Research Councils UK Energy Programme Strategy Fellowship

Energy Strategy Fellowship Report 3:

Summary of Workshop on

The Role of Environmental Science, Social Science and Economics

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Research Councils Energy Programme

The Research Councils UK (RCUK) Energy Programme aims to position the UK to meet its energy and environmental targets and policy goals through world-class research and training. The Energy Programme is investing more than £625 million in research and skills to pioneer a low carbon future. This builds on an investment of £839 million over the period 2004-11.

Led by the Engineering and Physical Sciences Research Council (EPSRC), the Energy Programme brings together the work of EPSRC and that of the Biotechnology and Biological Sciences Research Council (BBSRC), the Economic and Social Research Council (ESRC), the Natural Environment Research Council (NERC), and the Science and Technology Facilities Council (STFC).

In 2010, the EPSRC organised a Review of Energy on behalf of Research Councils UK in conjunction with the learned societies. The aim of the review, which was carried out by a panel of international experts, was to provide an independent assessment of the quality and impact of the UK programme. The Review Panel concluded that interesting, leading edge and world class research was being conducted in almost all areas while suggesting mechanisms for strengthening impact in terms of economic benefit, industry development and quality of life.

Energy Strategy Fellowship

The RCUK Energy Strategy Fellowship was established by EPSRC on behalf of Research Councils UK in April 2012 in response to the international Review Panel's recommendation that a fully integrated "roadmap" for UK research targets should be completed and maintained. The position is held by Jim Skea, Professor of Sustainable Energy in the Centre for Environmental Policy at Imperial College London. The main initial task is to synthesise an *Energy Research and Training Prospectus* to explore research, skills and training needs across the energy landscape. Professor Skea leads a small team at Imperial College London tasked with developing the *Prospectus*.

The *Prospectus* will contribute to the evidence base upon which the RCUK Energy Programme can plan forward activities alongside Government, RD&D funding bodies, the private sector and other stakeholders. The tool will highlight links along the innovation chain from basic science through to commercialisation. The tool will be flexible and adaptable and will take explicit account of uncertainties so that it can remain robust against emerging evidence about research achievements and policy priorities.

One of the main inputs to the Prospectus is a series of four high-level strategic workshops and six in-depth expert workshops taking place October 2012 - July 2013. Following peer-review, the first version of the Prospectus will be published in November 2013 and will then be reviewed and updated on an annual cycle during the lifetime of the Fellowship, which ends in 2017.

This document reports views expressed at an expert workshop held in November 2012. These views do not necessarily represent a consensus of workshop participants nor will they necessarily be endorsed in the final version of the Energy Research and Training Prospectus.

Contents

Executive Summary ... iii
1. Introduction ... 1
2. Opening Plenary Session ... 1
3. Plenary Session: What works and what doesn't work ... 2
4. Break-out session 1: How do disciplines need to interface with each other ... 5
5. Break-out session 2: Defining interdisciplinary research initiatives ... 15
6. Final Discussion ... 22
Annex: A: Workshop Programme ... 23
Annex B: List of Attendees ... 24
Annex C: List of Energy Strategy Fellowship Reports ... 25

Executive Summary

This report describes the discussions and outputs of the workshop *The Role of Environmental Science, Social Science and Economics* held at the Institute of Physics on 13 November 2012. This workshop focused on the role of social and environmental sciences and economics in fulfilling the UK's research and policy goals. The workshop engaged researchers from a range of relevant disciplines plus stakeholders from the public sector.

1. The workshop opened with two scene-setting presentations: an overview of the workshop and the wider process by Jim Skea, RCUK Energy Strategy Fellow and a review of the outputs from the first workshop, *Energy Strategies and Energy Research Needs*, by Matthew Hannon, Research Associate on the RCUK Energy Strategy Fellowship team.

2. The first plenary session then continued with four short expert presentations giving individual perspectives on interdisciplinary research. It was stated that engineers are essential but a greater variety of disciplines are needed to solve our energy issues, as problems and solutions can be distorted with a predominance of one discipline. Engineers and physical scientists are often seen as being good at applications, whereas social scientists are better at defining questions and methodology.

3. Session 1, the first facilitated break-out session, examined how disciplines needed to interface in order to address energy challenges. Attendees were assigned to four different groups, broadly corresponding to social science, environmental science, economics and system analysis disciplines, and asked to discuss how their discipline worked with others, including giving examples of success stories and challenges.

4. This session identified several factors that helped enable interdisciplinary energy research, including the deficiencies of single-discipline work in capturing the complexity of the energy system and increasing complementary and common ground between researchers. Inhibiting factors mentioned include the greater resources required to run interdisciplinary projects, the UK's narrowly-focused education system and issues with interfacing with the Research Councils and UK government policymaking. Recommendations for promoting interdisciplinarity included greater incentives and academic structural changes to promote interdisciplinary research, as well as greater use of knowledge exchange. Broader construction and wider engagement when designing initial scenarios and research remits should be considered.

5. The second break-out session placed attendees in several cross-disciplinary table groups, and they were asked to define a large interdisciplinary research initiative based around power generation decarbonisation, alternative-fuel vehicle rollout or deep reductions in residential energy use. They were asked to show how they would integrate different disciplines, to outline the key research questions and work packages and to identify how the disciplines would interface. One group was given a free brief to design an initiative of their own choosing.

6. A variety of results were produced, as some groups focused on organisational and procedural issues, whereas others focused on the new questions and topics an initiative could investigate. Several key points emerged: structure and defined work packages are more important for interdisciplinary projects, the method of facilitating cross-disciplinary working is important to define at the start of the project, and a longer, more flexible scoping stage should be considered. The project topics identified were holistic and broad-scale in nature, which could be a natural consequence of interdisciplinary working.

1. Introduction

This report describes the discussions and outputs of the workshop *The Role of Environmental Science, Social Science and Economics* held at the Institute of Physics on 13 November 2012. The workshop was the second in a series of three "strategic" workshops held under the auspices of the RCUK Energy Strategy Fellowship established earlier in 2012. One of the key aims of the Fellowship is to develop an *Energy Research and Training Prospectus* which will help the Research Councils to plan their portfolio of research and training in the energy field.

2. Opening Plenary Session

Overview of the workshop and wider process, Jim Skea, Energy Strategy Fellow

https://workspace.imperial.ac.uk/icept/Public/Jim%20Skea/ESF%20Strategy%20workshop%20%201%20Skea.pdf

Jim Skea's introductory presentation first described the process which had led to establishment of the Energy Strategy Fellowship and the current series of workshops. The origin lay in the International Review of Energy conducted for the Research Councils in 2010. This had recommended the establishment of a "roadmap" for energy research and training activities. Under the Fellowship, the "roadmap" had been re-named the *Energy Research and Training Prospectus,* the first version of which would be produced in autumn 2013. The presentation then went on to describe the workplan, the consultations conducted in summer 2012, the planned series of strategic and expert workshops and plans for updating the prospectus beyond 2013.

Messages from Workshop 1: Energy strategies and energy research needs, Matthew Hannon

https://workspace.imperial.ac.uk/icept/Public/Jim%20Skea/Workshop%202%20Presentation%20Hannon.pdf

Matthew Hannon from the Fellowship team presented key conclusions from the first Workshop on *Energy strategies and energy research needs*. This had focused, at a high level, on expectations about possible UK energy futures and consequent research needs.

The first break-out session at the workshop had sought to compare participants' preferred outcomes in relation to a set of key energy system metrics for 2050 with the outcomes that they actually expected. A general message was that people consistently expected the take-up of new technologies associated with the transition to low-carbon economy to be lower than the preferred take-up with incumbent technologies continuing to play a much large role than was desirable. For example, people preferred unabated fossils not to have a role in electricity generation but they expected them to still have a significant market share. There were large differences in view about the role of different technologies for meeting heat demand, though heat pumps were consistently the preferred form of renewable heat. Possible disruptive technologies were envisaged in the areas of electricity, smart meters, load shifting, smart business models and transportation (self-driving cars for example). Continuing innovation in the extraction and use of fossil fuels could be expected.

The second breakout session had sought to assess different areas of energy R&D in terms of their relevance to UK energy futures, the UK's industrial capacity in the area and the UK's scientific capabilities. Some areas of R&D scored highly against all the criteria, notably fossil fuels and energy systems analysis. A key message from the group was that although the R&D areas had been technologically defined, the importance of economic, social and systems research was emphasised by participants. In other areas, such as marine energy, the UK was seen to be strong both scientifically and industrially, even though the technologies had less relevance to energy futures. In some areas, for example fuel cells and advanced PV, the UK had scientific strengths but a weaker industrial capability.

A range of issues was raised in the brief discussion including: the role of socio-economic factors; a recommendation to "pick losers" and remove technologies that are not going to make it from the portfolio; if the chart had been framed in terms of underlying disciplines (e.g. geology) the picture would have been different; emissions trading has demonstrably not worked in promoting innovation; and the role of technologies for which no clear international lead had been established.

3. Plenary Session: What works and what doesn't work

In this session, four individuals who had extensive experience of interdisciplinary research in the energy domain offered their perspectives.

Why we need more than engineers, Duncan McLaren, Independent

https://workspace.imperial.ac.uk/icept/Public/Jim%20Skea/ESF%20Workshop%202%20McLaren.pdf

Duncan had been a member of the RCUK Energy Programme Scientific Advisory Committee for seven years and had previously been director of Friends of the Earth Scotland. The starting point for Duncan's presentation was the provocative observation that "most mad scientists are actually mad engineers". Science helps us know where we want to go while engineering is about how we get there. Engineering is not science - it is application.

Duncan argued that a predominance of engineers in the process can lead to the wrong means or even the wrong destination. This is not the engineers' fault. Partnering business with research and generating economic benefits from research brings *existing companies into the room*, rather than future companies. Research developed in this way is unlikely to create breakthroughs.

He identified four ways in which research priorities become distorted:

- We pay far more attention to energy (especially electricity) supply as opposed to energy demand management. Promoting energy demand research was like Sisyphus pushing his stone up the hill. "In seven years, it was like rolling a stone up a hill to get to demand. I'm sure that if we take our eye off the stone it's going to roll right down the hill again."
- Putting a disproportionate effort into kit as opposed to behaviour. Politicians also like kit, as it offers the promise of solving a problem by pressing a button rather than through the hard work of engaging with millions and trying to change their energy use behaviour. This happens on the demand side too: think smart meters, physical retrofit (the search for 'wonder insulation'). Technology and behaviour are intertwined, but research often isn't. It is also politically unpopular to ask people to reduce demand. Economic research in this area relies too much on neoclassical approaches.
- There is a focus on centralised rather than decentralised and potentially disruptive approaches. Peer to peer networks are revolutionising other areas of life, why not energy?
- A fixation on a narrow and technical set of indicators and targets and short-sighted economic optimisation (e.g. the "dash for gas", the cheapest option in the 1990s) are serving to undermine

> the resilience of the UK's energy system, which could be improved by a more diverse set of indicators and objectives. We ought not to fix too narrowly on climate targets as this will distort the research picture. Other planetary boundaries are important. We can't just focus on clean energy if the rest of the economy continues in an unsustainable way. Climate justice does not come from measures that exacerbate fuel poverty.

Finally, Duncan noted that this was not a call to replace engineers with economists, but to bring in a wider range of disciplines. In terms of stakeholders, we need to reflect a broad spectrum of future interests, not just current ones.

In discussion, one participant observed that such proposals had been made in relation to the water industry 20 years ago (e.g. using water meters) but nothing had happened even though the water system is much simpler. It was further noted that DECC had published its energy efficiency strategy and was consequently slowly shifting towards more demand focused interventions.

Social sciences, Paul Rouse, University of Southampton

https://workspace.imperial.ac.uk/icept/Public/Jim%20Skea/ESF%20Workshop%202%20Paul%20Rouse.pdf

Paul is now a postgraduate student at Southampton University but had previously worked for the Research Councils for 21 years, working at both EPSRC and most recently ESRC. He left the Research Councils only a few months ago to pursue his studies. The views he expressed were all personal.

He believed natural scientists were more open to interdisciplinary research than social scientists. A social scientist's first question is often "what do you mean by X?". Engineers tend to respond by finding a new proposition interesting. Some social scientists also feel threatened by natural science and it can be hard to open discussions. Paul observed that during his time at the Research Councils, social scientists had hardly ever called to ask him to identify natural scientists to collaborate with, whilst natural scientists had often contacted him to identify social scientists.

Natural and social scientists live in different worlds and use a different vocabulary. We need a "Babel fish" to translate. Social science is not positivist, but looks for interpretations. He also emphasised that social science is needed right from the start of the research process so you know what people want. Consider failed products/technologies such as Betamax, Segway etc.

Some barriers to interdisciplinary research were noted. Success rates for interdisciplinary research at the peer review stage are below average. There is a need for longer-running projects, because more time is needed in the beginning for scoping out the collaboration and finding common ground. Dialogue needs to be facilitated between those who undertake interdisciplinary work and those who don't. Only a tiny proportion of people actually undertake interdisciplinary issues. For example, with psychology only a few people look explicitly at environmental issues, but many others have insights that are relevant to environmental research. This underscores the need for accepting differences between fields.

In discussion, the distinction between "instrumental" and "critical" social science was raised. Paul noted that instrumental social science that helped answer policy questions directly was popular with funders right now. However, the ability to undertake instrumental social science required fundamental, critical work to have been undertaken. Another participant noted that experiments in social science were possible as in the natural sciences, but there may be a lack of political support. An insight from the work of the Centre for Environmental Strategy at Surrey, which had been running for 20 years was that you often get good outcomes if you formulate research questions that you couldn't have conceived within a single discipline. The common ground is the primacy of empirical evidence. If social scientists come in with that view, then collaboration works well.

Environmental sciences, Andrew Lovett, University of East Anglia

Andrew had a first degree in human geography but had developed an interest in quantitative geography which became GIS. He had been in the School of Environmental Sciences at UEA for 20 years. The School is highly interdisciplinary, spanning disciplines from economics and psychology, through to geophysics. The School tries actively not to separate its diverse faculty.

Andrew had learned a number of lessons about interdisciplinary working:

- Interdisciplinarity should be built in from the very start.
- Informal interaction is very crucial (finding a common language may be a whole other matter later). Most successful projects started with a meeting involving an overnight stay, so people get to know each other and build up trust.
- Methodological differences are important. For example, economists and hydrologists both like statistics, so they get along well. Temporal and spatial scales matter. There are vast differences for example between detailed local qualitative case studies versus evaluating a policy measure for the whole country.
- Interdisciplinary aspects of the project should be planned for and someone should be responsible for it, preferably not the Principal Investigator (PI).

Finally, patience is a virtue...

In discussion, it was proposed that there were intellectual similarities between the social and environmental sciences, because each effectively interpreted phenomena that the researcher cannot influence and are not susceptible to controlled experiment.

Economics, Richard Green, Imperial Business School

Richard has been studying the economics and regulation of the electricity industry for over 20 years anddescribed himself as someone who had been trained in neoclassical economics. He observed that neoclassical economics may be a good description of some 'planet' but probably not the one three rocks away from the sun. In particular he believed that it was helpful in understanding the short-term economic decisions of company managers.

Richard had been involved in several of the network SUPERGENs and had considerable experience of working together with engineers. In the early days, people talked mostly *at* rather than *with* each other. For example, during one of the projects Richard had noted that the engineers frequently referred to a "Doubly-fed induction generator", but made little efforts to help the other group members understand what it meant. However, later work became more interdisciplinary, as demonstrated by the book "The Future of Electricity Demand" which showcased a range of disciplinary contributions.

Richard summed up the disciplinary differences with the observation that engineers are good at answering questions, while economists are good at asking them.

General discussion

The comment was made that a good range of examples and case studies had been presented, but nothing had come up on the links between environmental sciences and engineering. It was noted that marine scientists involved in renewable energy programmes are starting to collaborate with engineers, another example of highly mathematical people working together. It was further noted that, in the oil and gas sector, environmental science works very well with engineering. Ecologists are in some sense closer to social scientists – they both deal with complex networks and very hard questions), so getting them to work with engineers is much harder than with, for example, hydrologists.

Finally, it was noted that time is a key issue. Centres which have the opportunity to establish common work over a number of years are more successful.

4. Break-out session 1: How do disciplines need to interface with each other

The first breakout session examined how researchers operating outside of the *Engineering* disciplines had sought to engage in interdisciplinary energy research, with a view to addressing a range of pressing international energy challenges.

Methodology

The workshop participants were divided into four different groups, each broadly corresponding to the following disciplinary areas:

- *Social Sciences*
- *Environmental Sciences*
- *Economics*
- *Energy System Analysis*

No group was designated for *Engineering,* which was considered to represent the traditional focus of UK energy research. Instead Breakout Session 1 examined how representatives from the above disciplines had not only sought to engage with the *Engineering* disciplines to address key energy challenges but also how they had engaged with one another.

Attendees were assigned to these groups on the strength of their previous experiences and present skills set, which the Fellowship team had identified via a combination of online research and past interaction with the attendees. Once the groups were established they were all assigned the following task:

'Consider how your discipline needs to interface with others to address key energy challenges'

To help guide the groups through this task they were presented with 4 key questions:

a) *What are the key interfaces between your discipline and others?*
b) *Can you identify any success stories of work between your discipline and others?*
c) *Are the connections between these natural or forced?*
d) *What needs to improve to enable such interdisciplinary activity?*

The groups were given approximately an hour to discuss these questions and were later asked to present back their conclusions. The discussions and presentations from each of the groups were recorded by the Fellowship team. In the following sections we examine the outputs of these discussions in relation to the four sub-questions outlined above. However, prior to doing so we present some of the key themes that emerged from all of the groups, focusing specifically on (1 & 2) the factors that have enabled or inhibited interdisciplinary energy research and (3) the steps that might be taken to promote interdisciplinary energy research.

Key Themes

Factors Enabling Interdisciplinary Energy Research

- ***Energy System Scenario Building –*** Typically draws upon a broad range of disciplinary expertise considering the multitude of factors that need to be examined

- ***Complementary Disciplines*** - Opportunities for certain disciplines to complement one another in the context of energy research, such as 'two-way' assumption checking between *Engineering* & the *Social Science* researchers as part of scenario building
- ***Researchers' Inquisitive Nature –*** Many researchers are intrinsically interested in phenomena outside their traditional discipline and seek to learn more about it
- ***Rising Profile of Interdisciplinary Energy Research*** - Commencement of a number of high-profile interdisciplinary energy research projects (e.g. Supergens, Transition Pathways etc) and research institutes (e.g. Energy Futures Lab, Centre for Integrated Energy Research etc)
- ***Deficiencies of Single Disciplinary Work*** - Acknowledgement that certain failures in the UK energy system have been partly due to the prevalence a single-disciplinary approach to research and policy-making, such as an over-reliance on economics to structure the UK's regulatory framework for its energy system
- ***'Common Ground' Between Researchers*** - Where 'common ground' naturally exists between researchers from different disciplines, such as between economic modellers and climate scientists

Factors Inhibiting Interdisciplinary Energy Research

- ***Resource Intensity –*** There is a high cost incurred with interdisciplinary research, in terms of time, funding and effort. Unfortunately, these costs are not generally balanced by associated benefits for researchers in career terms
- ***UK Research Councils & Funding Landscape –*** Groups generally felt that the disciplinary nature of the Research Councils and the majority of the research calls, as well as most of the processes they promote to facilitate interdisciplinary research, are not conducive to an interdisciplinary energy research community
- ***UK Government & Policy Making –*** Concerns that policy is typically very techno-centric and not interdisciplinary in nature. Also that government typically operates on a much shorter timescale than academia both in terms of project duration and time horizons
- ***UK Education System –*** Concerns that both schools and universities have been structured by discipline, which engrains 'disciplinarity' in individuals from an early age
- ***International Academic Journals –*** Typically these are disciplinary in nature and encourage reviewers to tackle only sections of the papers they are reviewing
- ***Mismatch Between Disciplinary Approaches –*** Frequently a lack of a common language, terminology and methodology, as well as conceptual frameworks between researchers from different disciplines was cited as a barrier to interdisciplinary collaboration

Recommendations for Promoting Interdisciplinary Energy Research

- ***Scenario Building Approach –*** The scenario building process should incorporate a broader range of disciplinary researchers during the stage of scenario formation, as opposed to after they have been constructed for feedback
- ***Constructive Criticism*** - Ensure that disciplines are critical of one another but in a constructive manner, seeking to present solutions for interdisciplinary working rather than detailed critiques of single disciplinary research
- ***Changes to REF*** - Restructure REF to recognise the higher value and costs associated with interdisciplinary research
- ***Restructure Education & Funding System*** - Restructure the Research Councils and education more broadly (e.g. secondary schools, universities) to incorporate a more interdisciplinary focus

- ***Forum for Developing Interdisciplinary Projects*** - Promote more informal and funding related opportunities for researchers to develop interdisciplinary research bids, in a similar fashion to EPSRC's 'sandpit' events
- ***Incentives for Interdisciplinary Research*** - Provide incentives for highly disciplinary researchers to step outside their disciplinary domain
- ***Promote Knowledge Exchange*** - Increase the funding available for knowledge exchange to promote interdisciplinary collaboration that stretches beyond academia, considering the value of working alongside non-academic organisations normally was
- ***Identify a 'Common Ground' for Different Disciplines*** - Making efforts to identify 'common ground' that exists naturally between different disciplines. Also, making efforts to develop a research approach that provides a 'common ground' between different disciplinary researchers
- ***Promote Interdisciplinary Policy Making*** - Encourage government to engage in policy making that not only draws upon a broad ranges of disciplinary insights but seeks to integrate these within its policies

Responses by Disciplinary Groups

Social Sciences Group

Key Interfaces with Other Disciplines

The group identified *Engineering* as one of the strongest relationships the *Social Sciences* shared with other disciplines in the context of energy research. They explained that collaboration between the two disciplines generally took place in order to develop energy scenarios, where engineers played an important role in checking whether the assumptions social scientists had made with regards to technology development and application were accurate.

Success Stories

The group did not identify many examples of successful interdisciplinary collaboration involving social scientists and researchers from other disciplines. However, one member of the group did highlight the success of the partnership between the University of Sheffield's Department of Psychology and representatives from a number of Local Authorities, as part of research focusing on satisfying consumers' energy needs. However, it is important to note that the group were keen to emphasize that there were numerous failures as well.

Connections Forced or Natural?

Enabling Factors

The group highlighted that an important factor driving interdisciplinary energy research involving social scientists was the importance of the social aspects of energy systems and particularly, energy system change. Members of the group explained that social science research, and in particular that which adopts qualitative methods, were crucial in order to fully appreciate social aspects of the energy system.

As mentioned previously, research developing energy related scenarios has provided an important space for the *Social Sciences* to engage with other disciplines. This was generally considered to be because detailed and robust scenario building demands input from a broad range of research communities. Members of the group emphasised that collaboration around energy scenarios for social scientists tends to be easier if it is quantitatively focused. This may be because it provides a common language for *Social Scientists, Engineers, Economists* etc to communicate, thus making interdisciplinary collaboration somewhat easier.

Challenges

In contrast to these factors which have encouraged collaboration between the *Social Sciences* and other disciplines, the group highlighted a number of important challenges facing social scientists seeking to engage in such interdisciplinary energy research. The first set of barriers relate to the institutional structure of the UK government, Research Councils and universities. The group noted that government energy policy was traditionally very techno-centric, often designed around specific technologies, with a view to promote their uptake. The group emphasized that energy policy need not be so concerned with technology and that such a focus had helped to marginalise the *Social Sciences* in energy research, specifically research relating to energy related behavioural change and community engagement. Broadly, the feeling was that the manner in which energy policy design and development had been structured in the UK reserved a relatively minor role for input from social scientists, which had to date been predominantly limited to policies to promote energy demand management.

Turning to the Research Councils, the group noted that the Economic and Social Research Council, offered research funding for shorter periods of time compared to the Engineering and Physical Sciences Research Council. It was felt that this shorter time period generally provided less scope for researchers to develop high-quality interdisciplinary research projects, which traditionally demand more time than mono-disciplinary projects. Additionally, the group were concerned with how 'disciplinary' the Research Councils and the funding calls they issued were. The group also expressed concerns around how 'siloed' UK universities were in terms of discipline. The group explained that this disciplinary focus at both the level of the Research Councils and the universities had encouraged researchers to adopt a similarly disciplinary focus in energy research.

Despite these concerns, the Research Councils had issued a number of calls for interdisciplinary funding over the past few years. The group emphasised that a number of universities had taken great strides towards improving their interdisciplinary capabilities by establishing 'umbrella institutions' designed to support interdisciplinary energy research. This observation raises the question as to whether it might be possible for Research Councils to employ a similar strategy by establishing an interdisciplinary research council to support energy research that draws upon expertise from a wide range if disciplines. It was explained that without this level of disciplinary integration at both the level of the Research Councils and the universities, the majority of interdisciplinary research projects are likely to remain 'bolted together', as opposed to projects where the disciplinary boundaries become blurred as researchers from different disciplines constantly interact with one another and begin to learn from one another.

The group highlighted that the *Social Sciences* have traditionally struggled to engage with scientists from other disciplines because they often regard social science research as an approach that provides more questions than answers. Consequently, other disciplines tend to be wary of engaging with the social sciences because they often provide an additional layer of complexity and can thus make 'life more difficult'. This was in part attributed to social scientists' reputation for being extremely critical, often spending significant periods of time questioning the assumptions underpinning the project's research questions. The group also believed that the perceived complexity of the *Social Sciences* could also be attributed to the 'highly crafted and obfuscated language' social scientists tend to use, which often presents a barrier to researchers from other disciplines seeking to engage with the *Social Sciences*.

What Needs to Improve?

One of the main recommendations that emerged from the group was for researchers constructing scenarios for the future energy system to ensure that social scientists were brought into the process of constructing the mathematical models from a very early stage. This would enable the *Social Sciences* to help shape the content and structure of these models, as well as frame the questions they are designed to address. Broadly, the emphasis was on presenting the *Social Sciences* with a less critical role and a more instrumental role in energy model development. Providing social scientists with such a role would encourage cross-disciplinary collaboration during the modelling process. However, the group warned that in order for social scientists to fulfil this role they would need to move beyond their 'default critical perspective' and focus on presenting positive alternatives, rather than detailed criticism. The group also believed that the *Social Sciences* could be more proactive in identifying opportunities for interdisciplinary research, in part by focusing on what other disciplines need and how the *Social Sciences* could fulfil this demand.

The group suggested that the Higher Education Funding Council for England (HEFCE) should restructure its Research Excellence Framework (REF) system so that it recognised the value of interdisciplinary research. At present, interdisciplinary research tends to get 'short shrift' in comparison to disciplinary research. The group also questioned whether additional support from the Research Councils for knowledge exchange could help to promote links between the *Social Sciences* and other disciplines. In particular, the group emphasised that the *Social Sciences* might seek to build a stronger knowledge exchange relationship between their research community and DECC, in a bid to inform energy policy. Finally, the group suggested that social scientists should make efforts to use a language that is more accessible to other disciplines.

Economics Group

Key Interfaces with Other Disciplines

Prior to examining the key interfaces *Economics* shares with other disciplines, the group was keen to explore why *Economics* had become a focus for interdisciplinary research in the first place. The group emphasized that other disciplines tended to engage with economists primarily because economics is ubiquitous. For example, economists typically make many of the key decisions throughout both government and industry, in relation to budgets, spending etc. Consequently, other disciplines often have to engage with the *Economics* community to fully understand and in turn influence how these financially oriented decision making processes unfold within the context of markets, policy-making etc. More broadly, other disciplines have often sought to engage with *Economics* because it was considered one of the more important disciplines amongst the academic community, with economists having a reputation of asking difficult questions.

In the context of energy research the group pointed out that other disciplines had tended to engage with economists because many of the current energy challenges in the UK revolve around the structure of the UK energy market. The group underlined the issues that had arisen as an outcome of the UK's privatization and subsequent liberalization of its energy markets, such as issues surrounding affordability and energy security. Consequently, the energy challenge was a fundamentally economic one, where there is an opportunity for alternative economic theory to be employed as a solution to these problems. However, the group were quick to point out that many of the issues that have arisen in the UK energy system can also be attributed to an over-reliance on economics, for example in the design of energy policy. This approach tended to ignore important aspects of the UK energy system, which sit outside of the traditional domain of economics, such as prices, markets etc. As a result, they underlined the importance of engaging with other disciplines to uncover potential non-economic factors that characterise energy markets. In turn this insight would help to inform the design of a suite of economic and non-economic solutions to address these issues.

Success Stories

The group were asked to identify some examples of where economists had worked successfully with other disciplines. One member of the group highlighted the effectiveness of the Supergen Flexnet consortium, an interdisciplinary project that was designed to meet the challenges facing the electricity networks posed by the transition to a low carbon energy system. Engineers and economists working on the project had complemented each other well, as the engineers brought knowledge of technical issues relating to the electricity networks and associated technologies, whilst the economists brought forward knowledge of the commercial viability and pricing issues associated with deploying such technologies. More broadly, one of the important outputs of the project had been a publication relating to the idea of 'uncertainty', which had been identified by the members of the project as a common issue amongst the different disciplines.

A success story highlighted by one member of the group related to Ofgem's efforts to engage a range of experts in different disciplines to help inform the design of the UK's energy regulatory framework. They explained that this approach was necessary to provide a balanced view of the various factors influencing the UK energy market. One member of the group noted the valuable outputs generated by collaboration between transport and economic modellers, where new models have been developed that jointly optimise transport price and time.

More broadly, the University of Surrey was identified as a centre of excellence for interdisciplinary energy research, which had developed a 'consumer focused' approach to energy research. Another example included the University of Manchester's *Sustainable Consumption Institute*, which has in recent years focused on global supply chain issues. It is important to note however, that the group were less comfortable talking about unsuccessful examples of interdisciplinary research because these might reflect badly on either themselves or their peers.

Connections Forced or Natural?

Enabling Factors

The group explained that many of the connections that had been formed between the *Economics* community and other disciplines had emerged via serendipitous processes. For example, economic modellers may have been developing a model that incorporated ecological systems and required *Environmental Scientists* to provide insight into the structure of these ecological systems. In simple terms, once the modellers began modelling something they didn't fully understand, they would normally call upon the help of researchers who did. The group were also keen to emphasise that interdisciplinary research involving economists tended to work best when there were already pre-existing relationships between the economists and other disciplinary communities. Interaction between these communities tended to take place as part of either informal meetings or formal interdisciplinary networks (e.g. Supergen).

'Common ground' was identified as a key factor that had enabled economists to engage in interdisciplinary research. This related to sharing a common language, focus or methodology, which provided economists with an interface with researchers from other disciplines. Such a common set of interests or research approach typically helped interdisciplinary researchers to mobilise their research efforts around a common goal or shared idea. Interestingly, the group emphasised that such 'common ground' was often found with disciplines that would not normally be associated with economics, such as climate scientists, as opposed to more closely related subjects such as law or policy studies. Economic modellers and climate scientists tended to work well together because they use similar modelling techniques, software applications (which often use General Algebraic Modelling System code) and approaches to systems analysis. However, the group warned that such collaboration must be 'common sense checked' by experts from other disciplines, to ensure that the models are grounded in reality.

Challenges

The group observed that 'common ground' between interdisciplinary researchers was often difficult to find, consequently hindering interdisciplinary energy research. For instance, more often than not, individuals working on interdisciplinary research projects might be unhappy with the manner in which the challenge had been conceptually framed or the language used to outline the research challenge.

Whilst the issue at hand might be successfully framed at a relatively broad level, once the group begin to approach the issue in greater detail, this framing normally begins to break down as the project members apply different meanings to the same system components. One member of the group noted that this had taken place during the interdisciplinary *Transition Pathways to a Low Carbon Economy* project, which had broadly adopted the Multi-Level Perspective (MLP) analytical framework for socio-technical system change. Whilst at a broad-level the economists had 'signed up' to this framing of energy system change, they soon began to question the manner in which the framework underplayed the importance of economic factors, such as energy prices and technology costs.

One of the key barriers identified was the lack of a perceived need amongst the economic community to engage with other disciplines. One of the group believed that a lot of economic research is so theoretical that 'you can have a successful career in economics answering questions with no relevance to the actual planet or real-world economy'. Consequently this has reduced the incentive for some economists to engage with other disciplines, which can provide the necessary experiential and empirical insights capable of grounding economic theory in reality.

The various costs associated with interdisciplinary research were also identified as a key barrier. The group emphasised the 'cost of time' incurred by good interdisciplinary research. Significant amounts of time were generally required to undertake interdisciplinary research because it is normally an iterative process, requiring the group to take time to conceptualise the research topic, reflect upon it and to also help each other understand many of the detailed concepts that members of the different disciplines were applying. Economists may need to explain complex economic theory to a group of social or environmental scientists The iterative nature of interdisciplinary research also meant it was quite inefficient compared to more traditional forms of research. For instance, a research group may take a particularly innovative, interdisciplinary approach to addressing their research questions but ultimately realise that the approach is unsuitable.

The group noted that interdisciplinary publications tend to take longer to prepare as they require the researchers to synthesize characteristically distinct styles of writing, theoretical concepts and methodological approaches. Additionally, significant amounts of time may also be spent identifying a journal that is suitable for the interdisciplinary nature of the paper, considering the broadly disciplinary nature of academic journals. Finally, greater amounts of time are normally required to prepare interdisciplinary funding applications compared to disciplinary applications. This was attributed to the efforts involved in bringing together researchers from different disciplines to develop the proposal and synthesizing a multitude of theoretical concepts within a single, coherent research framework: 'If it takes 6 months for a 1-in-5 chance interdisciplinary proposal you'll stick to your 1-in-10 chance disciplinary proposals that take only 1 month to come up with'.

Time in research terms also carries a financial cost as the project will typically need to be funded for longer. Additionally, larger research budgets are often required as centres of excellence for different disciplines tend to be located at different universities, consequently requiring more funding to cover travel, accommodation etc.

The group also raised concerns around the extent to which the research system was structured to support interdisciplinary research. For example, they highlighted the limited number of fora for this form of research. They supported EPSRC's 'sandpit' events but felt the wider use of similar fora would be beneficial. The group were also concerned about the UK Research Councils' bias towards the funding of engineering related energy research. They broadly felt that the majority of the budget was reserved for engineering types of energy research, with substantially less available for *Economics* and *Social Science* research (approx. 10%). This had served to promote a monocultured research landscape.

Questions were also raised around the structure of the academic journal publication system, highlighting how interdisciplinary research is not operating on a level playing field. Disciplinary research, despite the greater costs it entails, has a potentially greater impact and novelty. There were few interdisciplinary journals in existence. Finally, moving beyond academia, the group expressed concern that the structure of the UK's government policy making was not necessarily conducive to mobilizing the outputs of interdisciplinary research, considering the broadly disciplinary nature of the policies government implement (e.g. economic, social etc).

What Needs to Improve?

Returning to the amount of time that interdisciplinary energy research demands, the group believed that longer periods of time should be made available to develop and undertake interdisciplinary energy research projects. One member of the group emphasised that in terms of interdisciplinary energy research 'there are no failures, just delayed successes'. With respect to the lack of fora to bring together interdisciplinary energy researchers, the group highlighted how two-day residential workshops could potentially help researchers to develop specific ideas that could lead to high-profile interdisciplinary energy research projects.

Turning to the peer-review system for both papers and proposals, the group explained that interdisciplinary research might benefit from a system that selected reviewers who were able to understand and critique the whole publication, rather than sections of it. They felt this would begin to engrain interdisciplinarity throughout the wider academic system, as well as generating a greater need for interdisciplinary researchers.

In terms of the structure of interdisciplinary research projects one individual highlighted the importance of establishing avenues for frequent 'two-way consistency checking' between the different disciplinary groups in a team. This would help to ensure that the assumptions underpinning the research project remain both accurate and consistent. Additionally, the group explored the idea of developing research questions that were more robust to issues of framing in specific disciplinary terms. If possible research questions should be developed that transcend specific disciplines, structured to engage with 'deeper' questions of academic interest, which can in turn be approached by a multitude of disciplines, not just *Economics*. Finally, the group raised the idea of constructing methodologies that can promote future interdisciplinary research, i.e. the idea that disciplinary work might produce the type of data that can be utilised by an interdisciplinary team.

Environmental Sciences Group

Key Interfaces with Other Disciplines

The group noted that their disciplines shared key relationships with both *Psychology* and in particular *Economics*. Interestingly, the group believed that there was some overlap in their disciplines' interface with these two communities. For example, in relation to the field of behavioural economics, both *Psychology* and *Economics* have been integrated to some extent.

Moving beyond specific scientific disciplines, the group discussed how *Environmental Sciences* regularly interfaced with communities studying the 'governance of research', which have traditionally examined questions such as 'how do the *Environmental Sciences* influence regulation?' The group members emphasised the need for this community of researchers to engage more with environmental scientists and consequently, have a greater influence over the structure of their research.

Success Stories

Broadly, the group members struggled to identify any specific success stories. There was a general feeling that success stories of the *Environmental Sciences* working alongside other disciplines were sorely needed. However, they did highlight oil and gas exploration in the North Sea as a particularly high-quality example of interdisciplinary research involving environmental scientists. Interestingly, the group began to discuss how this nexus between the *Environmental Sciences* and other disciplines, which had been developed to utilise fossil fuel reserves, might be harnessed to drive forward the development of the renewable energy industry.

Another, more tentative success story was seen to be the progress the *Environmental Sciences* had made towards promoting the view among other disciplines that natural resources should be valued not only in monetary terms but should also be associated with the 'ecosystem services' and 'natural capital' they provide. Sadly no specific examples of where this shift in mind-set had taken place were identified.

Connections Forced or Natural?

Enabling Factors

The group believed that many of the connections between the *Environmental Sciences* and other disciplines had been 'forced' by the current structure of the research funding system. Calls for funding from the Research Councils' had required environmental scientists to work effectively with researchers from other disciplines to examine energy related phenomena.

Challenges

One of the challenges the group identified facing interdisciplinary energy research was the tension between the different timescales typically adopted by both policy-makers and research teams. For instance, government officials tend to work to shorter time horizons than researchers. Consequently, tensions can arise between policymakers and researchers, where the former may promote decisions designed to provide short-term benefits that do not take into consideration the long-term effects of such decisions. For example, the group believed that discontinuing subsidies for farmers to irrigate their land did not fully account for the efforts that would have to be made to return this land to its 'irrigated state' if this land were needed for farming once again in the future. In summary, making efforts to reconcile these contrasting time-scales is essential if we are to address key environmental problems and enable interdisciplinary research to bloom.

What Needs to Improve?

Generally, the group were keen to emphasise the need for further opportunities for representatives of the *Environmental Sciences* and other disciplinary communities to meet informally to discuss and develop opportunities for interdisciplinary research projects. The group also emphasised the need for more time for this process than is traditionally available to develop research proposals for disciplinary projects.

Other broader recommendations made by the group included the need for social scientists to adopt a language that is more accessible to other disciplines such as the *Environment Sciences*. Some of the group emphasised the need for some interdisciplinary energy projects to consult more closely with the Royal Geological Society. This was partly because geological scientists were likely to play a key role in identifying remaining reserves of oil and gas in the UK.

More specifically, the group members believed that it was important for environmental scientists and other disciplinary researchers to explore how they might address long time horizons, such as the year 2050. Concerns were raised that whilst environmental scientists were relatively comfortable working to such long time horizons, economists and social scientists were less so. If these disciplines could develop some common ground around developing scenarios and communicating uncertainties, as well as a common approach to identifying key future-oriented questions, the prospects for interdisciplinary research would improve.

Interestingly, the group thought that there was scope for greater interdisciplinary collaboration around questions relating to 'optimal' scenarios, i.e. the most desirable future energy systems. The group also believed that there were opportunities for developing 'Black Swan' scenarios, which focused on 'rare events with massive impacts' on the energy system and more broadly, human society. Finally, the group emphasised the importance of 'looking back to go forward' with respect to scenario development If environmental scientists and other disciplinary researchers initially drew lessons from historical economic, social, system and environmental change before they began to speculate about how the energy system might develop in the future, then they would consequently develop more robust scenarios founded upon historical interdisciplinary insights.

Energy Systems Group

Key Interfaces with Other Disciplines

It was believed that *Energy Systems* analysts had to interface with a multitude of energy related disciplines because they had to understand and engage with the full range of components and relationships comprising the energy system under investigation, including environmental, economic, social and technological aspects. In summary, good *Energy Systems* analysis should engage with a range of different energy related scientific disciplines in order to build a rich and comprehensive picture of the energy system being examined.

Success Stories

No specific success stories were identified by the group.

Connections Forced or Natural?

The group identified a number of factors supporting interaction between *Energy Systems* analysts and other disciplines, before turning to those factors which have made it difficult.

Enabling Factors

As reported above, the group believed that, by its very nature, *Energy Systems* analysis should interface with a range of energy related disciplines. Consequently, one of the key enabling factors identified by the group was the view that *Energy Systems* analysts tended to have a broad understanding of the energy system being examined and importantly, the associated fields of research. Consequently, *Energy Systems* analysts were considered to be interdisciplinary by their very nature, helping them to interact with scientists from other disciplines.

Interestingly, the group emphasised the importance of 'connectors' in good interdisciplinary energy research projects. These are individuals who were generally interested in innovative forms of research and worked to draw together different disciplines to engage in interdisciplinary energy research. *Energy Systems* analysts were normally in a good position to play such a role, considering their knowledge of the wider research field and crucially, their experience of engaging with different disciplines.

Interdisciplinary energy research projects tended to work best when they worked alongside user organisations. This situation often arose where a team of interdisciplinary researchers had been commissioned to undertake a research project for an organisation, which was designed to address a specific problem or produce a specific outcome.

Challenges

One of the major barriers to interdisciplinary energy research identified by the group related to the different intellectual styles that researchers from different disciplines employ. For example, engineers and social scientists frame energy challenges differently, with the former focusing more on the applications of a research project and the latter focusing more on the methodology being employed to obtain the results. The group noted that another key barrier is the difficulty in developing an interdisciplinary methodology that accommodates research considering the different approaches that researchers from disciplines typically adopt.

Other barriers highlighted by the group revolved around the way in which the costs associated with interdisciplinary energy research often outweighed the benefits. For instance, interdisciplinary research normally demanded more time and effort to deliver than disciplinary research projects. However, the group questioned whether this additional time and effort was translated into more 'valuable' papers under the Research Excellence Framework. Additionally, the group questioned whether researchers engaging in such interdisciplinary research were likely to be promoted as rapidly as disciplinary researchers, considering the limited number of interdisciplinary research projects and research positions. This situation was compounded somewhat by the highly disciplinary nature of universities, meaning there were few interdisciplinary departments where researchers of this ilk could progress their careers. Broadly, the group felt that if anything universities had in recent decades become more entrenched in terms of their different academic disciplines rather than become more interdisciplinary, consequently becoming 'siloed'.

What Need to Improve?

The key to promoting interdisciplinary energy research involving *Energy System* analysts entails promoting a broader understanding of the energy system across the full range of energy related disciplines. This, the group felt, would enable researchers from different disciplines to actively engage with others throughout the research process. This broader understanding would include an appreciation of different approaches to energy challenges and in particular, methodologies for analysing energy systems. For example, engineers could develop a stronger understanding of the qualitative methods often employed by social scientists, whilst social scientists could develop a stronger understanding of the more quantitative, experimental methods typically employed by engineers.

The group identified other recommendations for promoting interdisciplinary research. These included the development and use of key 'terms of reference' amongst individuals working on such projects, which would help to address issues arising from the use of jargon and different framings of the phenomena being researched. Another recommendation included the more efficient and effective use of resources to promote interdisciplinary networking. Finally, the group underlined the importance of institutionalising interdisciplinary research in education by moving away from the focus on separate disciplines at schools, sixth form colleges and universities.

5. Break-out session 2: Defining interdisciplinary research initiatives

Methodology

The attendees split into six small cross-disciplinary table groups, and asked to complete an exercise that involved defining an interdisciplinary research initiative (between £3-5m) that addressed a "grand" energy research challenge. Five out of the six tables could select from the topics:

- The decarbonisation of power generation over the next 4-5 decades
- The roll-out of alternative fuel private vehicles over the next 20 years (biofuel; plug-in hybrid; battery electric; hydrogen/fuel cell)
- Deep reductions in residential energy use, through efficiency, over the next 10-15 years

The sixth table were given a free brief to design a research initiative of their own choosing. The groups were asked to include the following in their answer:

- To show how they would integrate the ways that different disciplines would *frame* the problem
- To outline the key research questions and possible components/work packages of the initiative
- To identify how the different disciplines would interface with each other

Groups were asked to select a representative to report their findings and conclusions back to the workshop in plenary. Workshop materials such as flip chart paper were captured for analysis.

Group 1

The decarbonisation of power generation over the next 4-5 decades

Group 1 investigated the first question on power decarbonisation, taking a procedural approach. Their first major point was that it is very important to understand and define the rationale for the research, including understanding the audience, the language they use and their motivations. Stakeholder buy-in is important for interdisciplinary research, and the group suggested a thorough ground-preparing exercise before the initiative is launched, including holding a 'town-hall' style meeting with interested stakeholders.

They looked at two different options for structuring the initiative. Option one was to look at the decarbonisation of the power system on a technology basis. It was agreed that this would not be the best way to frame an interdisciplinary project. Option 2 framed the initiative as a series of components investigating barriers to a low-carbon system, including technical, environmental, political and others, was chosen instead.

Knowledge exchange was to be built into the initiative from the beginning, and an advisory group would be formed with strong links to the project throughout. The project would involve regular two-day meetings, held at least twice a year, to ensure that work was proceeding to plan and current results were being disseminated adequately throughout the project. The project would be separated into distinct work packages, coordinated by the PI, who must have sufficient time and resources to handle this responsibility. The users and audiences of the final project results should be involved throughout, with time being allocated in the final six months to take the barriers identified back to audiences to test the viability and relevance of the results to the users.

Group 2

The decarbonisation of power generation over the next 4-5 decades

This was seen as a SuperGen (a set of collaborative RCUK initiatives) type project by this group, and they worked towards a target of a project 5 years in duration with £3million funding.

The Energy Trilemma, a framing diagram showing the three main pillars of carbon reduction, energy security and cost, was the starting point for discussion with an additional element examining public acceptability. This was quickly deemed insufficient as the group decided that environmental aspects were present in all elements and that the programme could not be so easily divided. After discussion, the group decided to frame the research programme as '*How to decide between technologies to decarbonise power generation?*'

Four stages of work emerged through the discussion:

1. A framing and education stage to pin down the priority areas needed to research, as well as a definition and targets for decarbonisation.
2. A synthesis stage to find commonalities and establish a shortlist of priorities.
3. Turning these into smart objectives to pursue these identified priorities.
4. Establishing any critical interdependencies & sequences between pathways/technologies.

Common metrics across disciplines were seen as key to allow comparison of options across disciplines, but these are difficult to establish.

How are decisions made at the synthesis stage and throughout the process? Are decisions based on political/economic/environmental criteria? Alternate approaches could be technocratic (a top down approach) or community level (bottom up approach). Political science is an important discipline to engage with in this sphere. The information used to make decisions needs to be quantifiable, understandable and from a trustworthy source to allow for informed decisions from all audiences. Different audiences require different information, and framing this information is vital. Information needs to be consistent across all audiences but could be framed to suit the audience.

A further work package should be based on ongoing data gathering over the time frame of the programme and new knowledge generated should be fed back into the programme along the way.

Some questions that arose at this stage were:

- When choosing power generation sources how do you provide information to the public to evaluate the different power sources?
- Whose opinions do you care about more? Individual, community, nation or international…you will not be able to keep everyone happy.
- How do you activate supportive audiences and dispel negative myths around power sources?

The group focused on the question 'how can we develop an interdisciplinary interface?'. Suggestions were to create interdisciplinary working teams from the beginning, as well as providing space and permission to move outside disciplinary boundaries. The point was raised – is interdisciplinary research needed from the start of the programme, or is a critical mass of work needed before moving to an interdisciplinary manner? Key points from the discussion around this were firstly that questions need to be asked to audiences in the right way and using the right language in order to receive useful answers. Flexibility is crucial, and needs to be designed into the project to ensure that it is possible to respond when additional information or research aspects are required.

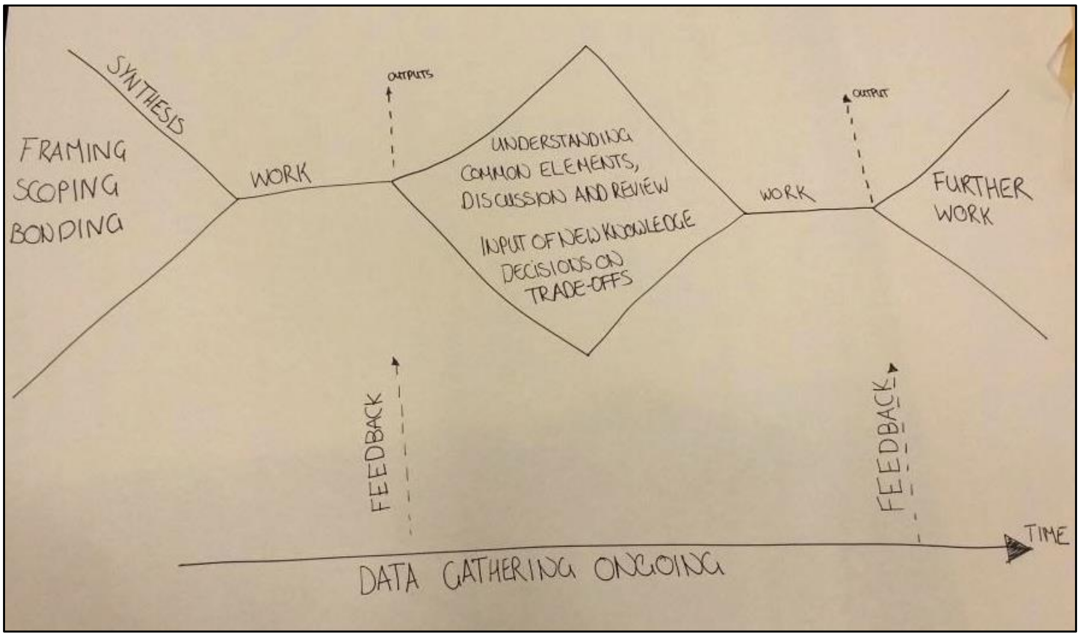

Figure 1: Photograph of worksheet from Group 2, showing their interdisciplinary project design.

Group 3

The decarbonisation of power generation over the next 4-5 decades

Group 3 addressed the power sector decarbonisation agenda. Most of the discussion was discursive with a number of key themes emerging. Towards the end of the session, the break-out group focused on the content of a possible research programme.

There was no discussion of individual technologies, e.g. nuclear, renewables, CCS. The entire discussion was about energy system aspects and how a decarbonised system impinged on the wider world – socially and environmentally. The point was made that an interdisciplinary system can be visualised as a transparent cube – every angle will show something different, depending on the viewer's perspective.

It was observed that there is a quite a lot we know already which would not need to be picked up in any new cross-disciplinary research: a) the "plug-and-play" technologies (e.g. renewables) associated with decarbonisation; and b) the public's attitudes to these technologies individually.

Key themes emerging included:

- Wider environmental impacts of decarbonisation, i.e. not the environmental impacts of climate change but the impacts of climate mitigation itself
- Planning issues associated with the siting of infrastructure
- Issues of cost – who would pay for decarbonisation and who would be compensated (and how) for negative impacts
- Issues associated with the acceptability of "electrification" on the part of consumers, e.g. heat pumps, electric vehicles etc
- The possibility of a "paradigm" change to a more decentralised power system and the social and environmental consequences of this

There were a number of cross-cutting links between these themes. “Cost” was seen to be particularly important as it linked “who pays/who is compensated”, planning/siting issues and environmental impacts via valuation.

The group ended up by loosely specifying a research programme which would be framed by two sharply contrasted scenarios or “paradigms – centralised versus de-centralised. The research would embrace the themes identified above, taking due account of cross-cutting issues.

Group 4

Deep reductions in residential energy use, through efficiency, over the next 10-15 years

This group began by looking at several aspects of the question:

- What factors shape consumer practices?
- The relationships between people and different types of energy.
- Different ways of engaging with consumers to manage their energy demand. Policy and the market are the standard way to interact – are there any other ways?
- What type of information is available that would alter energy demand?

The group decided that the problem with designing an interdisciplinary research project may not be the researchers themselves, but the process. The process of designing an interdisciplinary research project, and trying to come up with research papers that can fulfil expectations, is a difficult one. A lot of interdisciplinary research happens almost at random, as research groups branch out or invite other disciplines to help them solve research problems.

The group discussed the ‘sandpit’ process (typically a week long, residential workshop run by the Research Councils, in which participants design and start to prepare a bid for a large research fund). They thought that the traditional sandpit process may not produce optimal results in the case of a large interdisciplinary research programme.

It may be that a "stretched sandpit", with people getting together over a longer period of time, e.g. 6 months, would be a better way to understand both the problem and the interdisciplinary group, allowing a better research project to be developed. This process could also include consumers, companies and other stakeholders. It was noted that NERC run grants very similar to this idea, called ‘catalyst grants’.

Group 5

Deep reductions in residential energy use, through efficiency, over the next 10-15 years

This group started off by attempting to define a ‘household’ as it pertained to residential energy usage. The group eventually settled on the definition that a household is defined by demographics and practices. A demographic can be defined as a group of people with a specific set of practices. There is a pathway of practices, as people move through different demographics during their lifetime.

The group saw the research programme as exploring the practices of households and how they relate to suppliers and energy generation. It would look at the impact of technologies to shape household practices, and how changes in demand practices help to shape the supply infrastructure. The programme would ask if there could be scope to alter the load profile in order to change the investment landscape and thus alter the type of generation that comes onto the system.

The group considered two major drivers – the environment, including climate change and wider environmental concerns, and security of supply. The proposed programme would focus on the relationships between these drivers and household usage patterns, as well as the relationships between demographics and practices.

Research questions proposed were:

- What's the effect of changing demographics/life stages on energy demand?
- Are these demographic life stages *path-dependent*? Taking a technical systems terminology to demographics, early changes to practices can have lasting impacts.
- How do technologies influence practices and practices influence pacts through people's lives (path dependent equivalent to supply side lock-in) technologies?
- What would be the relationship between practices in the household and the supplier? Are changes needed in the supplier business model?

The group came up with a long list of disciplines which would be desirable to include in the programme. These included environmental science, sociology, engineering, economics, ecology, building engineering, metrology, economics and system modelling.

Group 6

Open-ended task – to design research initiative of their own choosing

This group was given a more flexible, open-ended task than the other five working groups, having the brief to design an interdisciplinary energy research project of their own choosing.

The group firstly considered two overarching themes, one looking at energy security, and the second to investigate what would happen if the UK returned to a nationalised energy market. Both of these themes were discarded in favour of a task investigating how to improve the uptake of goods and services with lower embodied and in-use emissions, otherwise referred to as 'how to make people want to use less energy'.

The group then described how the programme would be structured – in several work packages, each containing several distinct components.

- WP1: This work package would look at energy accounting and embedded emissions, with an emphasis on investigating how much carbon goes into new products versus reuse.
- WP2: This work package would look at other environmental effects caused or abated by using lower-carbon products, such as the effect on the landscape of using different building materials, as well as the health and safety implications of using and reusing older products for longer. Good examples of this are the health and safety effects of using cars for longer and refurbishing old car bodies versus producing new cars.
- WP3: This work package would investigate the system of incentives needed to speed the adoption of lower-carbon goods and services, including taxes and economic instruments to incentivise manufacturers to make their products easier to reuse. This WP would also examine compliance with EU and international law, as well as other legal and regulatory implications.

- WP4: This WP would examine people's attitudes to reusing products and moving to lower-carbon goods and services. This would include attitudes to the extensive reuse of common items such as clothes and cars, as well as more generalised quality of life issues.
- WP5: This final package would examine the impact on jobs and the manufacturing industries, including the need for reskilling and changing job roles.

This interdisciplinary project would necessarily require a range of different academic skillsets, including energy systems experts, industrial ecologists, economists, lawyers, historians, health and safety experts and other diverse skillsets, many of which would be newcomers to an interdisciplinary energy programme.

Conclusions

The groups went about this exercise in very different ways, some concentrating on the organisational and procedural issues associated with setting up a large interdisciplinary research project, while others looked at how interdisciplinary resources could be leveraged to create new and interesting research topics.

Some key points were:

- Interdisciplinary programmes require more structure and defined work packages than would normally be necessary for standard disciplinary research projects. Several groups identified regular meetings of the entire consortium, plus active and continuing engagement with outside stakeholders, as important to the success of the programme.
- Questions of how to facilitate interdisciplinary working were discussed – whether to form interdisciplinary teams from the start or to begin in separate 'silos' and bring work together as needed. A common thread was that flexibility for researchers to exceed their disciplinary boundaries when needed was a crucial part of the process.
- The difficulty of 'forcing' interdisciplinary research, instead of letting researchers evolve their work to a more interdisciplinary mode when required, was discussed particularly by Group 1, who suggested longer, more flexible programme-planning stages to take account of the time required to properly form a complex consortium and programme structure.
- Research topics considered were holistic in nature, looking more at the energy system and large-scale effects and trends than specific technologies and practices. This may be a consequence of interdisciplinary working – in order to incorporate a wide range of disciplines and world-views, the work done may need to be necessarily large-scale.

6. Final Discussion

Jim Skea had started the workshop by referring to a workshop on interdisciplinarity that he had facilitated 15 years ago. Have we made progress since then? Jim thought that we had made progress but did not believe the problem had been entirely solved. Based on recent interactions with energy researchers in the Netherlands and Germany, he believed that the UK was doing quite well.

It was noted that more people move across disciplines more than they did in the past, as part of a more general trend in society. That in itself puts us in a better place. However, although the trend is right, this applies only to a small number of people who want to do interdisciplinary research in spite of the career incentives to do otherwise. Most people still operate within their disciplinary boundaries. However, new funding mechanisms (catalyst grants, sandpits) are making interdisciplinarity easier these days.

Annex: A: Workshop Programme

10:00	**Coffee and registration**	
10:30	**Opening Plenary Session**	
	Overview of the workshop and the wider process	Jim Skea, Strategy Fellowship
	Messages from Workshop 1: *Energy strategies and energy research needs*	Matthew Hannon, Strategy Fellowship
11:00	**What works and what doesn't work: lessons from the coalface**	
	Why we need more than engineers	Duncan McLaren, Independent
	Social sciences	Paul Rouse, University of Southampton
	Environmental sciences	Andrew Lovett, UEA
	Economics	Richard Green, Imperial College London
	Discussion	
12:00	**First break-out session**	
	Break into groups broadly defined by discipline/ research "style"	
	Task: How does your discipline *need* to interface with others to address energy challenges? What needs to improve?	
13:00	**Lunch**	
13:45	**Report back from Breakout 1**	
14:15	**Second break-out session**	
	Break into cross-disciplinary groups	
	Task: To define a research initiative that addresses a "grand" energy research challenge, integrating the ways that different disciplines would *frame* the problem	
15:30	**Tea**	
16:00	**Report back from Breakout 2 and Discussion**	
16:30	**Close**	

Annex B: List of Attendees

Sam	Holloway	BGS
David	Howard	CEH Lancaster
Jon	Finch	CEH Wallingford
Niall	McNamara	CEH Wallingford
Prashant	Vase	Consumer Focus
Chris	Lloyd	Crown Estate
Adam	Cooper	DECC
Liz	Owen	DECC
Davinder	Lail	Defra
Paul	Nunn	Defra
Harriet	Orr	Environment Agency
Jacqui	Williams	EPSRC
David	Ridley	ESRC
Tapas	Mallick	Heriot-Watt University
Richard	Green	Imperial College
Philipp	Gruenewald	Imperial College
Matthew	Hannon	Imperial College
Adam	Hawkes	Imperial College
David	Reiner	Imperial College
Aidan	Rhodes	Imperial College
Jim	Skea	Imperial College
Stefan	Pfenniger	Imperial College
Duncan	McLaren	Independent
Franklin	Chris	NERC
Stefan	Bojanowski	Ofgem
Mel	Austen	Plymouth Marine Laboratory
Fred	Steward	PSI
Paul	Rouse	Southampton University
Florian	Kern	SPRU
Michelle	Shipworth	UCL
Neil	Strachan	UCL
Andrew	Lovett	UEA
Combe	Nicola	UKERC
Christina	Demski	University of Cardiff
Simon	Marvin	University of Durham
Susana	Batel	University of Exeter
Peter	Connor	University of Exeter
Janine	Morley	University of Lancaster
Katy	Roelich	University of Leeds
Peter	Taylor	University of Leeds
Roland	Clift	University of Surrey
Chris	Jones	University of Sheffield

Annex C: List of Energy Strategy Fellowship Reports

Report 1: *Summary of Stakeholder Views and Way Forward*, September 2012

Report 2: *Energy Strategy and Energy Research Needs*, November 2012

Report 3: *The Role of Environmental Science, Social Science and Economics*, December 2012