UK Energy Research Centre

# Flexible Fund Consultation

UKERC Report

April 2020

## Introduction to UKERC

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

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

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

UKERC is funded by the UK Research and Innovation, Energy Programme.

# Contents

# 1. Introduction

The UK Energy Research Centre (UKERC) is in its fourth five-year phase of research and engagement activities, which will run until April 2024. In addition to the core programme of research, a number of mechanisms have been put in place to ensure that participation in UKERC is broad, flexible and addresses the needs of the wider UK research community.

A Flexible Fund of around £3m (valued at 80% FEC) has been set up in order to commission new research and facilitate the integration of the existing programme. The Fund is overseen by UKERC's independent Research Committee. The key aims of the Fund are:

- To allow the research programme to develop flexibly in the light of new scientific insights or external developments, e.g. in energy policy;
- To bring a wider range of researchers and disciplines into UKERC's research programme, including researchers from outside the 'traditional' energy community;
- To promote integration in the UKERC research programme, and to fill gaps where needed;
- To build collaborations between the UKERC research community and other research communities – including other energy researchers, groups and centres; and
- To scope and develop new research agendas in partnership with funders, the research community and other stakeholders.

This report presents the outputs of two key consultation activities on potential Flexible Fund topics. Section 2 of this report sets out the outcomes of a workshop held on the 12th February with attendees from across the UK research community. This presents the research areas and ideas that were the most popular in the voting exercise, the key issues that were discussed in each of the breakouts and a record of the full list of ideas in each breakout group, as well as the outcomes of the voting exercise.

Section 3 presents the results of an online survey, it provides an analysis of the research ideas that were proposed and the broader research area which these fell into, and provides an exact record of the ideas that were proposed in the survey.

The Appendices includes a list of workshop attendees and pictures of breakout group outputs from the Flexible Fund workshop.

# 2. Workshop

This section presents the discussions that took place during a workshop that took place on the 12th February in London with approximately 30 attendees mainly from the UK research community, as well as representatives from industry.

The day was set up as follows:

1. In the morning session two presentations were given, firstly by Jim Fleming, UKRI, on the current state of the UK research landscape and then by Rob Gross, Imperial, on UKERC and the purpose of the Research Fund.
2. Attendees were reorganised in three breakout groups. Each attendee was asked to come up with a few research ideas, taking into consideration what type of project would be suitable, e.g. a smaller project, a large project, a scoping study or an evidence review, and what disciplines should be involved. Ideas were then discussed in each group and clustered in broader research areas.
3. Attendees came into plenary again in order to vote on their preferred topic or broader area. Attendees could vote for ideas across all breakout groups, not only on ideas that were proposed in their own group.

## 2.1 Research priorities highlights

This section sets out the research questions that were the most popular during the voting exercise. The most popular ideas are presented starting from the ones with the most votes. Only topics with 5 votes or higher are included. It's important to note that in some cases there are common threads between the most popular ideas. However topics and votes were recorded based on how they were discussed on the day. For example if a similar topic was discussed in two breakout groups, this was recorded as two separate ideas.

**1. The role of the financial sector in reaching net zero: 10 votes**

This topic was proposed under the 'green finance/ economy' research area. The project would explore how finance flows can be made consistent with climate goals.

**2. Clean cooling: 8 votes**

This topic was proposed under the 'demand shifts' broader area. Workshop attendees noted that there are data gaps on air conditioning uptake and that for net zero to be achieved cooling needs to be moved higher up the decarbonisation agenda.

**3. Decision making of heterogeneous actors in the electricity and heat sectors: 7 votes**

This was proposed under the 'policy governance/ actors/ agents' area. A key research question would be which actors need to take the lead and drive the transition to net zero. Agent based modelling was proposed as an approach.

4. **Investment, who will pay for net zero: 5 votes**

This was proposed under the 'actors and delivery' broader research areas.

Topics 1 and 4 above are closely aligned. Regarding broader research areas topics 3 and 4 were both proposed under a research area relating to the role of different actors in the transition to net zero. These are not reported together because they were suggested and discussed in different breakout groups.

## 2.2 Breakout group discussions summary

The attendees were reorganised in three groups in order to discuss research ideas. These section sets out the key points discussed in each breakout.

### 2.2.1 Breakout group 1

Facilitator: Graeme Hawker, Strathclyde

These were the key topics discussed in the group:

1. **Use of growing evidence base within policy context**

- What have we learned from deployments?
- What mistakes have been made?
- What unexpected gains have there been? (e.g. unexpectedly low costs in solar and offshore wind)
- What are the upcoming policy stages that research should be providing evidence to? (e.g. RHI replacement)
- Synthesis of evidence between UKERC themes

2. **Actors and agents**

- Political tenability of net zero - can a green govt making all decisions necessary survive an election cycle?
- Who pays, how is it financed, and who benefits from the financing profits? Consider actual net costs and true counterfactuals (e.g. not just BaU)
- Success of different project leaders/champions (companies vs local authorities vs community groups etc.)
- Social justice and equity - business models for heat networks that provide co-benefits

3. **Integration**

- Cross-sector vs cross-vector

- Resolving scales: interaction between local and national

**4. Local energy and social impacts**

- Identifying opportunities between tech deployments and social benefits (e.g. mine water heat extraction and post-mining deprivation)

**5. Gas transition and hydrogen**

- Resolving of dichotomy
- Framing of question within broader policy and social challenges

**6. Resolution of bottom-up technological analysis with top-down policy/social goals**

- What do different tech mixes look like in the middle and how are they deployed/paid for

### 2.2.2 Breakout group 2

Facilitator: Tara Hooper, PML

These were the key topics discussed in the group:

**1. Local governance opportunities**

**2. International interactions**

- How can the UK accelerate decarbonisation globally?
- How does the UK fit?

**3. Sustainability and nexus issues**

- Biodiversity
- Align net zero with SDGs

**4. Regional energy scenarios**

**5. Brexit: potential positive and negative outcomes**

**6. Role of low carbon gas in future energy system**

### 2.2.3 Breakout group 3

Facilitator: Oliver Broad, UCL

Specific gaps in the current research landscape were identified:

- **New legal and financial frameworks are required to support new climate targets**
  The financial sector is under represented in UKERC. Studies should look at making economic flows consistent with climate goals in the long term. Modelling in this area is not heavily researched. There is an important link to green finance that is currently missing: what role it can play, what structure should / could it have, how could it underpin and support fast and efficient transitions to net zero. The role of law in this transition is not studied extensively. This could include the use of empirical questionnaires and interviews - qualitative approach – to investigate the potential for taking policy into law effectively: there are currently no global legal mechanisms in relation to climate change and net zero; while national systems exist they do not apply strongly to different actors across different sectors.

- **The impacts of continued growth on the climate**
  While it has long been stated that there are “limits to growth” in a physically limited world, this discourse is not current and up to date. It is instead superseded by e.g. government stating that decoupling is taking place for the UK and that continued growth is possible at low emission levels. Understanding where the truth lies, what we do and dot understand or quantify in relation to the negative effects that a growing economy can have on the environment, is fundamental under net zero targets: increased production leads to increased impacts and increased carbon emissions.

Generally the discussions revolved around three pillars; buildings, green finance and transport. The following issues were addressed:

- **How are demands going to change in the future?**
  Aiming for net zero will mean important shifts in demand for final energy services. These shifts are expected to occur in terms of total level of demand across modes, but also in terms of timing, or amplitude, or variability within each mode. The use of big/ new data (e.g. smart meters in buildings) may provide important information as to how this shift will occur. Fundamentally, this topic calls for research into the frameworks – whether legal, infrastructural, institutional, financial, social or other – that are required to support these shifts in demand.

- **Who are the actors that are going to drive this change?**
  What institutions and actors are required in order to translate the technological solutions we know are available into “on the ground” realities. Do we have these actors and institutions in place? Are there barriers to their creation? Can we move fast enough to implement these new structures to push timely changes in the energy system in time for tighter emissions targets to 2050?

- Calls for flexible funding should include focus on cross cutting elements including gender; equity; the consideration of wider supply chains that

underpin net zero solutions for the avoidance of rebound effects and negative feedbacks further down the line; a focus on uncertainty, for which we need to focus harder on applying adequate methods for translating uncertainty consistently and honestly in our analysis.

## 2.3 Breakout group discussions: individual ideas and voting

This section provides a record of the exact topics that were proposed in each group, the topic clustering in broader research areas, as well as the results of the voting exercise. For the voting each participant was given five votes that could be allocated to any topic or broader research area across the three groups.

### 2.3.1 Breakout group 1

Facilitator: Graeme Hawker, Strathclyde

| **Local Energy: 2 votes (research area)** | |
|---|---|
| Links to Energy REV | |
| The local economic and social impact of local and community energy projects now and into the future | 2 votes |
| How local governments could sell energy to domestic customers. Local energy supply. | |
| Business models for domestic heat networks | |
| Smart local energy systems<br>• Design<br>• Technology<br>• Regulation<br>• Market<br>• Identifying technological/ social opportunities, eg waste/ mine heat | 4 votes |
| **Integration (research area)** | |
| Links to CESI | |
| Cross-sector integration and its implications | |
| Cross-sector interactions and interdependencies, e.g. heat and industry | |
| Integration of electricity and transport networks (with a view of higher integration and utilisation of EVs) | 4 votes |
| **Scales** | |
| Integration of multi-scale energy systems (low voltage-distribution- transmission) | |

| Assessing evidence/ emerging lessons: 2 votes (research area) | |
|---|---|
| Links to TPA | |
| Learning from recent events: beast from the east, august ’19 power cut, big windy storms | |
| Research on problems and opportunities arising from deployment | 1 vote |
| Research based on emerging challenges/ opportunities from and between existing themes | |
| Research that responds to changing policy landscape | |
| Linking theoretical/ original research with trial/ demonstration projects to understand the real life challenges | 2 votes |
| Synthesis of evidence or insights across/ between themes | |
| RHI, short term policy support | |
| Research on and in action | |
| **Actors and delivery: 1 vote (research area)** | |
| Investment- who will pay for net zero | 5 votes |
| System architecture | 1 vote |
| Role of different actors in transition to net zero | 3 votes |
| Political tenability of net zero | 3 votes |
| Efficacy of different project leaders | |
| Social justice and equity | 3 votes |
| What are the actual costs, what is the counterfactual | |
| **Individual ideas (research area)** | |
| New conceptual tools to support energy system modelling | |
| Options for dealing with un-decarbonisable sectors | |
| The future role of gas: in the transition phase? H2 in net zero? | |
| Hydrogen evidence and pathways | |

### 2.3.2 Breakout group 2

Facilitator: Tara Hooper, PML

| | |
|---|---|
| **Sustainability/ nexus issues: 2 votes (research area)** | |
| | |
| Co-benefits of energy decarbonisation (e.g. health from more walking/ cycling and less car use) | |
| Clear alignment of net zero projects with SDGs: opportunity to bring in allied sectors, e.g. agriculture, how can we address SDGs from a UK and broader perspective | |
| Local bioenergy supply chains and ecosystem services | |
| Perverse outcomes and risks | |
| **Equity/ fairness: 1 vote (research area)** | |
| **International interactions: 4 votes (research area)** | |
| How can the UK accelerate non-UK transitions to net zero (decarbonising just ourselves is not enough) | 1 vote |
| Where does the UK sit on the wider energy system (raw material, net energy exporter?, interconnectors) | |
| Small scale offshore energy systems<br>• learning labs for upscaling<br>• export potential (off-grid)<br>• small scale (Scoping) | |
| Real leapfrogging: global south adoption/ adaptation | |
| **Business models: 1 vote (research area)** | |
| Niche market formation: strategy, disruptive technologies/ business models | |
| Business models: devolution- impacts on net zero | |

| | |
|---|---|
| **Governance (research area)** | |
| Local governance of energy systems or governance of local energy systems<br>• 2.5yrs, multidisciplinary | 3 votes |
| Community/ local energy governance:<br>• Community energy projects only as sustainable as their governance arrangements<br>• Pockets of activity in UK, especially in developing contexts<br>• No learning<br>• Alignment with local policy poor, often decentralised and no resources | 2 votes |
| Living research and practice: centre to being it all together, learning and knowledge exchange and links to ODA | |
| Electricity system resilience (technically, infrastructure) | |
| **Multidisciplinarity and knowledge exchange: 3 votes (research area)** | |
| Addressing multidisciplinarity in the peer review process | |
| Learning from other sectors and countries | |
| What fundamental research in EG physics is applicable to energy | |
| **Economics (research area)** | |
| Regional economics assessment: distributional implications of energy scenarios<br>• Medium project (I-O model) | |
| **User perspectives (research area)** | |
| Public understanding of new energy technology<br>• 1yr survey | 1 vote |

| | |
|---|---|
| Public attitudes to heat pathways<br>• Size would depend on scale | 1 vote |
| **Policy (research area)** | |
| Post-Brexit opportunities for UK energy systems: what if anything is unlocked by UK post-Brexit status, e.g. flexibility on subsidy regimes, new energy trading systems, shifts in environmental regulations? | |
| Policy decision making<br>Tracing political discourse to understand how energy policy decisions are actually made | 4 votes |
| **Raising awareness: 1 vote (research area)** | |
| New methods of public engagements<br>• 1-2yrs<br>• Link with several UKERC projects | 4 votes |
| What works in communication across fields and sectors: using new technologies | |
| **Exploring innovation (research area)** | |
| A review of smart technology: evaluation, new directions<br>• 1-2yrs | |
| Longitudinal studies | |
| **De-risking energy industry investment (research area)** | |
| Industry to get involved with basic research at zero cost to them due to financial risk | 1 vote |
| **Low carbon gas (research area)** | |
| Future role of low carbon gas in net zero UK energy systems<br>• 2.5 yrs | 4 votes |
| **Energy storage/ lifecycle analysis (research area)** | |

| | |
|---|---|
| Energy storage technologies/ alternative generation: micro nuclear, sustainability, recyclability | |
| **Heating and cooling (research area)** | |
| Heaters and coolers | 1 vote |

### 2.3.3 Breakout group 3

Facilitator: Oliver Broad, UCL

| | |
|---|---|
| **Policy governance/ actors/ agents (research area)** | |
| Exploring decision making of heterogeneous actors in electricity and heat sectors<br>• What actors take the lead in low carbon investment and drive the transition to net zero<br>• Agent-based modelling | 7 votes |
| Explore the co-evolution of household decisions/ business strategies/ government policy decisions to reach net zero and decarbonise the electricity sector | 1 vote |
| Local energy systems<br>• Policy, regulation (ownership)<br>• Institutional frameworks across scales<br>• Community energy<br>• Case studies<br>• Local renewable source<br>• Energy storage technologies | 2 votes |
| **Green finance/ economy (research area)** | |
| Explore the role of the financial sector in reaching net zero and how to make finance flows consistent with climate goals | 10 votes |
| Growth? Alternatives to growing the economy | 1 vote |
| **Technology (research area)** | |
| Decarbonise freight transport<br>• Technology<br>• Battery/ other energy sources | |
| Synergy and integration within various technologies | 2 votes |
| **Cross-cutting (research area)** | |
| Legal frameworks to promote investments | |

| | |
|---|---|
| Support women in energy research/ ECR<br>• More funding support<br>• Female PI/ Co-I leading projects | |
| Compare UK with other countries: learning, case studies for comparison | |
| Longer length needed for social science research and primary/ qualitative data collection<br>• 2yrs or longer | 1 vote |
| Potential implications of net zero transition in buildings and more widely in the system | 2 votes |
| Equity implications of energy policy in a world of electric mobility | 1 vote |
| Decision making process and actors | 2 votes |
| Uncertainties in energy and infrastructure policy/ decision making<br>• Real options method | 1 vote |
| **Demand shifts: 1 vote (research area)** | |
| Whole systems for freight transport<br>• Logistics fleet objectives<br>• Multimodal freight solutions<br>• Implications for grid | 2 votes |
| Whole systems view of energy demand<br>• Buildings and transport<br>• Explore big data | 1 vote |
| Enhance building stock performance understanding, e.g. through use of information from new sources of data | |
| Whole systems view for decarbonising passenger transport<br>• Travel demand patterns<br>• Shared mobility<br>• Impact on grid/ transport | 1 vote |
| Move from understanding energy demand to predicting energy demand?<br>• Passive data/ AI | |
| Clean cooling<br>• Based on previous UKERC funded prediction of air conditioning uptake in the UK to rise- huge gaps in data<br>• No further funding to continue<br>• Zero carbon is not possible if cooling is not put high on the agenda<br>• All focus has been on decarbonising heat | 8 votes |
| Decarbonising cooling in buildings | |
| Implications of new work practices on demand and energy systems | |
| **Individual ideas (research area)** | |

| | |
|---|---|
| EV adoption and charging behaviours<br>• Impact on the whole energy system<br>• Further increase in energy demand at peak time, can't meet with renewable energy<br>• Further challenge consider heat electrification<br>• Local energy system solution (case studies, retail park | |

# 3. Online survey

This section presents the outcomes of an online survey that was open from mid-December 2019 to mid-February 2020.

The survey questions are set out below. Each respondent could propose up to 3 research topics. In total 32 responses were received and 70 topics were proposed.

**Q. Which topic would you suggest funding under the Flexible Fund?**

a. Why is this topic a good fit for UKERC?

b. What type of projects would be most appropriate for this topic?

b.i. If you selected Other, please specify

c. Which disciplines or areas of expertise are required for this topic?

## 3.1 Survey highlights and analysis

This section groups the ideas that were proposed in the survey in 13 broader research areas. The number of proposed topics under each area is indicated. Additionally, the high level ideas proposed under each area are also included. It is important to note that this is not the only way in which the survey outputs could have been grouped. Furthermore, many of the proposed research ideas cut across more than one of these categories.

**1) Net zero/ future pathways: 8 topics suggested**

- Decarbonisation to meet the net zero requirement
- Net zero emission whole energy system design.
- Control systems for net zero emission energy systems
- Skills and capacity-building for the transition
- Skills and training for net zero
- Something on plotting the transition pathways for different sectors - how do we get from where we are to where we want to be considering system

changes and capacities, necessary supporting interventions, delivery agencies, regulation, etc.
- Energy future studies- technological and cultural
- Regional pathways to net zero energy system

## 2) Power sector: 8 topics suggested

- Flexible back up generation
- Global power grid
- Regional aggregation
- Efficient Control and Optimisation of Flexible Local Energy Systems (LES).
- Large-scale optimal coordination of virtual storage plants for frequency and voltage support.
- Scheduling electricity generation, given uncertain forecasts of supply & demand
- Impact of different TOU pricing structures
- Impact of different TOU pricing structures- impact of market wide half hourly settlement reform

## 3) Buildings: 8 topics suggested

- Dehumidification of homes as a service
- Determine the extent to which variable internal temperatures are already acceptable (they seem to promote metabolic health, are affected by the improved radiant temperatures produced by pre-heating walls)
- How much heat supplied to homes is providing a dehumidification service that can be varied in time or provided explicitly. E.g. Drying laundry at night, using a built-in dehumidifier/ MVHR.
- How heating demands will increase with rising incomes and an aging population (women live longer, often with low incomes)
- Cooling
- Improving indoor environmental conditions using renewable electricity
- Home energy services offers including monitoring and control of indoor conditions and pollutant levels.
- Low energy buildings- a roadmap for the energy transition process

## 4) Methods and tools: 8 topics suggested

- Better integration of demand in system models
- Reducing industrial energy demand. It should deliver an innovative, Industry 4.0 based, software tool
- Forecasting renewable generation (and maybe demand as well)
- Interactive model for assessing the energy demands of NI
- Models of Circular Economy in the agro-industrial sector: barriers and opportunities

- Macro-economics of decarbonisation. Where is the value of decarbonisation for GB.
- Establishing a database of in situ (real life) performance of the low-energy technologies which will be mandated in the future.
- AI in Energy

## 5) Governance/ role of different actors: 7 topics suggested

- Architecture and governance of future energy systems
- International review of city-scale energy systems governance
- The political feasibility of the energy transition
- Regulatory Reform as a Driver of Energy Innovation
- Where does the money in the energy system go? Mapping flows of money into, through and out of the energy system to shed greater light on how financial resources that energy system actors draw on are distributed and used, and what the implications for change and the zero-carbon transition are.
- A high level cross cutting task force
- Local governance

## 6) Engagement/ acceptability/ network building: 5 topics suggested

- Construction Industry Energy Research Network
- Communicating risk and uncertainty
- Energy-related public engagement especially through collaboration with cultural institutions
- How to raise public's awareness of the importance of households' energy investment decisions for net zero
- Further deliberative work with different key delivery stakeholder (e.g. building developers, national and local policymakers, car manufacturers) on how to manage excess consumption in different sectors.

## 7) Heating: 5 topics suggested

- Smart hybrid heating
- Using renewable electricity to displace heating fuel use
- Regulating for heat
- Heat transitions in the UK and the Netherlands
- Estimating the acceptability of heating inputs that vary in time

## 8) N Ireland case studies: 4 topics suggested

- Northern Ireland as a test bed for demand flexibility to manage very high levels of variable renewable energy (VRE)

- Research into the feasibility of offshore wind in Ireland
- There is a real issue with lack of understanding of technology such as heat pumps in industry, which has led to a number of heat pump installations being removed and replaced with fossil fuel heating systems in NI. Research into the knowledge and attitude within industry for these key future technologies is needed if they are to be part of a successful energy transition.
- Lack of understanding of low energy buildings, technologies and expertise in the province of Northern Ireland. Research is required to understand stakeholder motivations and establish a roadmap for the energy transition process.

## 9) Storage: 4 topics suggested

- Very large/massive scale long-term (seasonal) electrical energy storage, using carbon.
- Very large/massive scale long-term (seasonal) thermal energy storage.
- Costing of battery recycling
- Gravity fed energy storage systems.

## 10) Infrastructure: 4 topics suggested

- New Energy Infrastructure Demand Analysis
- Investigate hydrogen infrastructure
- CCSU - non geological storage
- Desalination Engineering Energy Transport Networks

## 11) Mobility/ transport: 3 topics suggested

- Aviation and shipping sustainable fuels
- Decarbonisation of the shipping sector
- International passenger transport systems

## 12) Equity and justice: 2 topics suggested

- Fuel poverty and justice in energy transition
- Equity and heat decarbonisation

## 13) Community energy: 2 topics suggested

- Understanding the co-benefits of community energy projects.
- Developing new community energy business models: from outlines to workable models.

## 3.2 Survey responses

This section presents the raw data from the survey. A list of proposed topics follows, sometimes indicating a proposed project type and relevant disciplines. The research topics are ordered according to the order of survey responses.

1. **Smart hybrid heating systems implementation**
   Offer quick win for heat decarbonisation
   Evidence review
   Whole energy systems, appliance manufacturing and green gas producers

2. **Flexible back up generation - as renewable generation increases, what will be the role (say load factor) for standby/flex generation and what type would best suit the future environment.**
   Whole energy strategy implications
   Small project (£50-100k)
   Distribution level system operators

3. **Global Power Grid to support the Paris Climate Change Agreement**
   UKERC is UK's national research centre where this proposed work can fit into the programme of "UK Energy in a Global Context" very well. However, it was found that there was very little work being funded by Research Councils. On the other hand, at the University of Birmingham, my team has been working on this for some years, including a vision on "Global Power & Energy Internet" and the proposal "Energy Union", which led to the established the European Energy Union - 1st Energy Union in the World.
   Scoping study, Evidence review, Large project (£100k+)
   Electricity Grid technologies such as HVDC and Flexible AC Transmission Systems, Power Economics.

4. **Architecture and Governance of Future Energy Systems**
   This is a fundamental issue. Energy Systems Catapult and IET have addressed this but with a very limited scope. Fundamentally there is a lack of international dimensions. With the Brexit on the way, this becomes urgently important. University of Birmingham's team has been working on this for some years, including a vision on "Global Power & Energy Internet" and the proposal "Energy Union", which led to the established the European Energy Union - 1st Energy Union in the World.
   Scoping study, Evidence review, Large project (£100k+)
   Power Engineering, Economics, International Laws, Environments, Geo politics, etc.

5. **Costing of battery recycling**
   For electrifying the transport (road transport in particular), it is likely that we would largely rely on battery energy storage. For doing so, there is a

fundamental issue on the costing of battery recycling after their life time and also provide a roadmap how this recycling costs are going to be reduced.
Scoping study, Evidence review
Power engineering, EVs, Battery technologies, Energy Economics, Environment impacts.

**6. Communicating risk and uncertainty**

This would link with the Observatory for Societal Engagement with Energy. The Observatory for Societal Engagement with Energy (SEE) will develop new mapping approaches to generate openly accessible whole-system evidence about energy participation on an ongoing basis. In order to communicate with the wider community on openly accessible evidence, we as a community need to get better at communicating risk and uncertainty.
Large project (£100k+)
Risk and uncertainty modellers working with sociologists to investigate and evaluate methods of communicating risk and uncertainty

**7. Regional aggregation**

Optimise local system resilience and value realisation
Evidence review
Energy industry and market knowledge

**8. Impact of different TOU pricing structures**

Consumer behaviour
Evidence review
Understanding of industry pricing and settlement

**9. Impact of different TOU pricing structures- impact of market wide half hourly settlement reform**

Incentivising consumer response
Evidence review
Understanding of industry pricing and settlement rules

**10. Northern Ireland as a test bed for demand flexibility to manage very high levels of variable renewable energy (VRE).**

Northern Ireland is the best place in Europe to develop smart, clean, local energy systems. Through its DS3 ancillary services market, the Irish, all-island power system has already integrated the highest levels of wind energy anywhere in the world. When countries (such as Scotland or Denmark) claim to have generated very high levels (100% or more) of their electricity from renewables, this reflects political, rather than system boundaries, and ignores the fact that these countries can ‘offshore’ the management of wind power to bigger, power-hungry neighbours. In terms of the inertia required to manage very high levels of VRE, Ireland is completely isolated and manages all its wind power internally. Of the island’s two jurisdictions, NI has the higher level of connected wind power; because of this we smashed our target for 40% renewable electricity by

2020, achieving 45% in 2018 - a world record for a standalone power system. The scale and location of wind energy is also significant. NI has a dispersed, largely rural population and consequently a long and stringy network. Almost all of its wind generators are small scale and connected at network (rather than transmission) voltage. In respect of variability, NI therefore differs from GB, where variability can be managed by the SO at transmission voltages (for example, from large offshore wind farms) or by consumers, behind the meter (from PV). This creates an ideal opportunity to assess/demonstrate the value of smart demand to manage variability at local, network voltages. Because of the absence of flexible demand, in 2018 NI dumped 10% of its available wind generation (250 GWh). This would have had a retail value of c. £42M. NI currently has a further 1,000 MW of wind projects which cannot be connected due to archaic planning and codes. It also has among the best RES-e resources (onshore and offshore wind, tidal and wave energy) in Europe.
Scoping study, Evidence review
Energy policy Energy resource assessment Energy Systems Design & Planning Electrification of Heat & Transport Energy Markets Social Policy

**11. Regulatory Reform as a Driver of Energy Innovation**

Too much current research funding is directed to technology development; however the technological breakthroughs required to deliver the energy transition occurred some time ago. The most significant barriers to decarbonisation are policy and regulatory. While policy will/may fluctuate with political cycles, the regulator has a permanent role. Assessing how concepts of Performance Based Regulation can be incorporated into revenue structures for network companies (decarbonisation, addressing system inefficiency, protecting/empowering vulnerable customers) will hasten the transition to smarter regulation.
Evidence review, Small project (£50-100k)
Energy Regulation Utilities Research Energy Markets System Planning

**12. Using renewable electricity to displace heating fuel use**

It can cut CO2 emissions fast using existing LV grids
Small project (£50-100k)
Thermal imaging, energy monitoring, consumer questionnaires. Simulation. Construction of test rigs using common heating system components. Construction of new dual fuel radiator types with electric heating elements and large exposed radiant areas.

**13. Estimating the acceptability of heating inputs that vary in time**

Better match to the availability of renewable electricity. Has a health aspect, as variable conditions can be healthier, and health has high cash values.
Large project (£100k+)
Programming and remote control of heating inputs, measurement of heating system re-activations. Market research/ consumer survey expertise. Development of revised heating service offers.

14. **Dehumidification of homes as a service**
Drying is an energy using service that can be provided when more renewable electricity is available, and at times when electricity is not in demand by other users.
Large project (£100k+)
Programming and remote control of heating inputs, measurement of heating system re-activations. Market research/ consumer survey expertise. Development of revised heating service offers

15. **Something on plotting the transition pathways for different sectors - how do we get from where we are to where we want to be considering system changes and capacities, necessary supporting interventions, delivery agencies, regulation, etc.**
Currently there is a lot of research to identify desired levels of carbon reduction by 2030/50 but very little realism about what whole systemic changes are needed, in what timeframes, through which delivery mechanisms and how to get there without a total collapse of our economic and social wellbeing.
Small project (£50-100k)
Cross-disciplinary across all teams in CREDS - transport, buildings, materials, etc. with a social science lead and qualitative approaches.

16. **Further deliberative work with different key delivery stakeholder (e.g. building developers, national and local policymakers, car manufacturers) on how to manage Excess consumption in different sectors.**
It would build on the current Excess project which focuses only on individual behaviours to extend the issue of excess consumption behaviour to the structural factors that generate and embed them.
Small project (£50-100k)
Cross-disciplinary with a social science lead and qualitative approaches.

17. **Skills and capacity-building for the transition**
UKERC has led the technical/policy-relevant research agenda for the energy transition. A focus on the kinds of workplace capabilities required in a socially just zero-carbon future would build on UKERC's strengths. It would make explicit links to 'non-energy' energy policy and make a tangible contribution to defining what a just zero-carbon economy and society might look like.
Large project (£100k+)
Inter-disciplinary sectoral expertise (e.g. buildings, transport, industry, food systems); economics; education; inter-disciplinary expertise on systems governance; politics and policy.

18. **International review of city-scale energy systems governance**
UKERC is well placed to lead thinking on future energy systems. As electricity systems show signs of becoming increasingly decentralised, important questions arise about the roles and rules governing future system operation. For heat and transport, there is slower change on the ground, but plenty of potential for change (for example, through district

heat networks and modal shifts away from private vehicles). All these issues interact in complex ways at the scale of city-regions. The UK could learn valuable lessons from different governance arrangements in other countries. UKERC has the breadth of expertise to tackle such a complex and cross-cutting task.
Large project (£100k+)

**19. Construction Industry Energy Research Network**

It would build on UKERC's expertise on energy use in buildings and also the GLIDER project from UKERC phase 3. There is a small but growing community of researchers working on the construction sector as potential agents of change in delivering a low-carbon built environment. If UKERC were to host/enable a new research network, it would give that growing community a clear focus, provide insights to complement UKERC's core research programme, and create opportunities for future research.
This would be a network, rather than a research topic - similar to networks funded under UKERC 3. It could fund T&S for a seminar series, one or more report publications, and possible interaction/collaboration with UKERC, for example TPA.
This would be aimed at anyone (ie any discipline) with a research interest in the construction industry as agents of change in the energy transition. I have a list of ~20 individuals who could be invited, and that list could easily double or treble with networking/snowballing of contacts.

**20. Decarbonisation to meet the net zero requirement**

This is the biggest challenge facing Britain and the World. If we cannot resolve that challenge the future of civilisation - including universities and research - is at stake
Scoping study, Evidence review, Small project (£50-100k), Large project (£100k+)
This is potentially very wide. My fields of transport and spatial planning would obviously fit, but there would be many others in: engineering, agriculture, physical sciences, law, even potentially arts subjects

**21. Energy-related public engagement especially through collaboration with cultural institutions**

While the extinction-rebellion type radical popular movements have recently been highlighted in the media, various expert work, discussion and research remain relatively low-profile. This is partly because public engagement and communication in the energy research community is still insufficient. There is urgent need for increasing public trust in expert voices, and one way to achieve this would be through closer collaboration between energy research community and cultural institutions (museum, theatre, arts etc.). There are some isolated attempts but we need to establish more collective ways of engaging with the public.
Scoping study, Small project (£50-100k), Large project (£100k+)
Cultural studies, museum studies, literary studies, communication studies, theatre studies, contemporary art studies.

**22. Energy future studies**

Although there are some future energy studies in various institutions, there are either technology oriented or literature-oriented. There is not much work going on to combine technological and cultural visions of energy futures. Our society currently does not have clear visions for energy's future and uncertainty dominates today's discussion. Expert collaboration across disciplines is urgently needed to address the lack of future visions.
Scoping study, Small project (£50-100k), Large project (£100k+)
History, literary studies, philosophy, art, engineering, climate science

**23. Net zero emission whole energy system design.**

The integration of multiple sectors and vectors at high temporal and spatial resolution in energy systems is essential to achieve the new legal target of a net zero emission economy. Engineering constraints, innovation, and regulation frameworks are fundamental to create sound pathways to future energy systems. This topic will update UKERC research on whole energy systems to the new UK's net zero target.
Large project (£100k+)
Modelling in whole energy systems, transport, industry, buildings, system engineering, economy, and policy

**24. Control systems for net zero emission energy systems**

The integration of multiple vectors, power-to-heat, and synthetic fuels technology requires new methods to manage and dispatch energy in net zero emission systems.
Small project (£50-100k), Large project (£100k+)
Whole energy system modelling, engineering, and operational research

**25. Aviation and shipping sustainable fuels**

Net zero emission energy systems will need to include the sustainable production of fuels for aviation and shipping. This topic will extend UKERC research beyond road transport.
Large project (£100k+)
Whole energy, aviation, and shipping systems modelling

**26. New Energy Infrastructure Demand Analysis**

The transition to a low-carbon energy system is necessitating the creating of new infrastructures across different sectors. A case-in-point is the widespread deployment of public Electric Vehicle charging points which are replacing the need for traditional fuel stations. The establishment of first generation infrastructures is already progressed in certain places, providing a test-bed for analysis. Empirical research projects have the opportunity to reveal key planning and operational issues regarding these new infrastructures in the areas of:

- The temporal and spatial patterns of current energy demand
- The forecasting of these patterns into the future
- The citizen reaction to new energy infrastructures in the built environment
- The account of these infrastructures within local sustainability plans

This project shares overlaps with a number of current themes within UKERC's programme such as energy for mobility and energy infrastructure transitions. The project will make use of existing datasets on first generation EV infrastructures and provides a direct link with an emerging area of focus for the UK government's industrial strategy, being the future of mobility.
Small project (£50-100k), Large project (£100k+)
Quantitative and Qualitative Human Geography; Sociology; Psychology; Power Systems Engineering

27. **Determine the extent to which variable internal temperatures are already acceptable (they seem to promote metabolic health, are affected by the improved radiant temperatures produced by pre-heating walls)**
Relates to the amount of variable renewable electricity that can be used for heat, especially wind energy that is more available in winter and in the afternoon, is not required for power in the very early morning when it could provide pre-heating.
Small project (£50-100k)
Could be simply a review of temperature records in homes (where heating activations can probably be determined by comparing to external temperatures). An understanding of thermal mass, pre-heating and radiant temperature is desirable.

28. **How much heat supplied to homes is providing a dehumidification service that can be varied in time or provided explicitly. E.g. Drying laundry at night, using a built-in dehumidifier/ MVHR.**
Relates to the amount of variable renewable electricity that can be used directly when people are out at work or are asleep, when it is not needed for electrical power. Can provide extra consumer value/ revenues for wind energy expansion.
Evidence review
Some understanding of drying of fabrics, air movement in homes, ventilation, and moisture storage in materials useful.

29. **How heating demands will increase with rising incomes and an aging population (women live longer, often with low incomes)**
Determines the extent of carbon reduction effort needed to be available for housing. E.g. May indicate that much more insulation or zero carbon district heating is required.
Small project (£50-100k)
Familiarity with determining heating use in homes from known housing characteristics and preferences within groups of people.

30. **The political feasibility of the energy transition**
Understanding the political feasibility, processes of decision making, and consistency/permanence of policy is critical in a whole systems view of the energy system
Large project (£100k+)

Political science married to UKERC's usual mix of economic/engineering/social science expertise

**31. Decarbonisation of the shipping sector**

It is an essential element of the UK's energy and transport systems, and as with many other sectors, decarbonisation of shipping is to some extent dependent on/linked with national electricity network/grid development and micro generation (e.g. for cold ironing / charging in ports). It also need to be assessed with alternative fuels for other sectors in mind (e.g. developments relating to H2, ammonia etc.,).
Small project (£50-100k), Large project (£100k+)
Physical science/engineering including: mechanical engineering; electrical engineering; chemical engineering; climate science; energy systems modelling. Social science including: transitions and innovation theory; science and technology studies; governance and law.

**32. International passenger transport systems**

Transport is one of the most challenging areas to decarbonise, with an assumption that aviation is 'too difficult', including by implementing demand-side measures. Yet there is emerging evidence that there is appetite for more land-based international travel to replace air travel for short haul as individuals' concern for climate change rises. What is the scope for existing land-based infrastructure to accommodate a large shift away from air travel? With expertise in transport within UKERC, an understanding of the UK's decarbonising transport challenges would be well understood, but this area offers scope to expand this to assess opportunities for UK residents travelling within Europe to decarbonise their international travel, and identify where new or upgraded or expanded infrastructure may be needed.
Scoping study, Large project (£100k+)
Physical science/engineering including: electrical engineering; chemical engineering; climate science; energy systems modelling. Social science including: transitions and innovation theory; governance and law; mobility studies.

**33. Cooling**

IEA highlight cooling as an under-recognised and hugely important sector - CC resulting in increased need for cooling, growth in air-con increasing carbon emissions & de-stabilising electricity grids at times of peak demand.
Scoping study, Evidence review, Small project (£50-100k),Large project (£100k+)
All of them! Impacts on buildings, mobility, liveability. All the social sciences, natural science (impacts of CC on extreme heat), engineering, building science, health.

**34. Investigate hydrogen infrastructure**

Fits with UKERC and CCC for recommended areas for investigation.
Scoping study, Large project (£100k+)
STS. Innovation policy. Regulation. Regulatory economics.

**35. Regulating for heat**

Looks at an area which is essential for decarbonisation goals as well as enhanced security of supply in a world with increasing limits on gas consumption.
Large project (£100k+) STS. Energy & technology policy. Regulatory policy.

**36. AI in Energy**

AI could be the greatest disruptor this century. Its impact on energy will span all aspects of the energy system, from forecasting and scheduling supply, conducting autonomous operation, to informing planning and decision making and potentially even policy making itself. On the demand side AI could be equally transformative. Humans increasingly hand over control to AI systems, allow them to inform transport choices and purchasing decisions. Home heating systems already learn about activity patterns and greater intrusively on energy and appliance data allows energy and marketing relevant insights, but also raises major ethical challenges, which need urgent attention.
Large project (£100k+)
Computer/data science, Social science / Geography, Energy systems thinkers, Engineering, Philosophy Opportunity for engagement with a range of businesses in this space.

**37. Better integration of demand in system models**

Energy system models tend to have a range of ambitions for supply side decarbonisation. The ambition for demand reduction is rather tame. UK demand reduction in the past 10 years has shown what is possible and the remaining potential is significant. More ambition is needed on both scale and speed of demand reduction.
Small project (£50-100k)
This could be a linking project between CREDS and UKERC

**38. CCSU - non geological storage**

Because if you do it right you get 2 outputs, one is GHG reduction, the other is hydrogen production.
Scoping study, Evidence review, Small project (£50-100k), Large project (£100k+)
Chemical Engineering - Metal Catalysts. Chemical Engineering - Carbon Materials

**39. Desalination Engineering Energy Transport Networks**

Hydrogen generation via desalination.
Do you want to save the world? If you do it right you generate H2 for replacing gas and you also have a source for creating energy storage systems.
Scoping study, Evidence review, Small project (£50-100k), Large project (£100k+)
Chemical Engineering - Energy Storage (Salts) Industrial Engineering Desalination via Renewables expertise (see Prof. Takashi Yabe)

**40. Gravity fed energy storage systems.**

Pointless question no? Simply put if you take lithium or any other storage device, put it on rails, you can use the travel to store renewable energy. On top of this if you consider a total system design you can make the rails generate power by the moving load, over and above that from the loads own movement. Encapsulate it and you can even use the air or water pressure differential to scavenge more power. Then if you consider the entire superstructure, if it can move then more energy is available to be captured. Every little counts.

Scoping study, Evidence review, Small project (£50-100k), Large project (£100k+)

Battery Technology Electrical Engineering Industrial Engineering Rail Systems Marine Engineering

**41. Efficient Control and Optimisation of Flexible Local Energy Systems (LES)**

This should result in a new modelling framework for LES combining physic-based and data driven approaches and in novel optimisation-based control algorithms, which are able to deal with conflicting objectives and consumers' requirements, coordination of decisions distributed over multiple units and several sources of uncertainty.

It fits the themes/programmes: "Local and Regional Energy Systems" because of the focus on locally-integrated multi-vector systems, "Energy, Environment and Landscapes", because of the whole-system approach adopted, "Energy Systems for Heat", because of the inclusion of the environmental target and the heat-electricity interaction among the features of the proposed control framework.

Large project (£100k+)

Control - Power systems - Machine learning - Social science whether possible

**42. Large-scale optimal coordination of virtual storage plants for frequency and voltage support.**

It should aim to devise and demonstrate a scalable decision support and control framework to enable the large-scale utilisation of a very large number of geographically distributed energy storage systems of different technologies for system-level voltage and frequency regulation, taking the uncertain and time-varying nature of renewable generation and load conditions into account.

It fits the themes/programmes: "Energy, Environment and Landscapes" because of the focus on renewable integration and the energy system decentralisation.

Large project (£100k+)

Control - Power systems - Power electronics

**43. Reducing industrial energy demand**

It should deliver an innovative, Industry 4.0 based, software tool, which will minimise the energy demand of a small or medium enterprise manufacturing facility and find optimal ways of reducing equipment energy

demand through better utilisation of the machines, accounting for multiple production constraints, local generation capabilities and uncertainties in complex systems.
It fits the themes/programmes: "Industrial Decarbonisation" because of the focus on minimising the industrial demand and the optimised use of available low-carbon technologies.
Large project (£100k+)
Optimization and electrical energy  Manufacture and Industry 4 Data science

**44. Forecasting renewable generation (and maybe demand as well)**
Better forecasts should help reduce carbon emissions (by reducing the amount of spinning reserve required to firm up renewables); and should help reduce electricity costs.  Doing research into forecasting renewables requires open data, which the UKERC is already doing a great job of providing through the UKERC Energy Data Centre.
Small project (£50-100k), Large project (£100k+)
* Wind / solar power generation * Meteorology * Statistics / machine learning * Computing

**45. Scheduling electricity generation, given uncertain forecasts of supply & demand**
Existing approaches for scheduling & dispatching electricity generation cannot take advantage of the uncertainty information in modern probabilistic forecasts.  This wasn't a problem a decade ago, but is becoming increasingly troublesome as more and more renewable generation is added to the grid.
Small project (£50-100k), Large project (£100k+)
* Stats / machine learning / optimisation * Computing * Electricity system operation

**46. Very large/massive scale long-term (seasonal) electrical energy storage, using carbon.**
This type and scale of storage I believe is necessary, for both electrical and thermal energy, in order to maximise the efficient use of RE (renewable energy) sources, especially intermittent types such as wind and solar.  Maximizing the energy chain efficiency (production to end-use) is important in order to minimise the amount of new renewable energy resources we need to install all this minimising the time to reach zero carbon targets.  With large-scale integration of intermittent renewables in the energy mix long-term massive scale energy storage is probably the only way to avoid large-scale curtailment (wastage) of renewable energy power generation during summer months.  Using carbon as a large scale energy storage vector has numerous potential advantages compared to hydrogen, including improved closed cycle efficiency, lower-cost of storage and ease of transport.  Developing TWh scale, long-term storage would create a paradigm shift in the viability of intermittent RE sources particularly PV and wind. Developing it could make the UK a world leader.
Scoping study, Evidence review, Small project (£50-100k), Large project (£100k+)

Fuel cells. General electro chemistry. CO2 capture, storage, transport and conversion

**47. Very large/massive scale long-term (seasonal) thermal energy storage**

This type and scale of storage I believe is necessary, for both electrical and thermal energy, in order to maximise the efficient use of renewable energy sources, especially intermittent types such as wind and solar. Maximizing the energy chain efficiency (production to end-use) is important in order to minimise the amount of of new renewable energy resources we need to install all this minimising the time to reach zero carbon targets. Gas boilers run off hydrogen plus electrolysis will require roughly 5 times more wind turbines than using heat pumps with thermal storage.
Scoping study, Evidence review, Small project (£50-100k), Large project (£100k+)
Heat pump technology Materials science, sp. thermal properties

**48. Understanding the co-benefits of community energy projects.**

Fits with UKERC's whole systems approach to understanding energy. It is also a topic of interest to policymakers, who say they are frustrated at the state of data on this topic. Much is claimed for the social and environmental impacts of community energy. Some research has been done, including by the sector; but there is still a lack of rigorous independent evidence to back up these claims.
Small project (£50-100k), Large project (£100k+)
Economics and other social science disciplines needed. Project evaluation and/or social impact analysis experience possibly. Knowledge of community energy sector in the UK. Re the scope of project: new empirical research is needed to fill the gap. Any such project should include an evidence review.

**49. Where does the money in the energy system go?**

Mapping flows of money into, through and out of the energy system to shed greater light on how financial resources that energy system actors draw on are distributed and used, and what the implications for change and the zero-carbon transition are.
Fits with UKERC's track record of investigating the financial and political economy aspects of the energy system and how the transition will be paid for.
Evidence review, Large project (£100k+)
Disciplines: economics, accountancy, politics. Some element of investigative journalism skills might be needed to track down details of complex company ownership structures. Scope of study: possibly an evidence review, but I imagine this would take a large study to do thoroughly. It might meet with opposition from actors within the energy and finance sectors.

**50. Developing new community energy business models: from outlines to workable models.**

Follows on from previous UKERC work in this area and generating energy system impact.
Scoping study, Small project (£50-100k)
Energy economics, cooperative and community business studies, policy knowledge. This could be a partnership with community energy businesses and other stakeholders.

**51. Improving indoor environmental conditions using renewable electricity intermittently, in terms of reducing personal exposure to higher levels of pollutants including PM2.5, NO2, VOCs, CO2, and water vapour that promotes mould growth.**
By providing a new application and value for surplus electrical output at times of low demand for heat and power, improving health and wellbeing can provide additional revenues to fund the necessary expansion of zero carbon generation. The home and its furnishings provide a new storage function for drying and pollutant removal services provided without CO2 emissions, leaving more constant renewable output for transformations such as Hydrogen production that require a reliable return on large capital investments.
Evidence review
Critical thinking. Public health. Modelling of pollutant dispersal, offgassing from furniture, cleaning products, energy markets, moisture VOC and thermal storage in materials.

**52. Home energy services offers including monitoring and control of indoor conditions and pollutant levels. Customer attitudes and heating or ventilation activations, choices of bundled services, reacting to extra feedback on indoor air quality, humidity, radon and mould risks estimated from actual building fabric type and insulation levels, as provided during Energy Performance Certificate surveys.**
It is known that indoor environmental conditions in homes are often unhealthy. Identifies the likely energy demand required to meet expressed customer preferences for healthy conditions in homes, so that the proportion of this that can be met with renewable electricity in future can begin to be estimated.
Large project (£100k+)
Use of large numbers of environmental sensors, data dashboards. App development and rapid reprogramming. Customer research.

**53. Interactive model for assessing the energy demands of NI**
NI are asking for direction and decision makers could use such tools to identify a useful strategy for tacking climate change
Scoping study
Modelling, gathering data, analysing data, project management skills, a good network within the energy community

**54. Research into the feasibility of offshore wind in Ireland**
It's an untapped energy source
Scoping study
Gathering data, understanding the barriers, Lobbying

**55. A high level cross cutting task force**

It would help provide a more harmonised approach rather than individual bodies targeting areas which influence each other i.e. if we aim for 100% electrification of the grid how does this affect other industries, we need more alignment and a clear direction with an interdisciplinary approach
Scoping study
Varied background, policy, education, engineering, technology, business, environment, government bodies

**56. Regional pathways to net zero energy system**

Some regions are excluded from the UK wide models or included in the aggregated way. As a result, proposed pathways/scenarios are not suitable to some particular regions and provide erroneous recommendations to local governments and stakeholders. Moreover, potential benefits, which these regions could bring towards future net zero targets are not represented.
Small project (£50-100k), Large project (£100k+)
Energy modelling, energy economics, engineering, social science

**57. Fuel poverty and justice in energy transition**

Despite the fact that social justice in energy transition has received more attention recently, this area of research is significantly underrepresented. Some regions indicate quite significant levels (20% and more) of fuel poverty.
Evidence review
Energy policy, phycology, energy economics, social science

**58. Low energy buildings- a roadmap for the energy transition process**

There is a lack of understanding of low energy buildings, technologies and expertise in the regional and even national level. Research is required to understand stakeholder motivations and establish a roadmap for the energy transition process. Successful examples from Europe can be used
Evidence review, Small project (£50-100k)
Built environment, energy policy, economic

**59. Models of Circular Economy in the agro-industrial sector: barriers and opportunities**

Transport, land use change and agriculture have experienced the steepest growth in greenhouse gas emissions among Northern Ireland sectors between 1990 and 2017. Innovative models of Circular Economy in the agro-industrial sector can help the decarbonisation of energy intensity sectors, such as transport, heat and power. However barriers to their implementation are still in place. The idea is to look at non technological barriers such as policy, regulatory, financial, economic, managerial and social, through the analysis of innovative Circular Economy models for biofuel production.
Small project (£50-100k), Large project (£100k+)

Energy engineering, economics, biology, chemistry, social scientists. The role of industry is important, as well as the collaboration from government

**60. How to raise public's awareness of the importance of households' energy investment decisions to achieve a low carbon society.**

This topic builds on previous UKERC Whole Systems Networking Fund "Women buying green" project that found that a low percentage of people – generally less than 20% - are willing to invest in low carbon measures, with little differences across gender and geographical areas. It is therefore important to understand how to increase people's awareness of the importance of investing in low carbon solutions at the household level, considering the role of discounting, gender, and different socio-economic groups, as it is unlikely that "one size fits all". Such research would also contribute to the Northern Ireland Department for Economy call for evidence for the role of consumers towards a low carbon society. Increasing people's awareness of the importance of investing in low carbon solutions will help implementing the transition to a net zero energy system. This topic would complement UKERC's research of the Public Engagement Observatory

Large project (£100k+)

Behavioural/environmental/energy economics, energy engineering, sociology. It might be good to explore also the role of other disciplines, such as art to showcase future scenarios and increase people's acceptability of low carbon solutions. We also envisage the important role of organizations representing civil society and government departments

**61. Models of Circular Economy in the bioenergy sector: barriers and opportunities**

Transport, land use change and agriculture have experienced the steepest growth in greenhouse gas emissions among Northern Ireland sectors between 1990 and 2017. Innovative models of Circular Economy (CE) in the bioenergy sector can help the decarbonisation of energy intensity sectors, such as transport, heat and power. However barriers to their implementation are still in place. The idea is to look at non technological barriers such as policy, regulatory, financial, economic, managerial and social, through the analysis of innovative CE models for bioenergy production in NI. The work would fit the following UKERC's research themes: Energy infrastructure transitions, Energy for mobility, Technology and policy assessment, Public engagement observatory.

Small project (£50-100k)

Energy, Economic, Politics, Social science. The role of industry and local authorities would be key.

**62. Establishing a database of in situ (real life) performance of the low-energy technologies which will be mandated in the future.**

For Example the UK Ultra Energy Efficiency target which was proposed by the UK Climate Change Committee in March 2019 has some examples build currently (e.g. using the passive house standard and called for sustainable homes). By carrying out detailed Post Occupancy Analysis of

these dwellings insights would be gained to help inform the optimal approaches to achieving low energy buildings.
This topic is a good fit for UKERC as independence is required in order to evaluate the technologies employed (e.g. heat recovery ventilation systems versus demand controlled ventilation versus natural ventilation), in use performance of heat pumps, and also BUS evaluation criteria.
Evidence review, Large project (£100k+)
Engineering, architecture, built environment, psychology

63. **There is a real issue with lack of understanding of technology such as heat pumps in industry, which has led to a number of heat pump installations being removed and replaced with fossil fuel heating systems in NI. Research into the knowledge and attitude within industry for these key future technologies is needed if they are to be part of a successful energy transition.**
Independence is required, and a analysis skill set in addition to cross functional expertise.
Evidence review, Large project (£100k+)
Engineering, architecture, built environment psychology

64. **Given that so few examples exist, there is a lack of understanding of low energy buildings, technologies and expertise in the province of Northern Ireland. Research is required to understand stakeholder motivations and establish a roadmap for the energy transition process. There are examples from Brussels, Luxembourg et cetera which could potentially be used. This is not purely a technology project but rather is building on established methods of change management, influencing, skills transfer**
This topic is a good fit for UKERC given its cross functional nature and research expertise required
Evidence review, Small project (£50-100k),Large project (£100k+)
Change management, engineering, architecture, psychology

65. **Skills and training for net zero.**
Big unknowns here yet we know demand will go up in some area e.g. hear. It is a whole system issue and could have significant policy requirements/impacts
Large project (£100k+)
Likely mixed methods with some element of social analysis.

66. **Macro-economics of decarbonisation. Where is the value of decarbonisation for GB.**
This is another cross-sector issue, hugely timely particularly if the country is looking to fill a post-Brexit hole. Also potentially large policy/political interest.
Large project (£100k+)
Modelling, finance, economics

67. **Equity and heat decarbonisation.**

With so much money at stake, this is a huge issue, particularly with inequality in the UK and housing issues. This would be a wide study which spans across different parts of the energy system but could have huge social value.
Large project (£100k+)
Economics and finance, public engagement, modelling, social research.

**68. Heat transitions in the UK and the Netherlands**
Energy infrastructure transitions are a key theme for UKERC 4, and the heat transition will be both central to the UK transition and arguably the most challenging element. The Netherlands has a similar set of challenges in moving from a natural gas dependent system, and the UK could learn from the Dutch experience.
Large project (£100k+)
Energy systems, engineering, political science, sociology. Economics

**69. Local governance**
Meeting decarbonisation targets will include needing more DER. At a local level DER would include whole system decarbonisation e.g. heat, electricity and transport. Would local governance for DER be more appropriate than centralised control?
Large project (£100k+)
Social sciences - policy/politics, behavioural, physical geography; engineering; economics

# 4. Appendix A: List of workshop attendees

| First Name | Surname | Affiliation |
|---|---|---|
| Gloria M | Alvarez | University of Aberdeen |
| Elsa | Barazza | UCL Energy Institute |
| William | Burns | UKERC |
| Jenny | Crawley | UCL |
| Antzela | Fivga | University of Birmingham |
| Jim | Fleming | UKRI |
| Rebecca | Ford | University of Strathclyde |
| Virginia | Gori | UCL Energy Institute |
| Rob | Gross | Imperial College |
| Jon | Hall | Community Energy England |
| Matthew | Hannon | University of Strathclyde |
| Graeme | Hawker | University of Strathclyde |
| Ian | Hepburn | UCL |
| Tara | Hooper | Plymouth Marine Laboratory |
| Patrick | Keatley | Ulster University |

| | | |
|---|---|---|
| Ioanna | Ketsopoulou | UKERC |
| Konstantinos | Kopsidas | The University of Manchester |
| Matt | Lewis | Bangor University |
| Robert | Lowe | UCL Energy Institute |
| Strachan | McCormick | UKRI |
| Alison | Mohr | University of Nottingham |
| Meysam | Qadrdan | Cardiff University |
| Tony | Roskilly | Durham University |
| Anastasios | Rousis | Smart Power Networks |
| Hiroki | Shin | Science Museum, London |
| Aruna | Sivakumar | Imperial College London |
| Fei | Teng | Imperial College London |
| Xinfang | Wang | University of Birmingham |
| Jin | Yang | University of Glasgow |

# 5. Appendix B: Breakout group outputs