quarterly through to annually depending on the nature of the data. It was recognised that there were challenges arising from providing data at a higher temporal frequency than annual, including the need to make seasonal adjustments to data published at more frequent intervals, and that the additional costs incurred through the processing and publishing of interim reports.

The opportunity for data linkage was discussed and smart meters were identified as an obvious point of connection. In addition it was recommended the opportunity to link to HMRC data, and Benefits Record data, be considered. It was noted that this would need to be tensioned against potential impacts on recruitment and retention as collection of this data may adversely impact on participation in the study.

Attention was drawn to a range of issues including the following.

- The need to distinguish this initiative from others such as the TSB Smart Cities catapult, the TSB Energy catapult and the ETI Smart Systems and Heat programme, amongst others.
- The need to link data relating to the household and data relating to the dwelling.
- The need to be able to capture data from those people who had been through particular government policies and programs.
- The need to be able to identify particular patterns of energy demand in the context of managing the smart grid peak shifting and peak shaving.
- The need to be able to address key policy questions in areas such as the impact of Fuel Poverty policies and programs, assess the impact of changes in Building Regulations, and the potential for overheating arising from a combination of climate change and improvements in building regulations were all considered important. Additional areas considered important from a policy perspective where programmes aimed at the community scale, the provision of heating networks, distributed generation and product policy.

In addition to the policy workshop held with DECC and EEDO, a paper (provided below) was presented to the Low Carbon Innovation and Coordination Group (LCICG) on the 1st of April 2014 and discussed as an agenda point. **There was immediate in-principle support for the initiative from the ETI and BIS, and unanimous agreement that a facility of this kind is of interest from all members**. It was agreed that the LCICG would like to see more detail reported to future meetings.

10. Summary of the Academic consultations

Two academic workshops were held, one on the 5th of June at UCL, and one on the 17th of June at Loughborough University. In addition a poster presentation and discussion was held at the End Use Energy Demand (EUED) Gala event in Lancaster on the 3rd of June and individual discussions with academics were conducted at other times.

The broad aims of the events were:

- To inform the academic community of the UK Energy Lab feasibility project and its aims.
- To get an academic perspective on the feasibility of setting up a major new repeat-wave socio-technical survey for understanding energy use in homes and workplaces across the UK.
- To engage the community in assessing the need for, desired academic goals of, and structure of, any such new survey.

Attendees and invitees at the academic community workshops were as below, with additional academics consulted at the EUED Gala events and through individual meetings.

- Alun Humphrey (NatCen)
- Gary Raw (UCL)
- Jason Palmer (Cambridge Architectural Research)
- Michelle Shipworth (UCL)
- Gavin Killip (Oxford ECI)
- Nigel Goddard (Edinburgh)
- Tadj Oreszczyn (UCL)
- Jim Skea (Imperial)
- Steven Firth (Loughborough)
- Kevin Lomas (Loughborough)
- Vicky Haines (Loughborough)
- Simon Taylor (Loughborough)
- Andy Gouldson (Leeds)
- Jeremy Watson (UKERC)
- Nick Pidgeon (Cardiff)
- Nick Buck (Essex)
- Nigel Gilbert (Surrey)
- Harriet Bulkeley/Gareth Powells (Durham)
- Josh Thumim (Centre for Sustainable Energy)
- John Hills (LSE)

Amongst those academics consulted, there was unanimous agreement on the need for a new survey instrument at the national scale able to collect socio-technical data on energy use, the drivers of energy use and how they change over time. Particular attention was drawn to the fact that existing data sources the national scale provided an inadequate basis on which to try and explain why the observed changes

in energy use were occurring. In this context, the longitudinal nature of the UK Energy Lab project was seen to be of upmost importance. Additional aspects drawn out were the need to provide a "statistical backcloth" against which the findings from other studies could be contextualised and for which the uncertainties in the data could be quantified. It was suggested that consideration should be given to the incorporation of a qualitative component at level 3 of the design to support understanding why observed changes were happening.

Particular attention was drawn from those with energy field trial experience to the need to ensure that adequate time and resources were allocated to the development and testing of instruments prior to commencement of the study. Experience from field trials such as that recently commissioned by the ETI under the Consumer Behaviour and Response component of the Smart Systems and Heat programme, and the ongoing work under the RCUK BuildTEDDI programme, led to the universal comment that monitoring energy consumption in homes was always far more challenging than initially expected. There was also strong encouragement to ensure that sufficient time was left for pilot testing the monitoring equipment and the communication technologies for logging the data. Attention was also drawn to the need to allow time to develop, pilot, and field-test any new questions incorporated into face-to-face interview components.
Two additional areas that drew emphasis were the need to think through the integration and analysis of the social and technical data through focusing on the social functions of energy - and not simply traditional categorisations of energy demand; and the need to consider how the data generated from a UK Energy Lab would be integrated into existing modelling efforts. Current data sources are primarily focused on providing data suitable for inclusion in BREDEM-style housing stock models, but it was felt that the type of data collected should also be appropriate for use in more powerful building physics models such as EnergyPlus and ESPr. Consideration of data needed to populate such models, along with advances in computing power, may create the opportunity to apply such models to the housing stock as a whole.

The frequency of monitoring was considered important, and that this should be done on an annual basis to ensure that seasonality effects could be properly addressed, but that surveying every two years would raise problems due to the chances for significant changes in some classes of data over this period of time. Attention was also drawn to the need to think carefully about the rationale for following both households and dwellings longitudinally. It was noted that in household moves it is a minority of moves in which the household remains intact. It was recommended to think carefully about the analysis that would be undertaken, before following households through multiple dwellings, as there was scope for potential misinterpretation of findings. This caveat being noted, it was also felt that it was important to understand factors governing the rate of turnover of households through dwellings and the implication this might have for rates of change in the efficiency of the UK housing stock.

The workshops devoted considerable time to the types of research questions such an instrument should be able to address. This elicited a large range of research

questions that are grouped into theme and are presented in this annex above. From these several cross-cutting themes emerged including:

- an emphasis on understanding cohort effects;
- the capacity to understand life course impacts;
- interaction effects between energy and health;
- the power of longitudinal designs to afford greater predictive capabilities of future energy consumption across population segments;
- the capacity to disentangle observed changes in energy consumption arising from planned versus wider impacts on energy consumption;
- the capacity to be able to explain a greater percentage of the observed variability in energy consumption between homes.

There was also a consensus that although in principle collecting data at the national scale on the non-domestic building stock would be of great value, it was widely acknowledged that the challenges to doing this were such that the focus should remain on the domestic building stock for the foreseeable future. While some work has emerged on potential units of analysis, such as Self Contained Units (SCUs), that this work was still developing and required further time before it could be realistically deployed as a unit of analysis at the national scale.

Appendices

Appendix A: Energy-Lab feasibility paper presented to LCICG on 1 April 2014
Appendix B: UK Government-funded surveys by Department

Appendix A: Energy-Lab feasibility paper presented to LCICG on 1 April 2014

A Feasibility Study for a UK Longitudinal Survey of Energy Use

Purpose

The UCL Centre for Energy Epidemiology are leading a study to review the feasibility of setting up a major new repeat-wave socio-technical survey for understanding energy use in homes and workplaces across the UK. This paper provides an overview of the study and invites LCICG members to consider:

1) how you wish to be involved in shaping the direction of the project, and;
2) whether members have an interest, in principle, to contributing resource towards future governance and funding of a proposed survey of this nature.

Background

The UCL Centre for Energy Epidemiology (UCL CEE) together with the UCL Department of Science, Technology, Engineering and Public Policy and the National Centre for Social Research are carrying out the project. The project is joint-funded by DECC, building on the RCUK investment in the UCL CEE. The feasibility study aims to provide a comprehensive analysis of the feasible and cost-effective approaches to collecting policy and academic-relevant longitudinal, social and technical data on energy end use demand in domestic and non-domestic settings. This will be provided to both DECC and the RCUK for them to consider whether to invest in further development.

The feasibility study will explore what data collection is needed to address research questions such as; what really drives energy demand in buildings? What emerging social and technical trends will come to dominate demand in the next decades? Will current data streams allow us to isolate, track, and establish the causality of impacts from policy interventions in this highly complex socio-technical arena?

The work is divided into 8 strands, each dealing with different aspects. These cover:

1. Available Data
Evaluating what the available data is in the UK, and whether there are any longitudinal energy surveys elsewhere in the world, is essential. A key output will be a small database of data relevant to understanding energy, and a mapping of what kinds of variables have been gathered in the past.

2. Design options
Issues of sampling and survey design determine data quality and the sort of questions the survey can answer. In particular the socio-technical nature of the approach will be taken into account, with a view to generating integrated social and technical data rather than siloing them into parallel data streams. This work-package will explore the benefits (both in terms of rapid construction of a panel and of drawing on other complementary data) of linking with already ongoing surveys.

3. Non-domestic settings
It is widely recognised that conducting statistically representative surveys of non-domestic buildings presents enormous challenges. For this reason, the feasibility study will explore what can be learned from any international examples of surveys in non-domestic settings and consider what specific strata of that stock that it may be cost-effective to survey.

4. Ethics and data security
Consideration needs to be given to data privacy and the issues of commercial confidentiality and data access where major energy companies are concerned. In addition, any interventions planned for homes, including monitoring equipment used and any material interventions proposed through the 'innovation lab' would need to be subject to stringent health and safety assessments.

5. Governance
A key part of the project is to identify an effective model of management and operation for the survey. A governance model needs to be identified that protects the core component of the survey from the variability of Government department funding cycles and priorities, whilst enabling it to retain a link to government departments so it is used as a valuable asset. A review of existing governance structures for major relevant surveys such as Understanding Society in the UK and the Residential Energy Consumption Survey in the US will be undertaken and an appropriate model identified or designed to address these issues.

6. Finance
This work-package will address how much different options for a) setting up the panel and b) running it over the medium to long-term are likely to cost. This section will also link to Governance as it relates to how partners might invest in the programme and what value they might extract from it.

7. Pragmatics and piloting
This work-package will explore the logistics of establishing and running a longitudinal panel survey in energy. In particular this section will consider the issue of piloting and further development work prior to full roll out.

8. The Case for UK Energy Lab
This will draw off the other elements but will be combined with input from important stakeholders on their needs for new data in this space. This will comprise understanding what are the perceived gaps as viewed by academic and policy audiences and to what extent can a longitudinal panel address those gaps. A key consideration will be the role of the panel in supporting broader policy evaluation.

The work commenced in January 2014 and is expected to report in the summer of 2014. We would be happy to present findings on recommended survey design options to the next LCICG meeting and consult members on these options.

ACTION: Questions for the LCICG to discuss:

Q1: how do you wish to be involved in shaping the direction of the project? Specifically;

a) Are you content for UCL CEE to present recommendations from the feasibility study at the next LCICG meeting to consult members on survey design options?

b) Are members interested in providing input to the study before it reports in summer? If so, we would be happy to arrange follow-up discussions with your organisation individually.

Q2. Is a survey of this nature something your respective organisations would, in principle, be willing to fund?

If you require any further information about the study please contact Jeremy Vincent on contact details above.

Appendix B: UK Government-funded surveys by Department

In addition reviewing existing policy landscape documents, a review of existing government-funded surveys by government department was undertaken. This is presented below. This has assessed existing surveys broken down by Government Department, and assessed whether they were department funded, ONS funded, Joint funded, or RCUK Funded. It also includes an assessment of the sample size in each of the surveys. From this review it is clear that DECC currently supports no surveys that provide an overarching view of energy demand and its drivers in buildings for broader strategic planning purposes. A full table in MS Excel format is provided in an associated document.