UKERC
UK Energy Research Centre

UKERC Flexible Research Fund Town Hall Meeting

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Meeting Report

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Jim Watson, UK Energy Research Centre
Ioanna Ketsopoulou, UK Energy Research Centre
Christophe McGlade, UCL Energy Institute
Matthew Aylott, UK Energy Research Centre

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Contents

1. Introduction

In May 2014, the UK Energy Research Centre (UKERC) was awarded £14 million from EPSRC, ESRC and NERC for a third five year phase of research and engagement activities (2014-19). This new phase will build on UKERC's first two phases (2004-2014). As was the case for UKERC phase 2, the new phase of UKERC includes a flexible research fund that will be allocated through a series of open research calls, overseen by an independent Research Committee. Around £4 million will be available for the flexible research fund during UKERC phase 3.

The flexible research fund has a number of objectives, including:

- To bring a wider range of researchers and disciplines into UKERC's research programme, including researchers from outside the energy community;
- To build collaborations between the UKERC research community and other research communities – including other energy researchers, groups and centres;
- To allow the research programme to develop flexibility in the light of new scientific insights or external developments (e.g. in energy policy);
- To fill gaps in the UKERC research programme and/or the wider Research Councils Energy Programme; and
- To scope and develop new research agendas in partnership with funders, the research community and other stakeholders.

On 30 June 2014, an initial Town Hall Meeting was held at the UCL Institute for Sustainable Resources in London, to discuss potential priorities for flexible funding. This was the first of a number of similar consultation meetings that will be held during the course of UKERC phase 3. These meetings will be complemented by other activities to inform decisions about research fund priorities, including bilateral meetings, horizon scanning and scoping activities led by the UKERC research co-ordination team.

Around forty academics and representatives of other organisations attended the meeting. This report summarises the research questions and ideas that were proposed by meeting participants, and presents UKERC's analysis of these proposals and the priorities identified by participants.

The meeting started with a presentation on the core research programme for UKERC phase 3[1], and an opportunity for participants to ask questions about the content, organisation and further development of the programme. This was followed by facilitated breakout sessions to gather and cluster research questions and ideas for the flexible fund, followed by an opportunity for participants to indicate which ideas from all of the breakout groups they thought UKERC should prioritise.

This report comprises two further sections. Section 2 presents an analysis of the research questions and ideas that were proposed which was prepared after the meeting by members of the UKERC research co-ordination team (Jim Watson and Ioanna Ketsopoulou). This analysis groups proposals into major themes, and highlights research areas that were particularly popular amongst attendees. Section 3 presents the raw data from each of the three meeting breakout groups. These sections are followed by appendices: a list of attendees and pictures of breakout group outputs.

We would like to thank all attendees for their enthusiastic participation in the meeting and for being willing to share their ideas. We would also like to thank staff from the UCL Institute for Sustainable Resources for hosting the meeting, and breakout group chairs and note takers for their assistance on the day.

2. Analysis of proposed research questions, ideas and priorities

This section presents the analysis of the research questions and ideas that was carried out after the town meeting by the UKERC research co-ordination team. This analysis grouped the proposals into eight related themes. It is important to note that this is not the only way in which the meeting outputs could have been grouped. Furthermore, many of the proposed research ideas cut across more than one of these themes.

[1] Further details about the core programme, its six research themes and initial core research projects can be found here: www.ukerc.ac.uk/support/UKERC+Phase+3

a. *The analysis of UK energy system transitions*, including research on:

- The drivers of energy system change, including how changing social norms and trends (e.g. ageing and the development of medical technologies) could affect energy demand and energy transitions. There was a particular focus on the drivers of transport demand, and how these might affect the balance between different components of demand and transport modes;
- The current energy system, particularly the emissions that are 'locked in' due to existing and committed infrastructure and the challenges of decommissioning existing infrastructure once it is no longer needed;
- What socio-technical pathways are possible, including the interactions between low-carbon and more carbon intensive pathways, and the scope for transitions that involve rapid changes in supply and/or demand;
- What lessons could be learned from innovation in other sectors (e.g. Information and Communication Technologies (ICTs)) and from historical energy transitions, particularly the extent to which these were 'controlled' and the extent to which they are cyclical;
- The role of ICTs in shaping and enabling energy system change, including the impacts on behaviour, energy demand and the implications for demand reduction policies and energy security;
- The scope for energy efficiency, including end use efficiency, the net energy yield of energy supply resources and technologies and the potential rebound effects due energy efficiency and lower cost sources of energy supply; and
- Methods for exploring energy transitions including the pros and cons of energy systems and macro-economic models, how and why real energy systems deviate from optimal pathways predicted by some models, and how publics can be engaged (e.g. through social horizon scanning).

b. *The nexus between energy systems and other systems*, including research on:

- The potential implications of climate change for energy demand and energy system resilience, and what technologies and other changes could help energy systems to adapt;

- The impact of different energy futures on biodiversity and ecosystem services, and the energy policy implications of a greater focus on biodiversity;
- How data from diverse, interdisciplinary models, tools and analyses can be better integrated, and what opportunities there are to fund research that bridges between energy and ecosystems research communities;
- The interactions between food and energy security including the energy implications of potential changes in diets, and the energy required for transport within the food system; and
- Energy demand for materials and the production of chemicals, including the implications for carbon intensity of shifting production to emerging economies.

c. *The assessment of specific technologies and fuels within energy systems*, including research on:

- The role of gas, including the role of unconventional gas in community energy systems, and the scope for power to gas at all infrastructure levels.
- The integration of new storage technologies in the UK electricity system;
- Analysis of specific energy vectors, e.g. the costs and benefits of burying electricity transmission lines underground, and modelling of hydrogen energy systems;
- The decarbonisation of heating including the whole systems economic, social and technical appraisal of off-grid biomass heating, the development of innovation systems for heat pumps, and the development of technological roadmaps for heating and cooling technologies;
- The future role of negative emission technologies such as biomass carbon capture and storage (CCS), and the implications of capturing and storing (or using) ambient CO_2;
- Assessing the factors that could affect the adoption of electric vehicles including their role in rural communities, the costs of rapid charging, affordability among less affluent consumers, and the development of charging infrastructure in different geographical contexts; and
- Comparative analysis of technical, economic and social justifications for different technologies.

d. The *spatial analysis of energy systems*, including research on:

- The energy required to transport energy (e.g. gas via pipelines and tankers or biomass resources by road, rail and ship), and goods (road freight);
- Upscaling UK biomass production using less land, focusing on public acceptability and technical challenges for farming and boiler design;
- Spatial analysis low carbon technology deployment, and how that might be limited by physical, social and other factors. This includes the impact of shale gas on renewable energy deployment at specific locations;
- The development of microgrids in isolated communities, and potential interactions with the 'mainstream' grid-based energy system. This could also focus on developing countries;
- Urbanisation and its impact on energy and transport systems, the implications for energy consumption, and the impacts on the local environment (e.g. via overheating); and
- Spatial analysis at continental scale (e.g. the European Union), including the cost effective geographical locations for energy generation, the operation of a High Voltage Direct Current (HVDC) 'supergrid' and a comparison of UK energy visions, pathways and strategies with those of other European countries.

e. The *engagement of communities, publics and society in the development of energy systems*, including research on:

- The role of publics in energy system change (e.g. through social horizon scanning), and social attitudes to different systems. This includes the conditions under which consumers could shift from gas central heating;
- The public acceptability of energy sources and technologies including waste to energy, nuclear power and unconventional gas exploration.
- Engagement of communities with energy planning at local, regional and national scales. This includes research on the impacts of shared ownership of energy infrastructure and/or the provision of community benefits;
- Energy consumption, including the extent to which behaviour can be influenced to reduce demand, the extent to which this could be made attractive (e.g. to young people), the influence of national politics on patterns of consumption

(including why different policies work in different contexts), and whether early influences affect people's consumption patterns; and

- The acceptability of 'imperfect' energy systems (e.g. those that may not be as reliable as the current system), including the acceptability of different demand management options.

f. *Equity and justice in current and future energy systems*, including research on:

- Deliberative and participatory process to increase procedural justice in decision making about the future direction of energy systems and technologies;
- Broader appraisals of energy technologies that account for impacts on justice and equity;
- The spatial distribution of the costs and benefits of current and future energy systems, including in particular low carbon heating solutions for communities who are not connected to the gas grid;
- The political economy of energy policies, focusing on potential losers, the impact of policy targets on existing power relationships, and the broader equity implications of energy policies and strategies; and
- The relationship between income and environmental values.

g. *UK energy policies and strategies* including research on:

- The strengths and weaknesses of markets and regulation for mitigating carbon emissions, and how decarbonisation could affect energy markets, business models, regulation and governance;
- The development of markets and market mechanisms, including the development of spot electricity markets, competitive tendering for offshore wind deployment, and mechanisms for electricity system services.
- Informing decisions about government support for energy technologies, including when to stop support for a particular technology, and the pros and cons of taking greater risks with government support (e.g. nuclear fusion);
- Policies in other domains that impact on the energy system, e.g. education, healthcare, bio-diversity. This also includes the integration between energy and

environmental policies, and the role of geo-engineering in future climate change mitigation and adaptation strategies;

- Evaluations of current or past policies, including the practice of evaluation within government and the extent to which there is sufficient policy learning. Specific areas for evaluation could include the impact of low carbon retrofits, smart meter trials, capacity mechanisms and offshore wind auctions;
- The interaction between the EU and the UK, including the UK's influence on EU energy policies and the implications of a UK exit from the EU;
- Opportunities for strengthening local energy governance, the pros and cons of local vs national governance, and the role of Local Authorities;
- The development and implementation of new business models and practices. For example, how would a shared or leased model with 'mobility service providers' affect the interaction between transport and energy? Is the UK electricity system set up for multi-directional flows of power in smart grids? Will industrial energy consumers be willing to change the way they operate as the energy system includes more intermittent renewables?
- The role of the mainstream investment community in financing sustainable energy transitions, and the factors that affect their decision making;

h. The *international role of UK energy actors*, including research on:

- The role of UK energy actors in energy governance in the global south, e.g. energy companies that invest in growing markets, the role of Department for International Development (DFID) aid programmes and UK-based non-governmental organisations (NGOs);
- The analysis of energy technology patents and how changes in the global distribution of innovation could impact on the UK innovation system;
- The implications of development and growth in the 'global south' for UK energy policies, carbon targets, strategies etc.; and
- How energy systems in developing countries could be steered in a less carbon intensive direction, and the implications for the UK of transitions that are occurring or will occur in developing countries.

The prioritisation exercise at the end of the Town Meeting provided participants with an opportunity to indicate which areas they thought should be prioritised. Each participant was given seven 'votes' to distribute among the research themes, topics and questions they would like to be prioritised. In some cases, participants voted for an overall cluster of research topics whilst in others they voted for specific research topics. Care is therefore needed in the presentation and interpretation of the results. Furthermore, the priorities from this Meeting will need to be examined alongside ideas proposed during other forms of consultation (e.g. bilateral conversations with researchers who were unable to attend).

The themes, topics and clusters that were particularly popular include:

- Research clusters from two breakout groups on ***public engagement, attitudes and values***. Taken together, these were the most popular by a significant margin. The proposed questions and topics covered a broad area including the engagement of publics in energy system change, the use of social horizon scanning in decision making, attitudes to particular energy technologies, and research on participation and justice. There was particular interest in social science-led research on heating systems for communities off the gas grid, which would also include some technical analysis. In addition research on the public acceptability of shale gas exploration and distributional justice received particular attention;
- The second most popular area is closely related to the first, and includes clusters of research ideas focusing on ***decentralised energy***. These clusters included community engagement, ownership and preferences as well as local energy governance, the analysis of local energy opportunities, and the pros and cons of local energy systems when compared to more centralised systems;
- ***Negative emissions technologies*** and the capture and storage (or use) of ambient CO_2. Within this, research proposals included an evidence review of biomass CCS technologies from an economic, technical and social; and research that compares the relative economics of biomass CCS with bio-sequestration and atmospheric sequestration;
- The ***spatial costs and benefits of energy futures***, including the geographical distribution of these costs and benefits (e.g. between urban and rural areas, or between different UK regions), and justice issues;
- The ***appraisal of energy technologies, options and pathways***. Within this, the upstream impacts of energy generation technologies were particularly popular.

Other proposals in this cluster included research on a range of specific technologies, on methods to analyse energy system change (e.g. a critical appraisal of models), and decommissioning existing energy infrastructure.

- Research on ***the drivers of energy debates and energy system change***. There was particular interest in drivers from outside the 'energy sector', and in the impacts of government policies outside the energy domain. Examples of the former include the influence of ageing on energy demand.
- A specific research proposal on ***imperfect energy systems***, which would focus on the impacts of blackouts on energy investments, the assessment of energy resilience measures, the costs and benefits of 'second best' energy systems, and how communities would respond to energy shocks.
- Research on ***finance and investment***, particularly the role of the mainstream investment community in financing sustainable energy transitions – and what affects their decision making;
- Research on ***international roles of UK energy actors from the public and private sectors***, including their investment activities and roles in energy governance in the 'global south';
- ***Policy evaluation research*** to better understand the impacts of past energy policies in order to help inform future policies. This could include specific research on recent policies for energy efficiency, renewable energy support and smart meters;
- Research on the ***politics of energy consumption***, with an emphasis on comparisons between UK and other countries, and on what policies and approaches have been more or less successful in different countries;
- The ***interactions between food and energy systems***, particularly how food and energy security are related. This cluster includes proposed research on the energy required for transport in the food system, and the energy implications of changes in diets.

3. Research questions and ideas in detail

During the breakout groups, participants were initially given some time to identify research questions and ideas individually. These questions were then presented and discussed with the rest of the group, and were then clustered into broader themes. In addition to identifying potential research questions or topics, participants were also asked to consider what type of research activity might be required to answer those questions, and what combinations of disciplines could be required.

Breakout Group 1

Chair: Jim Watson, UK Energy Research Centre; **Note taker:** Ioanna Ketsopoulou, UK Energy Research Centre

The suggested research questions and topics from Breakout Group 1 are as follows:

1. The future of energy technology patents in the UK innovation system.

   Associated disciplines & expertise: economics, business, corporate strategy, geopolitics.

2. The evolution of freight transport energy use given the variety of stakeholders.

   Associated disciplines & expertise: logistics, transport, energy technology.

3. The rebound effects of unconventional fossil fuels.

4. Technology innovation and deciding when to stop supporting a particular technology.

   Project type: initial review, followed by a larger project.

   Associated disciplines & expertise: science, engineering, economics & modelling.

5. The strengths and weaknesses of a market led approach compared to a regulation led approach in mitigating carbon emissions.

   Project type: initial review, followed by a larger project.

   Associated disciplines & expertise: economics, social science, legal, pathways.

6. The role of geoengineering in future mitigation and adaptation strategies.

Associated disciplines & expertise: social science, climate science, engineering.

Project type: small project.

7. The spatial representation of limitations in low carbon technology development.
   - A UK map of infrastructure, social and other limitations, showing the overlap of available space for competing technologies

8. The impact of shale gas on renewable energy development and the attitudes towards it.
   - A spatial and temporal analysis

   Associated disciplines & expertise: geography, geographic information systems (GIS), social science, media studies.

9. How will unconventional gas become more acceptable?
   - Associated disciplines & expertise: environmental science, social science

   Project type: large project

10. Quantification of energy that is consumed in transporting energy.
    - The effect of international developments on transport patterns

    Project type: small project that could sit between Themes 2 and 3.

11. Upscaling UK biomass production on less production land using seed propagation of *Miscanthus*.
    - This would explore public acceptability issues, as well as the technical challenge to farmers and boiler designers

12. What energy storage technologies are needed to smooth out kinetic renewables?

    Project type: large project from an engineering and economics perspective, medium project from a social sciences perspective.

    Associated disciplines & expertise: engineering, economics, social science.

13. The promotion of functional sustainability in the UK.

    Associated disciplines & expertise: engineering, political, social.

14. The relationship between the UK and the EU in terms of geopolitical, economic, social energy & governance.
    - This project would include workshops with international delegates

15. What should will the rise of energy in the post 2015 international development architecture?
    - The implications for the UK
16. How fast is energy demand growing in the global south?
    - How does that impact global emissions and what are the implications for the UK
    - This project would explore the reliability of 2050 calculators and the associated key drivers of change
17. The role of UK energy actors in energy governance in the global south, e.g. energy companies that invest in growing markets, the Department for International Development and NGOs.
18. How to effectively engage with young people to make energy seem fun.
19. The effective deployment of energy services at City scale:
    - This project could create links with the Energy Technologies Institute (ETI) and the Technology Strategy Board (TSB) Future Cities programme

    Associated disciplines & expertise: governance, policy engagement.
20. How to get consumers to move away from gas for heating.

    Associated disciplines & expertise: consumer research, economics, social science, policy studies.
21. The role of unconventional gas in community energy systems.

    Associated disciplines & expertise: engineering, economics, policy studies, social science, environmental science.
22. The future role the gas network in a low carbon energy system. What are the alternative areas for investment?

    Associated disciplines & expertise: engineering, economics, policy studies, regulation, finance.
23. Heating and cooling roadmaps and strategies.
    - This project was identifies as a possible collaboration with the i-STUTE Centre

    Associated disciplines & expertise: technology, business, policy, consumer behaviour.
24. What technologies are needed for heating and cooling?
    - This project would follow a top down approach, using heating and cooling demand as a starting point in order to identify technological challenges

Project type: initial scoping workshops that could lead to a Research Challenge.

25. Power to gas at all infrastructure levels.

    Associated disciplines & expertise: infrastructure, modelling, technology, economics.

26. How to make waste to energy projects acceptable to communities.

    Project type: small project.

    Associated disciplines & expertise: environmental science, social science, economics, engineering.

27. How to make nuclear acceptable to the public.

28. The losers of climate change mitigation and the effect of policy targets on existing power structures.

29. The key turning points in historical energy transitions and the applicability of those lessons to future energy pathways.

    - A historical analysis of previous transitions to determine the degree to which the transitions are they controllable, especially at consumer level.

30. The balancing of energy security costs and benefits at a national level. What incentives are needed for security improvements?

31. Smart grid governance. Is the UK electricity system conducive to new multi-directional flows of power?

    This project would link to Themes 2, 3 and 5.

32. The integration of new storage technologies in the UK electricity system.

    - What technologies are likely to be available and when, how do they integrate with demand expectations and how much of demand will be non-electric

    Project type: initial review that could lead to a Research Challenge.

33. How does ICT shape the future of energy system change, in terms of social behaviour and energy security?

34. ICT as a system enabler and the high dependency of the energy sector on ICT.

    Project type: the social aspect could be analysed in a smaller project, while a more in-depth study would be required to investigate energy dependency.

35. The model of system change that underpins the UKERC energy pathways and how does it deal with various factors.

36. The decarbonisation of off-grid heat.
    - What are the barriers and alternative decarbonisation options
    - The role of biomass

    Project type: small project in terms of engineering, medium in terms of economics, large in terms of social science.

    Associated disciplines & expertise: engineering, economics, social science.

37. How will considering the energy system on a continental scale alter the most cost-effective solutions for individual countries?

    Project type: initial review, leading to a modelling project.

38. Accounting for the social and societal dimensions of energy technology appraisals, e.g. justice and equity.

39. The role of the publics in whole energy systems analysis.
    - Future social horizon scanning

40. Shale oil and its rebound effects.

In the second part of this breakout group discussion the individual ideas were assigned to the following thematic clusters: *spatial analysis, public engagement, technical pathways & technological assessment, land-use, energy policy & strategy, the international role of UK actors, history & transition theory, social change, governance* and *security & resilience*. A summary of the resulting thematic clusters is outlined in the Table below. As can be seen, some of the research topics fall under more than one thematic area.

Table 1. Clusters of research topics for Breakout Group 1

Cluster	Research topic numbers
Spatial analysis	2, 7, 8, 10, 37
Public engagement	9, 13, 18, 20, 26, 27, 36, 39
Technical pathways & technological assessment	3, 21, 22, 23, 24, 25, 32, 35
Land-use	11
Energy policy & strategy	2, 4, 5, 6, 19, 28, 37, 38, 40
The international role of UK actors	1, 5, 16, 17
History and transition theory	29, 33, 35
Social change	21, 25, 39
Governance	19, 31, 38
Security & resilience	29, 34

The final section of the breakout session focussed on important areas that have not been covered so far, and on themes that had not been highlighted in the way the individual research questions had been clustered. Several further points were made:

- *Distributional effects*: the distribution of the costs and benefits of change, and the impacts of current / future energy systems on equity.
- *Tools and methods vs empirical research*: most of the research topics are about applying the tools that already exist. They are not reflective about the existing methodologies and do not lead to the development of new ones.
- *Deployment issues*: the practical requirements of heat decarbonisation.
- *Balancing the energy policy trilemma*: how policy is conducted and what drivers are viewed as important by the public.
- *Metrics of 'progress'*: traditional metrics, such as GDP growth might be insufficient.
- *Social change and the drivers behind energy demand*: future energy demand projections and the impact of changing social norms. Domestic hot water and the use of appliances were given as examples of key drivers.

Breakout Group 2

Chair: Nick Eyre, University of Oxford; **Note taker:** Christophe McGlade, UCL

In this breakout group most of the suggested research topics were presented individually and many were not clustered under larger research themes. However, in a number of cases some of the individual ideas were grouped together. The research questions and ideas suggested are set out below. These include information on the type of activity that may be required, and on the disciplines that might be needed to address these research areas.

1. **Microgrids**:
   - The governance of local energy systems. Local energy versus centralised energy generation and personal choice versus Local Authority choices.
   - To what extent can communities on the mainland benefit from the development of microgrids from isolated communities and developing countries? In particular looking at local vs distributed energy systems

   Project type: Small initial scoping project via interviews/social study/literature survey (links with Theme 3).

   Associated disciplines & expertise: Electrical engineering, social scientists.

2. **Energy and development**:
   Industrialised nations have high energy intensities. How can development trajectories for less industrialised societies be steered into less carbon intensive routes? What are the implications for the UK of the transitions that are occurring or will occur in developing countries? How can we better understand these and what lessons can be learnt from these?

   Project type: Workshop/scoping study.

   Associated disciplines & expertise: Wide network of parties.

3. **Electric Vehicles pathways:**
   How can we translate the notional pathways for electric vehicles to reality? E.g. electric cars in rural communities, the actual cost of rapid charging (generally much greater than modelled), and the context-specific nature of EV charging e.g. how would it work within a large block of flats? What are the social implications of EV (since these are currently only bought by the affluent)?

   Project type: Synthesis/thinking through some specific scenarios. Position paper?

Associated disciplines & expertise: Town and grid planners, big 6 energy companies, DNOs, car clubs.

4. **Lean operations:**
   Is there a tension between 'lean operations' that favour smooth workflows and an increasing penetration of renewable energy? Will companies be willing to become less lean to consume less energy? How will they manage this tension?

   Associated disciplines & expertise: Operations management, economists.

5. **Finance and investment:**
   How can the role of the mainstream investment community focus on sustainable energy transitions? What affects the decisions that investors (e.g. fund managers, venture capitalists) make? Mapping how finance is provided to finance the low carbon transition?

   Project type: Exploratory/scoping study?

   Associated disciplines & expertise: Investors, economists.

6. **Biodiversity and energy feedback:**
   - Can we better understand the feedback of ecosystem services research to energy policy? The impact of different energy futures on biodiversity and ecosystem services with a focus in ecosystem services feedback into energy policy and economic models.
   - How can flows of data from diverse, interdisciplinary models, tools and analyses be better integrated?

   Project type: Smaller research projects – proposing a framework to help make variables consistent between the very different research areas.

   Associated disciplines & expertise: Biodiversity scientists, geographers, economists.

7. **Mitigation and adaptation:**
   Should we be developing technologies to better handle the impacts of climate change? Have resilience studies taken into account energy system implications? e.g. geo-engineering/flood defence. What technologies would better help the energy system (including houses) adapt?

   Project type: Synthesis project, Joint funding with ARCC?

   Associated disciplines & expertise: Engineers, town planning, biofuel cells, buildings.

8. **Business models and agendas:**
   - How could decarbonisation affect energy markets, market structures and business models, regulation, governance? What are the market options for 2050?
   - The future of transportation. How would a shared or leased model with 'Mobility service providers' affect the interaction between transport and energy?

   Project type: £500k initial study.

   Associated disciplines & expertise: Economists, modellers.

9. **The post-2050 energy system:**
   What difference would fusion or other backstop technologies make to the post-2050 energy system? Should we throw all energy research money at fusion? Risk/reward playoff

   Associated disciplines & expertise: Modellers, nuclear physicists, economists.

10. **Policy evaluation:**
    - Can we better understand the past evaluation of energy policy and policy impacts to help inform future policies? Is the policy system integrating sufficient resources for the evaluation of current policies and lesson learning on policy implementation?
    - Randomised Control Trials on issues like smart metering. This project would likely require co-funding from industry or government.
    - Lessons learned from natural experiments, like the capacity mechanisms and offshore wind auctions.

11. **Macro-economic modelling:**
    Can we generate future energy scenarios that use alternative economic approaches not based on partial or general equilibrium models? The impact of decisions on the macro-economy.

    Project type: Pilot project to test.

12. **ICT and energy**
    What are the impacts of ICT on energy consumption (infrastructure, attitudes towards un-interuptable access, power-supply, green algorithms)? What interventions are there to reduce energy consumption in ICT?

    Initial review and may lead into a broader project.

    Associated disciplines & expertise: Computer scientists, social-scientists.

13. **Learning from innovation in other sectors**
How useful is it to look at innovation in other sectors (such as telecommunications) for learning about transitions in the energy system?

Project type: £100k study.

Associated disciplines & expertise: Economists and social scientists.

14. **Energy systems transitions:**

- Do energy systems go through cycles? What drives these? What's coming next?
- What are the sociotechnical pathways and the interactions between pathways for low carbon and non-low carbon options?

15. **Materials:**

Energy for materials and chemicals: industrial energy demand for materials and chemicals production continues to grow in a consumer-driven society. As production shifts to emerging economies carbon intensity may increase. How can we quantify the impacts of this shift and identify lower carbon alternatives?

16. **Freight versus energy:**

What is the impact of passenger and freight transport on energy demand and energy security?

Associated disciplines & expertise: Transport specialists, modellers.

17. **Food and energy security:**

Ensure food security and energy security research are linked. These are often disparate research fields and there is a need for more inter-linkages between the communities

E.g. how can you influence dietary choice? How can energy use in freight be minimised? The role of freight in the wider energy system? Given that supply chains are international, this area would need to look in an international context.

Project type: Initial high level study that draws together the evidence that is already there. Could compliment the nexus research, but with a more technical focus. If did take all aspects into account, this could become a challenge.

Associated disciplines & expertise: Engineers, geography, economics, social-scientists, policy people, transport specialists.

18. **Responses to unpredictability:**

How do you cope with deviations from the 'optimal' pathway? Can we understand the transition as it occurs, and why does this differs from what we had modelled? Would ideally be used to help inform policy.

Associated disciplines & expertise: Real options, economists, policy people, military planner.

19. **Non-energy policies:**

- Non-energy policies that impact on energy. E.g. education, healthcare, bio-diversity, the media. What are the drivers of the public policy debate on energy and is there a disconnect between public opinion and the policy debate?
- The implications of big societal trends, e.g. ageing and the development of medical technologies.
- Do early influences affect energy consumption patterns as young adults become consumers and bill-payers?

Project type: Research fund project.

Associated disciplines & expertise: Disciplines depend on the project itself.

20. **Politics and consumption:**

- Politics and consumption. E.g. looking internationally, why do some consumption policies work there and why not in the UK, and how could they be adopted/adapted to work here?
- From the perspective of energy demand reduction how far do you go to influence human behaviour in order to effect energy savings?

Project type: Pilot study to more detailed surveys (interviews, focus groups).

Associated disciplines & expertise: Social scientists of different types, economists.

21. **The interaction between the EU and the UK:**

What would the implications of a UK exit from the EU be on UK energy policy? UK energy policy within the context of the EU? Give flexibility to look at issues such as what happens if UK leaves EU, how has the UK influenced EU energy policy?

Project type: Research call.

Associated disciplines & expertise: Economists, regulatory, political scientists, bankers.

Breakout Group 3

Chair: John Barrett, University of Leeds; **Note taker**: Matthew Aylott, UK Energy Research Centre

The research questions and ideas that were proposed are as follows:

1. Define the 'baseline' that we are starting from:
    - What would happen if you did nothing to the UK energy system, what is the business as usual response given current policies?
2. Opportunities for localisation of energy supply:
    - What scales work?
    - What governance structure is needed to achieve it?
3. Societal attitudes to energy:
    - Expectations
    - Tolerance of the imperfect
    - Understanding of the drivers for the UK
4. What are the potential link programmes?
    - UK (e.g. GFS, Nexus) and Internationally
    - And can UKERC leverage funds from them
5. Decommissioning energy infrastructure

    Project Type: Workshop or small research project
6. Integrating energy and environmental policies

    Project Type: Workshop or evidence review
7. Energy futures in off gas grid areas:
    - Exploring policy integration, correlation with fuel poverty, non-standard contracts, LPG in rural areas

    Project Type: Evidence review or workshop
8. Upstream impacts of energy generation:
    - Evidence review or small scale project on topic such as global footprint of bioenergy
9. Managing the operation of a HVDC European "Supergrid":
    - Individual country energy production and usage patterns

- Economic and policy influences
- Engineering challenges

10. Engagement of communities with energy planning at local, regional and national scale:
    - Dissemination of technical, scientific and economic justifications for decisions

    Link with UKERC themes 3 and 5.

11. Techno-economic modelling – critical analysis:
    - Improving the skill and accuracy of techno-economic models, incorporating more of the technological detail
    - Consider future uncertainties

    Link with UKERC themes 2 and 6.

12. Looking at climate change impacts on demand and supply:
    - Scale of implications and responses
    - Risks (e.g. extreme events), costs and adaptation

    Project Type: Scoping review.

    Link with UKERC themes 2 and 3.

13. Introducing competitive tendering for offshore wind round 4:
    - Assess the viability and benefits of bidding for the allocation of areas
    - Allocation of areas for wind rather than allocation of developers
    - Procedural justice with local population for tendering
14. How do we fundamentally change markets and business models:
    - Behavioural changes and long-term impacts
15. Market mechanisms for electricity system services:
    - Inertia in electricity systems, how do we value this?
16. Hydrogen system modelling:
    - Energy storage role and energy demand reduction in transport system
    - Valuation of services – with diverging markets
17. Comparing UK visions, pathways and strategies with those of our European neighbours
18. Transport – drivers for changing demand (linked to 38)

19. How do we make people happy to use less energy:
    - How do we change business models to reduce demand
20. Role of ICT in energy transition:
    - Visions versus societal and economic trends
    - How business models can be changed
    - Control consumption
21. Value of back up generation and dealing with extreme events:
    - Impacts of blackouts on energy investments
    - Resilience measures
    - B/C of second best energy delivery systems
    - Do we need a phased re-connection system
    - Implications of shock
22. To what extent can energy efficiency be improved to deliver value for money and take into account lifestyle changes (linked to 25)
23. Heat pumps and UK innovation systems:
    - Mapping and evaluating the UK innovation system for key energy efficiency technologies, e.g. heat pumps
24. Systematic review of the net energy yield of energy supply sources:
    - Modelling the net energy implications of different energy transition pathways, i.e. what is the net energy yield of rapid development of renewables
    - Poor quality resources (fossil)
    - Energy return on investment
25. Using behavioural economics to shape energy demand decisions:
    - Experimental surveys and trials of influencing household investment decisions and operational decisions
    - Can people be nudged towards energy efficiency measures
26. What emissions are locked in to existing and committed infrastructure:
    - Implications of more rapid energy system change
27. Relationship between personal expenditure and environmental values:
    - What are these environmental values and how do these relate to attitudes

28. Update of the UKERC Technology and Policy Assessment (TPA) rebound effect study.
29. Cost-benefit analysis of burying pylons underground:
    - Independent evaluation of the relative costs of overground versus underground power lines
30. Social and community acceptance of shale gas exploration:
    - Tracing community and societal acceptance of unconventional fossil fuels, including CCS
    - From local to national scale
31. Community benefits provision:
    - Assessment of their intended and unintended consequences, from perspective of multiple actors
32. Deliberative and participatory process to increase procedural justice:
    - Innovating mechanisms of public engagement at multiple scales, from local to national and EU levels
33. Distributional justice, society and scale:
    - Tracing where the costs and benefits of energy system changes fall
    - Shared ownership of community energy projects
    - Scales of deployment
34. Equity and low carbon heating solutions off the gas grid:
    - Enabling low carbon heating in an equitable way
    - Particularly focussing on urban and rural diversities, fuel poverty and vulnerable groups
35. Impacts of shared ownership:
    - Following DECC (2014) Community Energy Strategy, assess impacts of wider ownership models from multiple perspectives
36. Societal preferences for low carbon energy pathways:
    - Investigating acceptability of different system configurations
    - Models of ownership, scales of deployment, models of decision making
37. Transport mode shifting and demand reduction:
    - Decomposing what are the potential savings in reducing demand for transport: drivers, carbon and energy impacts, geographic impacts, behavioural change

38. Analysis of the drivers for transport demand:
    - Barriers to reduce demand
39. Cleaning urban air
    - At what energy costs and the role of transport and building heating, ventilation, and air conditioning (HVAC)
40. Urban energy consumption and its contribution to overheating/preventing under-heating
41. The future role of negative emission technologies:
    - What is the scale, what are the relative economics of bio-sequestration, BECCS, atmospheric sequestration and what are the consequences for the energy system

    Project Type: Evidence review, perhaps with UKERC Theme 6 (economics, technology, learning curves and social acceptability etc.)
42. Capture of ambient CO_2, its re-use and interactions with the energy system:
    - Power to gas and energy inputs to the capture process
43. Increasing urbanisation – what does it mean for selection of energy vectors for buildings and transport
44. Putting bounds on potential efficiency savings:
    - Improving energy efficiency through infrastructure change
    - Closing the gap between energy service demand and energy consumption: where are the theoretical, technical and economic limits, by sector (industry, buildings, transport, services)
45. Spot electricity markets – coping with the merit-ordering effect:
    - Creating a market mechanism that can deal with 1 day, 1 hour or 30 minute market for generation
46. Evidence review on low carbon retrofit investments in the housing sector:
    - Energy efficiency in private sector, domestic and government funded building improvements
    - Scope for policies to direct existing funding towards more energy efficiency
47. Longitudinal study of people's energy use:
    - Decomposing causes and early identification of trend shifts
48. Spatial flows of costs and benefits of energy futures:

- Equity, distribution, economics, rural/urban, sub-national/regional/local, geographical)
- Not just a CBA
- Project Type: Could link to Theme 1 on Pathways. Could be a smaller project just looking at off-gas grid areas (standalone project).

49. Comparative analysis of scientific, economic and social justifications of different technologies:
    - Offshore wind, on-shore wind and shale gas fracking
50. Rapid change in supply and demand:
    - Physical impacts on energy transitions

The clusters of research topics and questions identified by breakout group three are shown in Table 2:

Table 2. Clusters of research ideas from Breakout Group 3.

Cluster	Research Question
Policy design	
	6. Integrating energy and environmental policies
	13. Introducing competitive tendering for offshore round 4
	15. Market mechanisms for electricity system services
	25. Using behavioural economics to shape energy demand decisions
	34. Equity and low carbon heating solutions off the gas grid
	45. Spot electricity markets – coping with the merit-ordering effect
Data/evidence issues	
	4. What are the potential link programmes
	5. Decommissioning energy infrastructure
	8. Upstream impacts of energy generation
	11. Techno-economic modelling – critical analysis
	14. How do we fundamentally change markets and business models
	23. Heat pumps and UK innovation systems
	28. Update of the TPA rebound effect study

	29. Cost-benefit analysis of burying pylons underground
	46. Evidence review on low carbon retrofit investments in the housing sector
	47. Longitudinal study of people's energy use
Decentralised energy issues	
	2. Opportunities for localisation of energy supply
	10. Engagement of communities with energy planning at local, regional and national scale
	35. Impacts of shared ownership
	36. Societal preferences for low carbon energy pathways
Climate change risks on energy demand/social impacts	
Impacts of Europe and rest of the world	
	9. Managing the operation of a HVDC European "Supergrid"
	12. Looking at climate change impacts on demand and supply
	16. Hydrogen system modelling
	17. Comparing UK visions, pathways and strategies with those of our European neighbours
	20. Role of ICT in energy transition
	24. Systematic review of the net energy yield of energy supply sources
	44. Putting bounds on potential efficiency savings
Attitudes and values	
	3. Societal attitudes to energy
	7. Energy futures in off gas grid areas
	19. How do we make people happy to use less energy
	27. Relationship between personal expenditure and environmental values
	30. Social and community acceptance of shale gas exploration
	31. Community benefits provision
	32. Deliberative and participatory process to increase procedural justice
	33. Distributional justice, society and scale
48. Spatial flows of costs and benefits of energy futures	

Transport/Urban	
	37. Transport mode shifting and demand reduction
	38. Analysis of the drivers for transport demand
	39. Cleaning urban air
	40. Urban energy consumption and its contribution to overheating/preventing under-heating
	43. Increasing urbanisation – what does it mean for selection of energy vectors for buildings and transport
Negative emissions	
	41. The future role of negative emission technologies
	42. Capture of ambient CO_2, its reuse and interactions with the energy system
Imperfect energy systems – acceptability of different demand options	
	21. The value of back-up generation and dealing with extreme events
Pathways and futures	
	1. Define the baseline that we are starting from
	26. What emissions are locked in to existing and committed infrastructure
49. Comparative analysis of scientific, economic and social justifications of different technologies	
50. Rapid change in supply and demand	

Appendix 1: Town Meeting Participants

Name		Institution
Ben	Anthony	Cranfield University
Colin	Axon	Brunel University
Matthew	Aylott	UKERC
John	Barrett	University of Leeds
David	Bonilla	University of Oxford
John	Broderick	University of Manchester
Ed	Brown	Loughborough University
Mike	Colechin	Energy Technologies Institute
Lucy	Cradden	University of Edinburgh
Bob	Critoph	University of Warwick
Patrick	Devine Wright	University of Exeter
Jennifer	Dickie	University of Leicester
Razgar	Ebrahimy	Newcastle University
Duncan	Eggar	BBSRC
Paul	Ekins	UCL
Nick	Eyre	University of Oxford
Paul	Fleming	De Montfort University
Rick	Greenough	De Montfort University
Astley	Hastings	University of Aberdeen
Richard	Heap	Energy Research Partnership
Ilkka	Keppo	UCL
Ioanna	Ketsopoulou	UKERC
Noel	Longhurst	UEA
Andrew	Lovett	UEA
Greg	Marsden	University of Leeds
Sara	Martone	Canterbury Christ Church University
Christophe	McGlade	UCL
Paul	Nunn	Defra
Richard	Pearson	UCL
David	Rainer	University of Cambridge
Jon	Saltmarsh	DECC
Robert	Sansom	Imperial College
Ben	Shaw	Policy Studies Institute
Andrew	Smith	UCL
Steve	Sorrell	University of Sussex

Savvas	Tassou	Brunel University
Patricia	Thornley	University of Manchester
Dan	Van Der Horst	University of Edinburgh
Francesca	Vantaggiato	UEA
Jim	Watson	UKERC

Appendix 2: Breakout Group Outputs

Breakout Group 1:

Breakout Group 2:

Breakout Group 3: