UKERC
UK Energy Research Centre

UKERC Interdisciplinary Review

Survey Results

Working Paper

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Mark Winskel & Ioanna Ketsopoulou

UKERC Research Coordination Team

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Executive Summary

This report is part of a review of the UK Energy Research Centre (UKERC) Phase 2 research programme (2009-14). The review considers UKERC's interdisciplinary energy research achievements; its strengths, weaknesses and lessons for the future. The review project is being carried out internally by staff from UKERC's Research Co-ordination and Meeting Place teams.

The report presents the findings of an online survey of the UKERC research community and invited UKERC stakeholders, carried out in Q3 of 2013. Just under half of the UKERC Phase 2 research community responded to the survey (n=90) – indicating a significant level of interest in interdisciplinary research among UKERC researchers. The respondents included a broad mix of researchers by discipline, seniority and role, spanning engineering and physical sciences, social and economic sciences, and environmental sciences. A small number of UKERC researchers see themselves as having multiple (or no specific) disciplinary identities.

The survey indicated mixed views on the strength of representation of different disciplines in UKERC. While social scientists made up the largest disciplinary community (in terms of survey respondents), it was suggested that UKERC research was skewed towards engineering and physical sciences. Respondents highlighted the need for stronger engineering representation, and improved collaboration between engineering and social sciences.

For most survey respondents, UKERC was not their first experience of interdisciplinary research, and UKERC was rated by most being as good, or better than, comparable interdisciplinary initiatives. Over three-quarters of respondents agreed or strongly agreed that the content and structure of the UKERC research programme supported interdisciplinary collaboration. However, UKERC was seen as having tended to carry out *multidisciplinary* rather than more deeply *interdisciplinary* research. The most common interdisciplinary experiences in phase 2 UKERC have been single scholars (in studentships) or small groups of project-based researchers, rather than cross-theme and cross-centre projects. This is also reflected in a tendency to rely on committed individuals in UKERC's interdisciplinary achievements.

These results can be understood in the balance between openness and cohesion in UKERC's Phase 2 research programme. As was intended, the allocation of around half of UKERC's research funds through a series of competitive research calls led to an opening-up of UKERC to a wide range of research disciplines, but this has perhaps reduced the prospects for more ambitious forms of interdisciplinary research which

rely on sustained cross-disciplinary understanding and familiarity. As compared to Phase 1, UKERC Phase 2's more diverse (and temporary) research community is reflected in an emphasis on *theme-level* interdisciplinary research synthesis, and less emphasis on *Centre-wide* 'Flagship' projects.

Nevertheless, there is clear acknowledgement that UKERC is helping to build the UK's interdisciplinary energy research capacity. Respondents overwhelmingly agreed that UKERC had helped develop an interdisciplinary community that will have an impact on future research and policy, and also, that their involvement in UKERC had made them more likely to participate in interdisciplinary energy research in the future. Just under half of respondents have published their research in more interdisciplinary or more policy-oriented journals as result of their UKERC participation. The greatest perceived strengths of UKERC research is its capacity to address 'real-world' problems and bring together different disciplines; it has made less impact at developing novel interdisciplinary research methods.

A repeated message – for funding bodies and research managers – was that the extra time and effort needed for successful interdisciplinary research needs to be explicitly acknowledged into research funding and programme design, with dedicated time and effort on interdisciplinary exchange and support for cross-disciplinary 'translators'. Respondents also called for improved collaboration between the UK Research Councils, and for UKERC to more clearly define its role in the rapidly changing UK energy research landscape.

Most UKERC researchers have a keen interest in developing collaborations across disciplines, and for many, an interdisciplinary perspective is seen as essential to fulfilling UKERC's ambition to address critical and complex research problems. At the same time, researchers are concerned about the extra challenges of interdisciplinary research: the difficulty of combining disciplinary identity with interdisciplinary achievement, and the persistent barriers to funding, publication and career progression. Academic institutions and incentives – such as the UK's Research Excellence Framework (REF) – tend to privilege disciplinary identity and outputs, and this has provided a difficult context for UKERC Phase 2. Ultimately, UKERC's interdisciplinary achievements and limitations cannot be judged in isolation.

1. Introduction

1.1 Survey Background

The UK Energy Research Centre (UKERC) is funded under the Research Councils' Energy Programme (RCEP) to carry out 'whole-systems' interdisciplinary energy research, and to act as a central hub for University-based energy research in the UK. UKERC was created in 2004 under a 5-year award from three Research Councils: the Natural Environment Research Council (NERC), Engineering and Physical Science Research Council (EPSRC) and Economic and Social Science Research Council (ESRC). A *Phase 2* programme of work was commissioned in 2009, for a further five years. A third phase of UKERC research will commence from May 2014.

The research reported here is part of a project commissioned by UKERC's independent Research Committee to review UKERC's research programme in terms of its interdisciplinary research achievements, challenges and lessons learned. The project is being carried out internally, by staff drawn from UKERC's Research Co-ordination and Meeting Place teams.

As well as the survey reported here, the project includes a review of the existing literature on interdisciplinary energy research, a workshop convened at UKERC's Annual Assembly conference in July 2013, and a number of in-depth interviews with UKERC researchers, and members of the wider energy research community and UKERC's non-academic stakeholders. A final report will be made publicly available on UKERC's website in early-2014.

1.2 Survey Introduction

Within the overall project, the survey provided an opportunity for the involvement of the entire UKERC Phase 2 research community, and many of UKERC's academic and non-academic stakeholders.

The survey was designed by UKERC's Research Co-ordination Team. It was informed by issues raised at a workshop convened during UKERC's Annual Assembly 2013, and by follow-up exchanges with some UKERC researchers, Research Committee and Advisory Board members. The survey included 23 questions, presented on an online platform, and was open to invited applicants over several weeks between June and September 2013. As well as specific questions, the survey was designed with many 'free text' boxes to allow less constrained input. A full list of the survey questions is provided in the Annex.

Invitations were sent to all members of UKERC's Phase 2 research programme, including Core and Research Fund researchers from across UKERC's five research themes and UKERC's interdisciplinary PhD research students.[1] Invitations were also sent to members of UKERC's independent Research Committee. As the next Section describes, the respondents included a broad mix of researchers by discipline, seniority and role in UKERC.

The survey was structured in three parts:

- The first part provided information on the profiles of respondents – their career stage, disciplinary background and role in UKERC; the findings are presented in Section 2 of this report.
- The second – and largest – part of the survey explored respondents experiences of interdisciplinary research in UKERC and elsewhere, across several areas: UKERC's overall performance compared to other centres; particular elements that have worked well or less well; the way in which different disciplines were represented and interacted; the wider impact of UKERC's interdisciplinary efforts; and the motivations and barriers for researchers' involvement in interdisciplinary research. The findings are presented in Section 3 of this report.
- The third and final part of the survey invited respondents to offer recommendations to researchers, research managers and funding bodies, as well as any general observations or comments. These findings are presented in Section 4 of the report, which also presents some overall conclusions based on the findings of the survey.

[1] Details of UKERC's research and non-research activities are available at www.ukerc.ac.uk

2.Survey Respondents

2.1 Status and disciplinary backgrounds

The overall survey response rate was 44% (90/206) – suggesting a significant level of interest in interdisciplinary research among UKERC researchers. Survey respondents came from a range of academic positions by seniority (Figure 1).

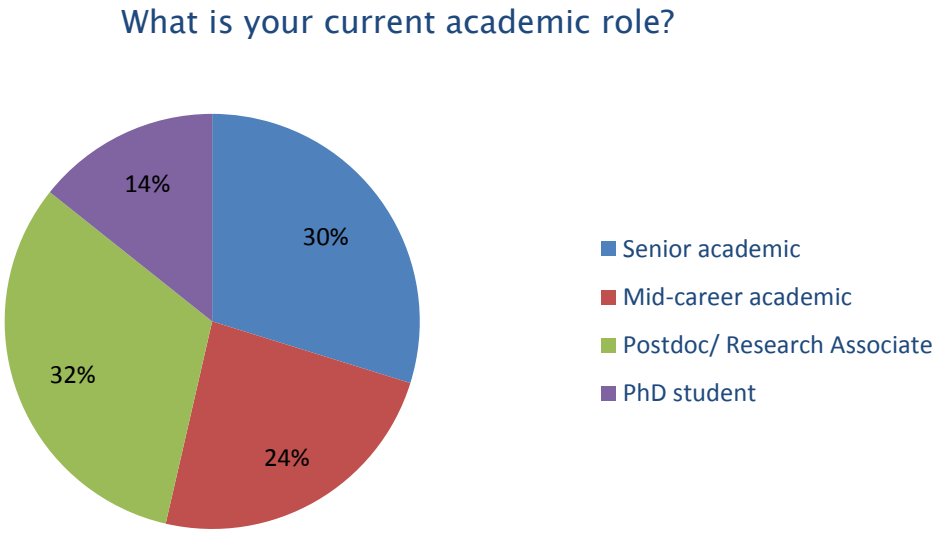

Figure 1: Survey respondents by career stage

Respondents were also drawn from a range of broad disciplinary identities (or 'macro-disciplines') spanning the Centre's cross-disciplinary remit and funding bodies, including social sciences; engineering and physical sciences; economics; and environmental and biological sciences (Figure 2).

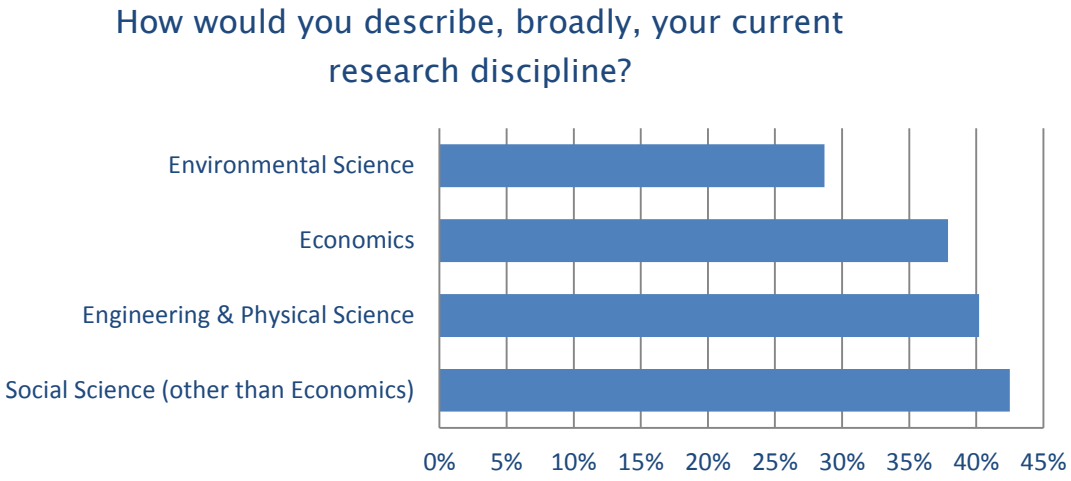

Figure 2: Respondents' self-declared disciplinary backgrounds

A small number of respondents – all senior or mid-career academics – identified themselves with multiple macro-disciplinary identities. A few respondents' comments highlighted the difficulty (or even irrelevance) of disciplinary identity, as their expertise has shifted over the course of their career.

> *'I don't think of being in a discipline any more'*
>
> *'engineering originally, but now a social scientist'*
>
> *'generalist, but most comfortable at the … boundaries'*

Beyond these macro-level disciplinary identities, a variety of more specific disciplinary identities were revealed in respondents' comments. Self-defined sub-disciplines mentioned here included some familiar and established academic disciplines, such as human geography, ecological economics, mechanical engineering and oceanography, but also some highly applied and quite specific identities that don't fit easily into established academic structures, including energy policy, energy demand reduction, energy modelling, ecosystem services, technology policy, risk and uncertainty modelling, and human-centred design.

2.2 Research roles in UKERC

A range of research roles in UKERC were represented in the survey, including researchers, co-investigators, principal investigators and interdisciplinary research students (Figure 3). A number of respondents declared more than one role and participate in a number of projects. Other participants included members of UKERC's Research Committee, Supervisory Board and Advisory Board.

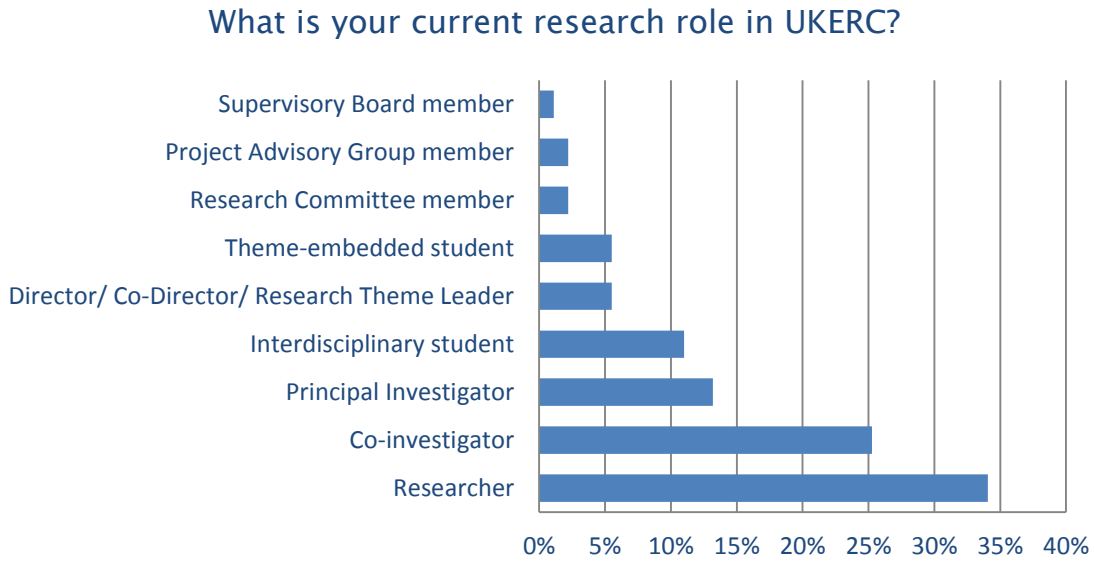

Figure 3: Respondents' Roles in UKERC

Although all levels of seniority are seen as having been engaged in interdisciplinary research, junior researchers – PhD students, postdocs and research assistants – are seen as having had particularly strong interdisciplinary engagement in UKERC (Figure 4). This raises the need for support for interdisciplinary career progression, especially given the extra challenges of interdisciplinary academic careers (discussed in Section 3.8 below).

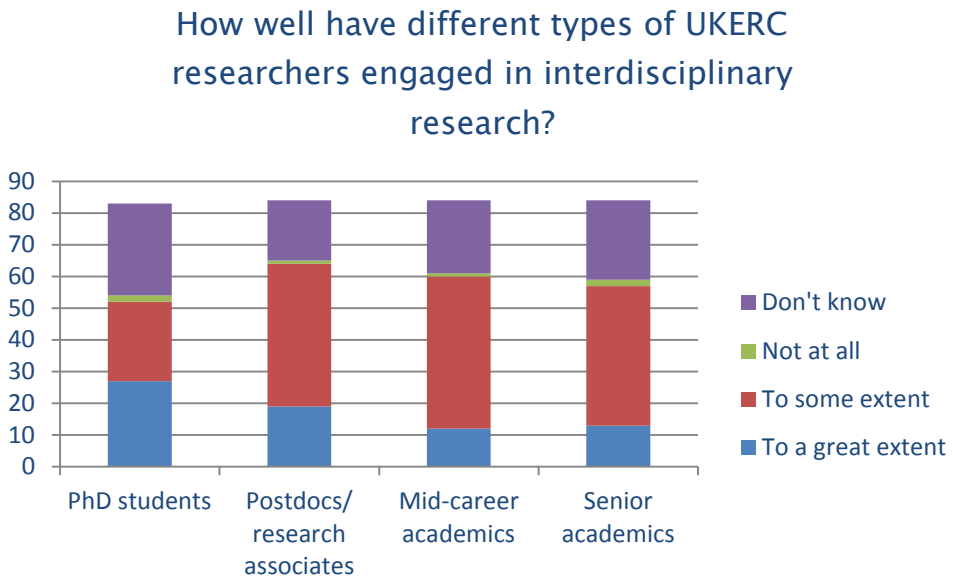

Figure 4: Perceived engagement in interdisciplinary research, based on career stage

UKERC's five Research Themes were all reasonably well represented in the survey (Figure 5), and the results broadly correlate with the size of the themes in terms of person years. However, less than a fifth of respondents (17%) were involved in either of the two Phase 2 'Flagship' projects, which are designed to offer Centre-wide research insight.

UKERC's relatively limited efforts on Centre-wide research integration in Phase 2 reflect its changed funding model and programme design. While Phase 1 UKERC was supported by a pre-assigned five-year allocation of resources, around half the research funds for Phase 2 was allocated by a series of open and competitive research calls.

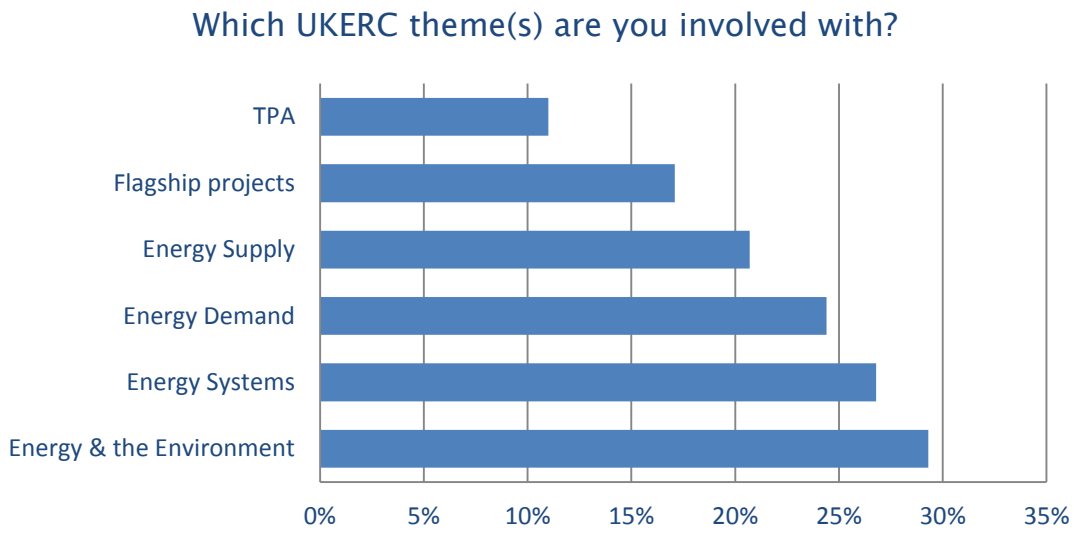

Figure 5: UKERC Research themes' representation

Just over half of the survey respondents identified themselves as being supported by Research Fund – rather than Core-funded – projects, confirming that the Research Fund has led to a significant remaking of the UKERC research community. For many researchers, the 'Core/Flex' distinction is immaterial: around one-third of respondents stated that they didn't know whether they are Core or Research Fund funded). At the same time, a quarter of respondents participated in more than one theme, indicating a degree of cross-thematic interaction.

While this 'Core and Flex' funding model has injected flexibility and diversity to UKERC's research, it has also presented greater challenges in terms of research integration, and the Centre's Phase 2 research strategy has focussed on theme-level synthesis as well as centre-wide Flagship projects. Experiences from UKERC Phase 2 highlight the challenge of combining flexibility and openness with coherence and integration, and as the next sections (3.1. and 3.2) discuss, this also has possible implications for UKERC's ability to engage in more ambitious forms of interdisciplinary research.

3.Interdisciplinary experiences

3.1 Interdisciplinary research experience

For most respondents (just under two thirds), their participation in UKERC is not their first experience of interdisciplinary research. When invited to compare UKERC to their other experience, around half indicated that UKERC's approach towards interdisciplinary research rated 'about the same', with just under a quarter stating UKERC had performed better (Figure 6).

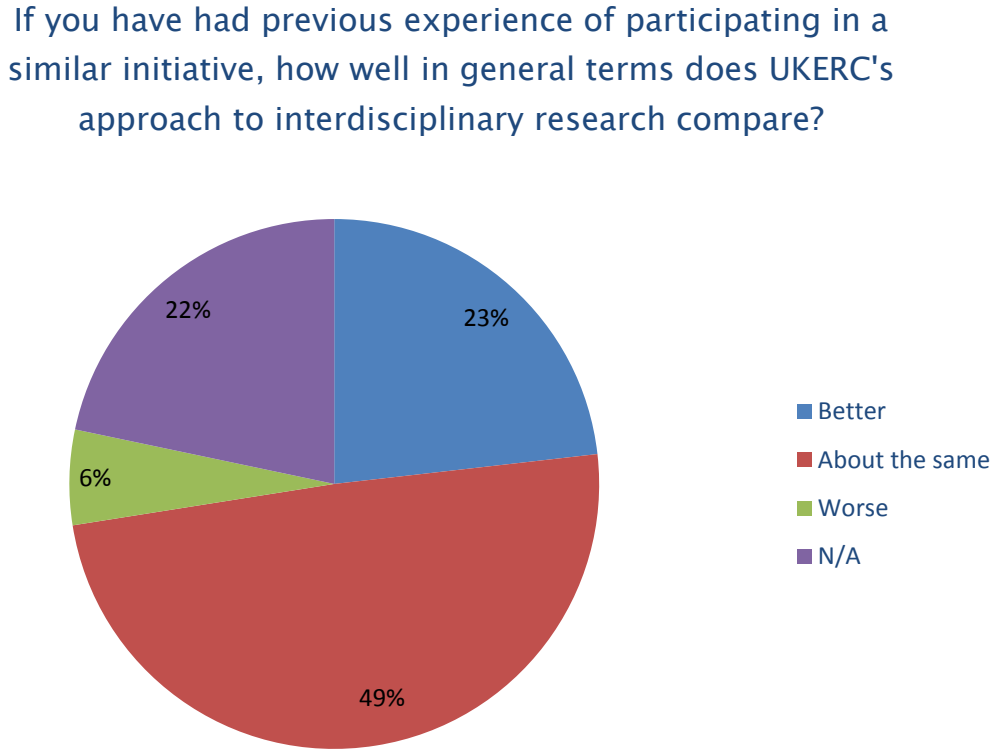

Figure 6: UKERC's interdisciplinary research rating, compared to previous experiences

Respondents' comments confirmed this pattern, with some researchers highlighting UKERC's achievements in interdisciplinary working:

'UKERC has been very successful in interdisciplinary research'

'[my] previous 'interdisciplinary' activities were mostly in name only'

'UKERC has better inter-theme interaction and integration'

'access to fellow researchers through the UKERC network has been invaluable'

For others, UKERC's efforts had more limited or partial impact, and one respondent highlighted a more visible focus on interdisciplinarity in another initiative:

> *'UKERC is making greater efforts to help disciplines understand and value one another's contributions, but I'm not sure we've quite got there yet'*
>
> *'UKERC is better than some and worse than others. Basically, I do not feel that it is explicitly encouraged or supported, but neither is it discouraged or shunned'*
>
> *'[there are] some patches of very good collaboration and other patches where there seems to be less effective interdisciplinary working'*
>
> *'I was involved in several RELU [Rural Economy and Land Use] projects - the emphasis on interdisciplinary working was more explicit there'*

Other than in-project commissioning and reporting – perhaps less visible parts of the research process for many researchers – UKERC has supported interdisciplinarity by mainly 'soft' measures, for example Centre-wide meetings and thematic workshops. For some respondents, this is reflected in a reliance on committed individuals for interdisciplinary achievement, rather than more 'top-down' directed activities.

> *'it encourages interdisciplinary bids, but [there is] less collaboration between groups beyond research projects'*
>
> *'it is down to the individual's desire to embrace interdisciplinary working practices'*
>
> *'there is primarily reliance on the attitudes of individual researchers'*
>
> *'UKERC has tried very hard to achieve [interdisciplinarity]. However this has not always worked out. Perhaps it doesn't need to … [it] is perhaps more a function of individuals than the centre itself'*

3.2 Research content and structure

There is broad acknowledgement that UKERC has supported interdisciplinary energy research. Over three-quarters of participants agreed or strongly agreed that the content and structure of the UKERC research programme supported interdisciplinary collaboration (Figure 7).

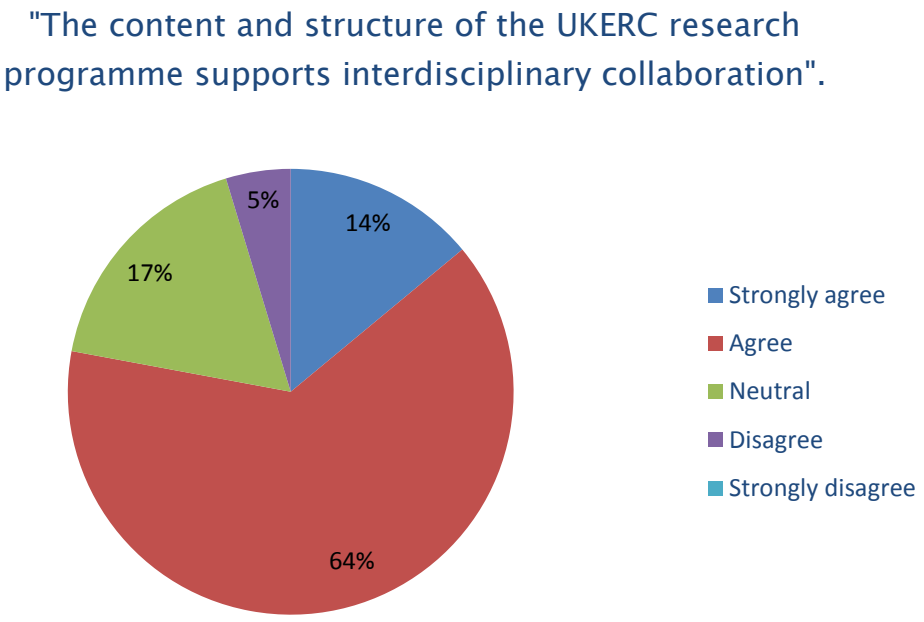

Figure 7: Assessment of UKERC's research programme

Respondents' comments paint a more mixed picture, and offer some insight on the underlying tensions and barriers. A recurring theme here was that UKERC had tended to carry out *multidisciplinary* research (where different disciplines work alongside each other in parallel) rather than *interdisciplinary* (where there is an effort at disciplinary combination or integration).

> *'interdisciplinary research is often discussed, but it is difficult to think of specific examples of successful application, as opposed to multidisciplinary research, which … is more prevalent'*
>
> *'the content and structure allows people in different disciplines to communicate occasionally, but fundamentally to continue to work separately'*
>
> *'each of the groups may still be 'in their discipline' yet their collaboration at the very least encourages interdisciplinary between them (or is that multi-disciplinary?)'*

Other comments suggested that the organisation of the Phase 2 research programme into five domain-based themes (*supply, demand, systems, energy and environment* and *technology and policy assessment*) had presented barriers to interdisciplinary working:

> *'Supply versus … demand is an immediate disadvantage'*
>
> *'[better] to organise the research around "Big Questions" as opposed to themes'*

3.3 Research-supporting activities

Respondents were asked to consider the role of UKERC's research-supporting functions and activities in enabling interdisciplinarity (Figure 8). The results suggest that the thematic workshops convened by UKERC's Meeting Place function and the regular calendar of Centre-wide meetings were seen as the most effective mechanisms – the Meeting Place was highly rated here by more than half of respondents.

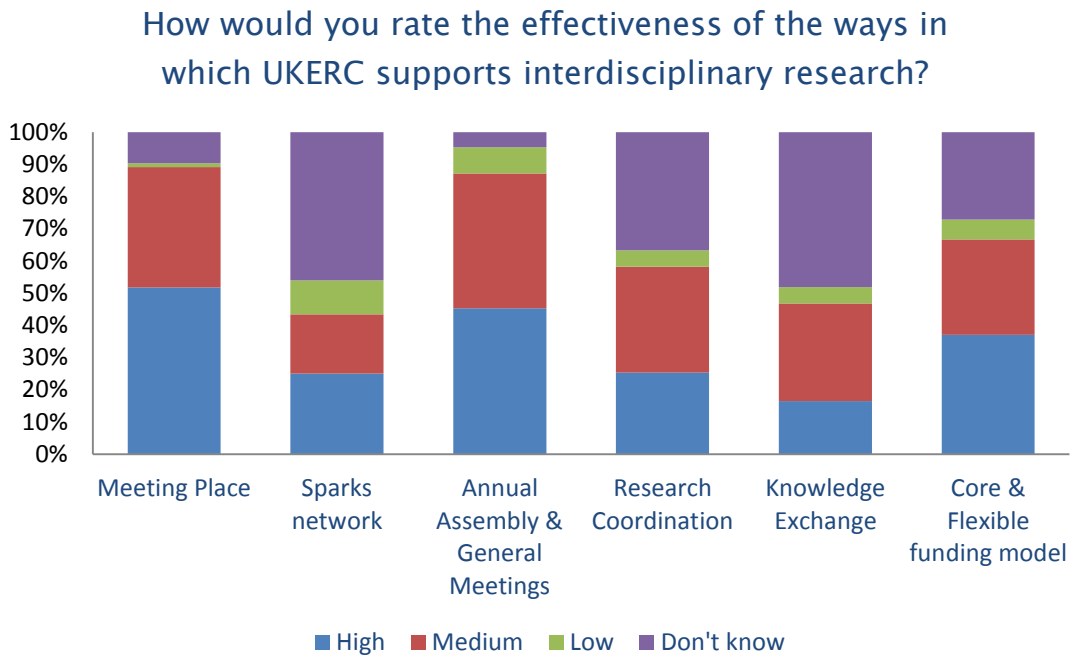

Figure 8: Effectiveness of interdisciplinary research support

A significant proportion of respondents felt unable to judge the effectiveness of UKERC's research supporting functions. This is perhaps understandable: many of the roles here are carried out 'behind the scenes': specifying calls for proposals, supporting annual monitoring and organising Centre meetings, serving the wider UK energy research community, or having more targeted remits, such as to early-stage researchers; this makes general comparisons difficult.

'flexibility supports collaboration – not 'content' or 'structure'. The exception to this is the Meeting Place, which is a structure that supports flexibility'

'[the interdisciplinary studentships] … develop true interdisciplinarity'

'theme meetings … have been very effective'

'the communication function for promoting UKERC reports has worked very well'

3.4 Sources of interdisciplinarity

Respondents were invited to assess where interdisciplinarity has been most prominent within the Centre's research programme (Figure 9). The results suggest that interdisciplinarity has been strongest in UKERC's smaller-scale activities: individual projects and researchers, and *within* rather than *between* research themes. By comparison, larger-scale and more outward-facing activities – such as cross-theme collaboration, and links with the wider research community and non-academic stakeholders – were seen as being less effective.

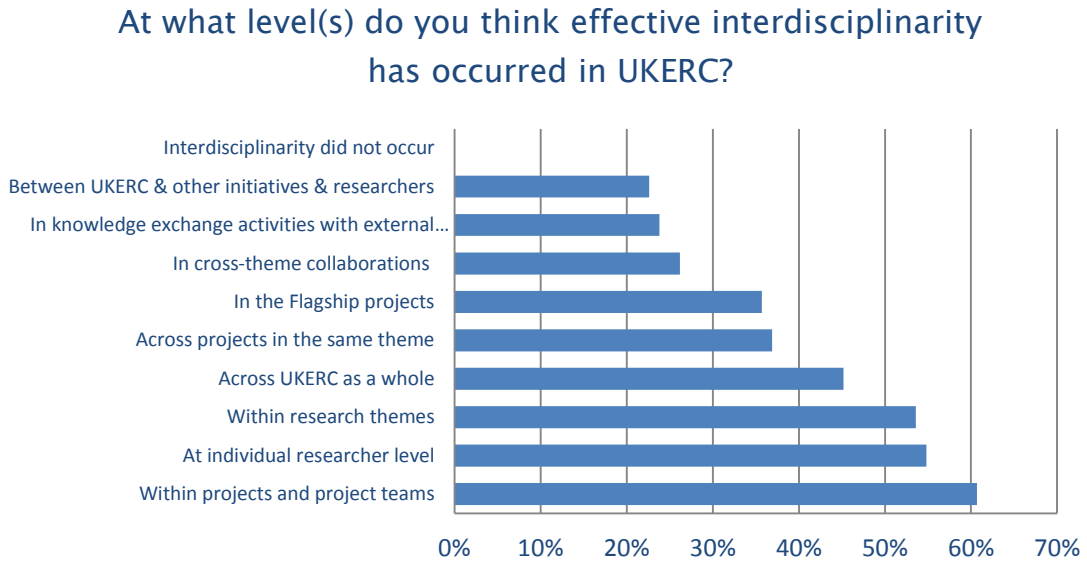

Figure 9: Different sources of interdisciplinarity in UKERC

Again, some caution is needed in interpreting this question: as a number of respondents themselves pointed out, researchers tend have more direct experience of project-level activity than higher-level initiatives. In addition, some higher-level efforts, such as theme synthesis projects, are recent additions to the Phase 2 research programme. Even so, the indication here is that the prevailing interdisciplinary experience in Phase 2 has been among relatively small groups of researchers involved in studentships, projects and themes, rather than larger-scale initiatives across themes and the Centre as a whole.

There was some suggestion in respondents' comments that this pattern relates to the structure of the UKERC Phase 2 programme, in terms of its orientation to *flexibility* rather than *integration* – a significant change from the less-open and diverse but more tightly integrated Phase 1 research programme, as manifest in the Phase 1 *Energy 2050* project. Among Phase 2 projects, a Research Fund interdisciplinary project on Carbon Capture and Storage (CCS) was mentioned as an example of successful engagement across the social and engineering sciences.

'it has occurred …less … between different projects and across the themes'

'Energy 2050 was arguably the furthest down this route that UKERC has gone. As an interdisciplinary exercise it was far from perfect but it did force some useful interactions'

'in the CCS project … we had some good interaction between social scientists and … other backgrounds, although there was probably still some room for improvement'

As is discussed later (Section 4.1) interdisciplinary research often relies on cross-disciplinary relationship-building over time, and the suggested trade-off here between *programme flexibility* and *depth of interdisciplinary interaction* has some important implications. As UKERC's Phase 2 experience suggests, an emphasis on flexibility and diversity may reduce the prospects for more ambitious forms of interdisciplinary research. Another respondent explicitly highlighted this trade-off – though in the context of a perceived orientation in UKERC towards cohesion rather than openness.

'there is a cohesiveness and strong sense of identity within UKERC. This is the positive flip side to it being seen as a bit of a closed shop by some not part of UKERC'

3.5 Disciplinary identity, representation and interaction

All of UKERC's 'macro' disciplinary communities – *environmental sciences, engineering and physical sciences, economics* and *social sciences* – were seen as being reasonably well represented among respondents. However, although social science (other than economics) was the biggest disciplinary community in self-declared identity (Figure 2), engineering and physical science was perceived as having the strongest representation in UKERC research (Figure 10). Although the differences between disciplinary identity (Figure 2) and representation (Figure 10) are small and shouldn't be overstated, they suggest a slight perceived bias in UKERC research toward more 'techno-economic' disciplines.

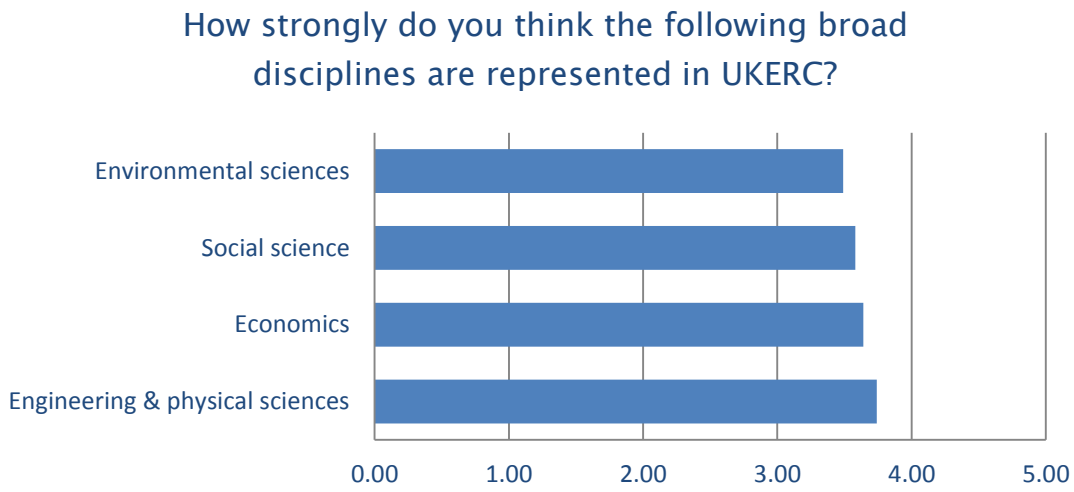

Figure 10: Strength of disciplinary representation in UKERC research

Respondents' comments allowed some further consideration of disciplinary identity and representation in UKERC – with references to the quality and standing of social science and engineering research. These comments highlight the challenges of reconciling interdisciplinary achievement with strong disciplinary identity, and reveal the nuanced and interpretive nature of disciplinary identity and representation.

> '*[interdisciplinarity] is strong … but … dominated by technical/ engineering expertise'*
>
> '*social science … has … recently become more strongly represented*'
>
> *'although many people and projects involve aspects of social science …. most people have a hard science or engineering background'*
>
> *'although there are lots of 'engineers' within UKERC, I think their research is often at a higher systems level … than being involved in … the application of technologies'*

In terms of the strength of cross-disciplinary interaction, the strongest links were seen as being between *economics* and *engineering*, then between *economics* and *environmental science*, and then between *social sciences* with *environmental sciences* (Figure 11). One respondent highlighted the role of the *UK Energy in a Global Context* flagship project in strengthening the connection between *environmental science* and *social science.* Levels of interaction were seen as being lowest between *social sciences* and *economics* and *environmental sciences* with *engineering*.

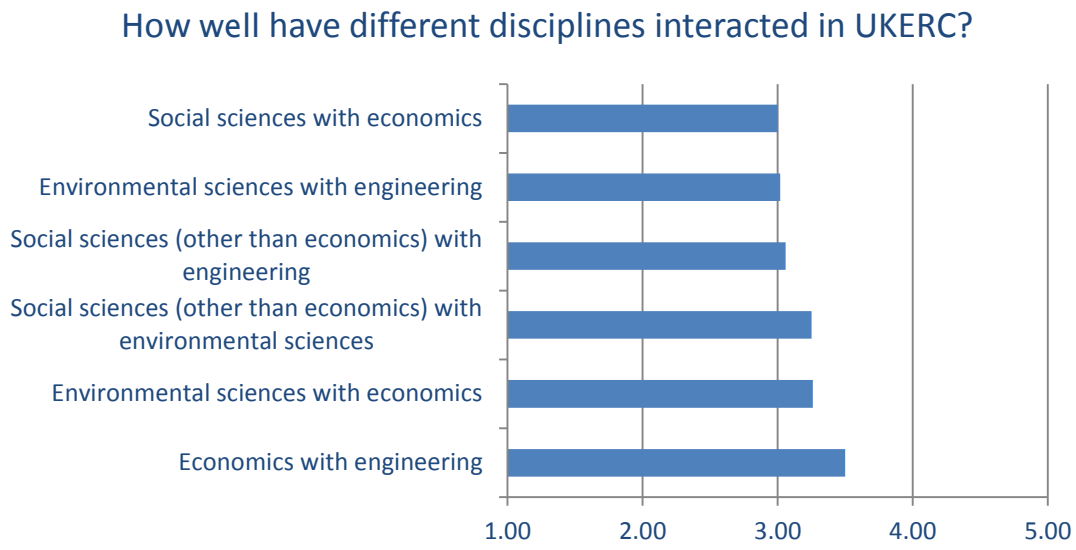

Figure 11: Perceived strength of interaction between disciplines

3.6 Research impact and dissemination

Survey participants were asked to assess the main academic and non-academic impacts of UKERC's interdisciplinary energy research. The greatest perceived strengths of UKERC research was its orientation to 'real-world' problems and bringing together different disciplines; it is seen to have made less impact at developing new research approaches and methods (Figure 12).

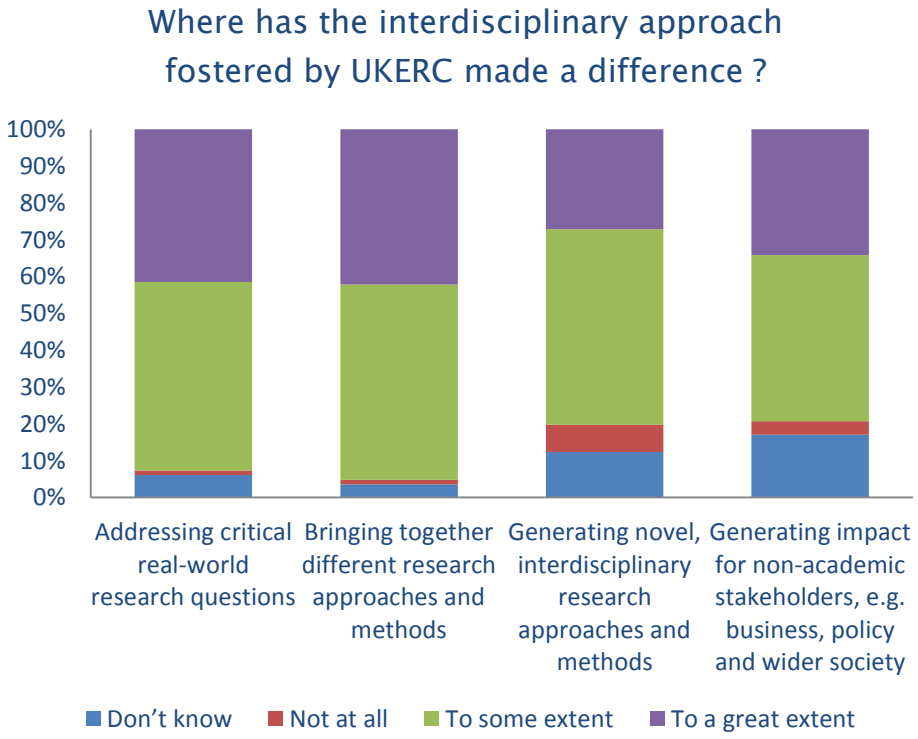

Figure 12: Effect of UKERC's interdisciplinary approach

The results also suggest that UKERC has had an impact on many of its researchers' publishing strategies, with just under half of respondents having found novel publication channels as a result of their involvement in UKERC research (Figure 13).

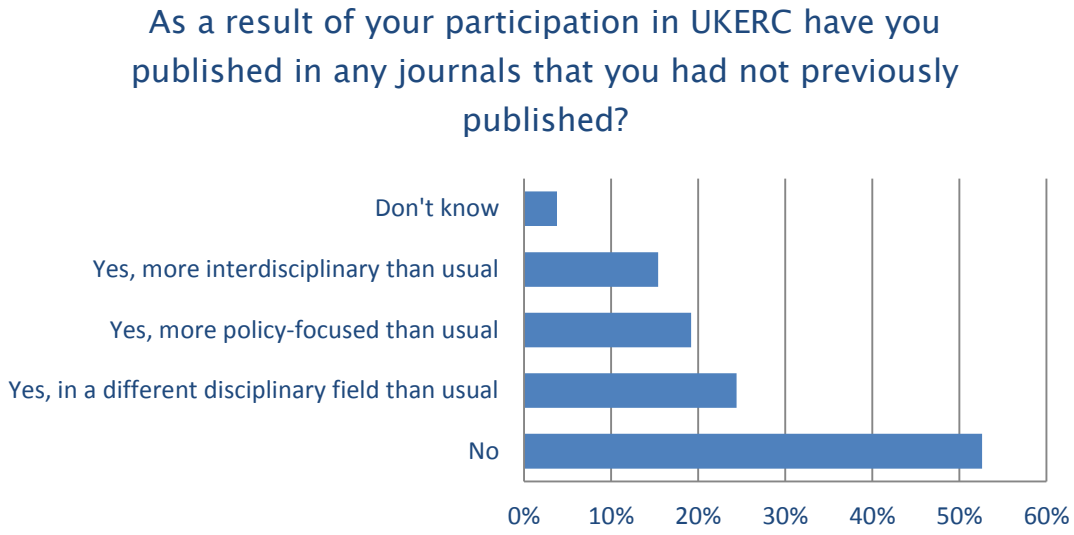

Figure 13: Impact on publication strategy

This is encouraging, given the well-documented challenges of publishing interdisciplinary research in the highest-rated academic journals; indeed, one respondent pointed to the higher anticipated impact from interdisciplinary work.

> '*[we] have targeted social science journals that I would not normally publish in'*
>
> *'[we] anticipate getting higher impact publications than without interdisciplinary collaborations'*

3.7 Capacity Building

There is strong evidence that UKERC is helping to build the UK's interdisciplinary energy research base. Almost 90% of respondents *agreed* or *strongly agreed* that UKERC has helped develop an interdisciplinary research community (Figure 14), and almost three-quarters *agreed* or *strongly agreed* that their UKERC involvement had made them more likely to participate in interdisciplinary energy research in the future (Figure 15).

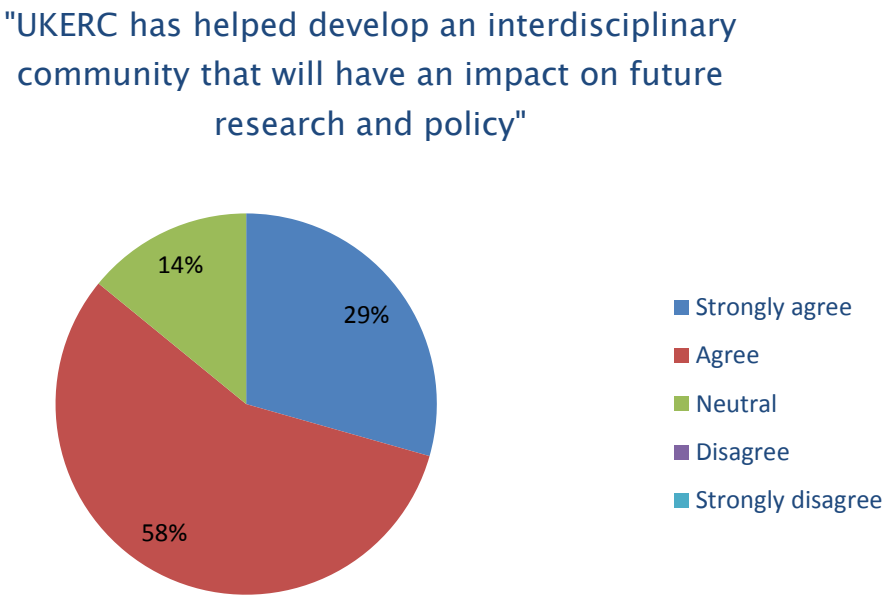

Figure 14: UKERC's impact on future research and policy

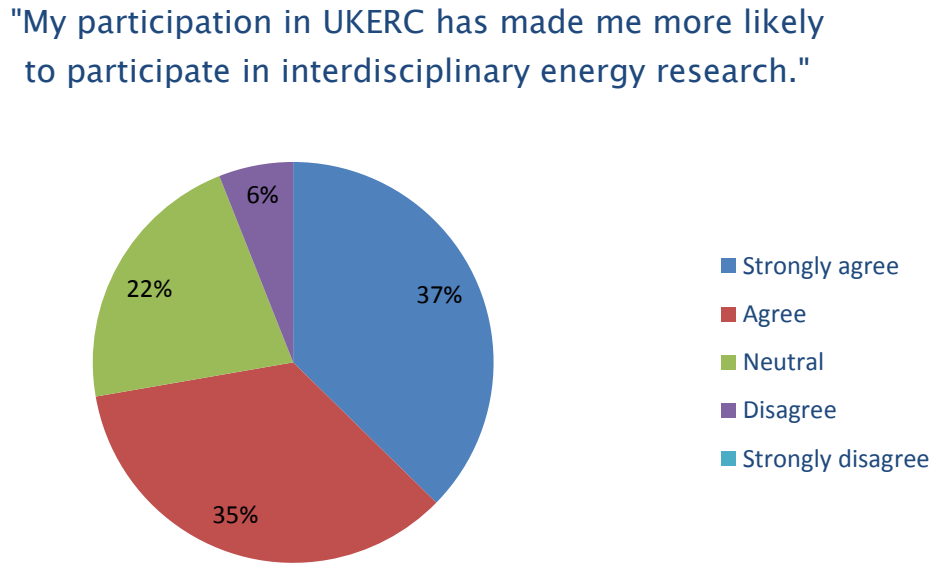

Figure 15: Future participation in interdisciplinary energy research

3.8 Motivations and barriers

Perhaps unsurprisingly, given the extra challenges involved, the strongest reported reasons for involvement in interdisciplinary research are personal and inquisitive: developing new collaborations across disciplines and following a personal interest in novel research questions and methods. More outward or formal incentives – improved publication or research funding opportunities, or changed career ambitions – are less significant (Figure 16).

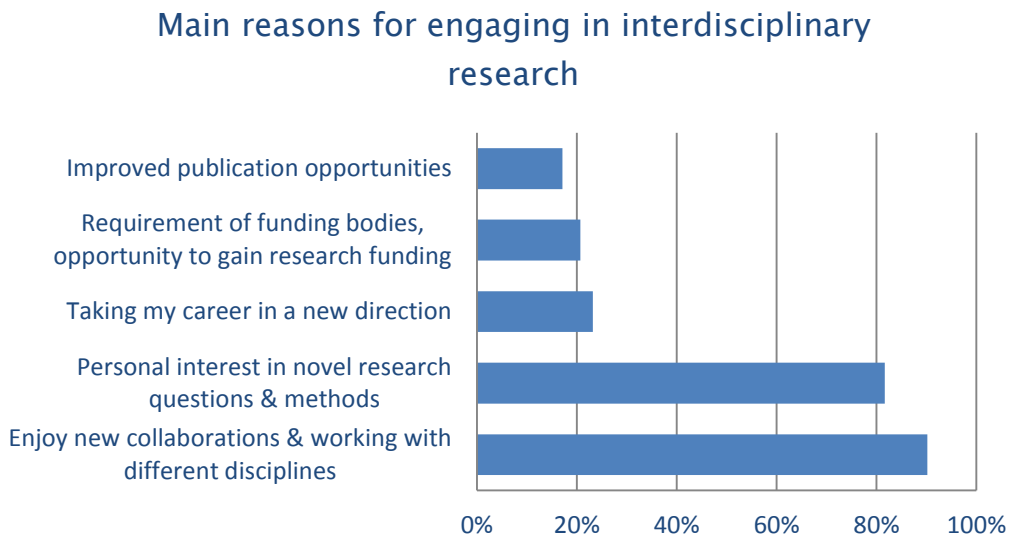

Figure 16: Motivations for interdisciplinary research

'single discipline approaches are (not) effective for looking at the questions I hope to help answer'

'[interdisciplinarity] is essential if we are to address the problems relating to energy'

'addressing real world issues which cannot be resolved by one discipline alone'

Alongside this strong personal interest, however, is considerable concern about the added challenges and practical difficulties of interdisciplinary research, especially the greater demands of interdisciplinary research design and its diluting effect on disciplinary identity, in a still highly disciplinary-oriented institutional environment (Figure 17).

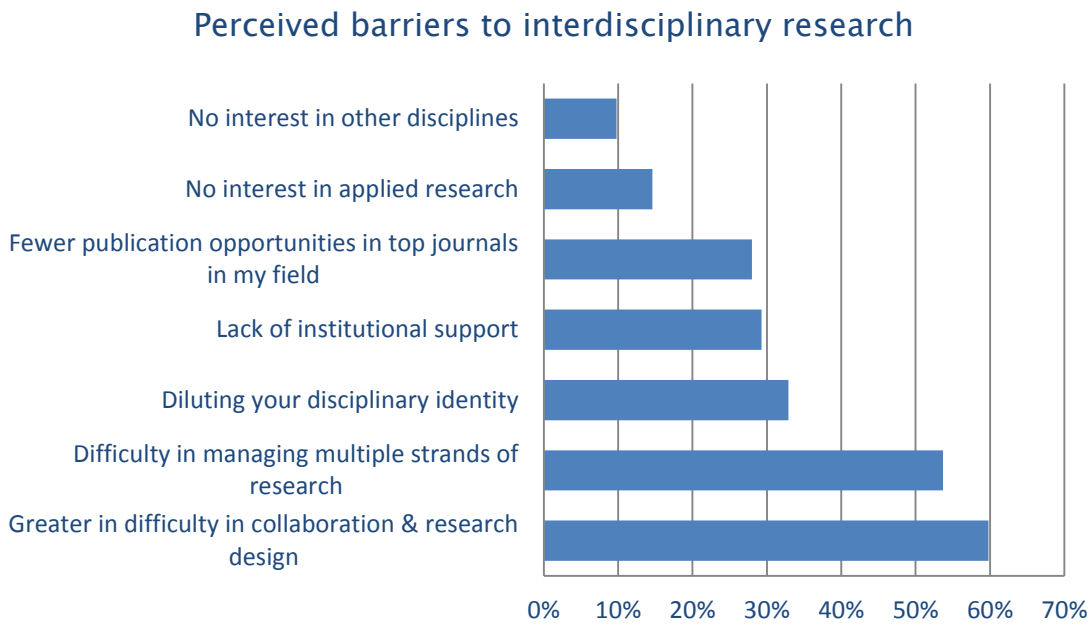

Figure 17: Barriers to engaging in interdisciplinary research

Respondents' comments highlighted the multiple perceived disadvantages to academic career progression – publishing, funding and promotion – presented by interdisciplinary research:

> *' publishing and funding are still more difficult for interdisciplinary work'*
>
> *'there is still very limited (funder) support … outside a very techno-economic, innovation and technology transfer type model'*
>
> *'funding can be more difficult due to lack of ownership of interdisciplinary area'*
>
> *'being interdisciplinary can have negative effects on publication rankings and career prospects'*
>
> *'most academic appointments are still focused on single disciplines'*
>
> *' [it's] easier to progress as an academic if you can give yourself a strong disciplinary home'*

Some respondents highlighted the UK's Research Excellence Framework (REF) as a particular barrier to interdisciplinary research during UKERC Phase 2:

> *'REF is a major barrier'*
>
> *'[there is no] REF category for energy research. Policy-related papers are 'no-go' in an engineering panel'*

'REF is a disincentive to potential partners … since they will have to justify 'mixed' papers to a discipline specific submission panel'

Alongside this, others suggested that, in the right circumstances the barriers to interdisciplinarity can be reduced or overcome:

'I've been lucky in that I've always worked in interdisciplinary environments – so the barriers have been less important for me'

'the opportunity is there if you want to take it'

4. Recommendations and Conclusions

In the final part of the survey, respondents were given an opportunity to offer suggestions for researchers, research programme leaders and funding bodies involved in promoting and developing interdisciplinary energy research, and to pass on any final observations or comments.

4.1 Recommendations

A recurring theme in respondents' recommendations was that successful interdisciplinary research requires additional time, effort and resources as compared to disciplinary-based research. A number of respondents highlighted the value they have derived from UKERC-enabled interpersonal interaction and networking, and the need to provide for this in research programme design and funding:

> '*being able to have access to such a wide range of energy researchers, with a variety of disciplinary backgrounds but sympathetic to interdisciplinary approaches, has been immensely helpful to me as an early career researcher*'
>
> '*For interdisciplinary PhD students, it's particularly important to develop a good network of other students and academics in both (or several) fields of your research… having regular contact with students in my second discipline really helped to refine some of the research questions. These contacts were nearly as valuable as having a supervisor in that discipline*'
>
> '*more networking events [are needed]… so new collaborations can be developed – perhaps save funding to help foster this'*

For a number of respondents, the need for explicit attention to cross-disciplinary relationship-building reflected the 'language barrier' between different disciplines; one respondent highlighted the problem of discipline-specific language at interdisciplinary events such as the UKERC Annual Assembly.

> *'arts and humanities speak a different language from the sciences… we need to take time to educate each other a bit in each other's disciplines so that we have inter-disciplinary individuals within each project'*
>
> *'people from different disciplines speak different languages. Getting over this language barrier is a key challenge and one that few researchers are willing to take on*'
>
> *'presentations at interdisciplinary events such as the Annual Assembly use a great deal of jargon and assumed knowledge … [they] can be difficult to follow and the key message is lost'*

Reflecting the barriers between disciplines, some respondents recommended building-in dedicated time for researchers to familiarise themselves with the contributions and methods of different disciplines – especially in the early stages, but also on a recurring basis.

'it takes a while to understand … other techniques … outside your field … [the] first few months are just understanding what you can do'

'ensure enough resource is available to enable time for different disciplines to get to know each other and see the benefits of working collaboratively'

'*all long term research projects … [should] be subject to the PI's in each discipline attending a 3-5 day [meeting] … to get to know each other's methods and come to agreement on common … terminology and units of measurement … to set out the scope of the collaboration … and provide points of contact throughout'*

'specific funding [should be] allocated to create interaction between different disciplinary parts … e.g. away days … recurring meetings … talking in less formal settings is valuable'

One respondent highlighted the particular need to support early-stage interdisciplinary research careers:

'my main concern is for the future prospects of UKERC PhD students … additional support would be welcome'

Alongside built-in 'interaction time', a number of respondents suggested the need for research managers and funding bodies to recognise the value of cross-disciplinary co-ordinators or 'translators', who tend to have less traditional academic profiles.

'[we need] dedicated human resources for fostering and facilitating collaboration, and leadership programmes to encourage this type of role … to foster collaborative work between groups, themes and disciplines'

'many researchers … remain disciplinary experts. The challenge is in developing 'coordinating individuals' who can develop and facilitate their collaboration'

'for successful interdisciplinary collaboration, you need two types of people: … disciplinary experts who are willing to collaborate with aliens from another discipline … and … translators and facilitators (who may not be disciplinary experts themselves)'

Other aspects of research programme design and funding that were highlighted included: striking a different balance between 'core' and 'flex' funding; the need to change UKERC's organisational structure to a 'problem-based' structure; and the need for greater interaction within themes.

> '*make more use of flexible funding to bring in the people, teams, disciplines you need - have less committed [core funding] … as this causes lock-in and stagnation'*
>
> *'be 'problem-focused' rather 'theme-focused'. It's the outcome that is important*'
>
> *'[we need] greater coordination at theme level to encourage students of … different areas within the same theme, to mix and share ideas, information'*

In terms of future interdisciplinary representation and collaboration, suggestions included improved representation of engineering, and engineering-social science collaboration. Respondents also highlighted the need for improved cross-Council collaboration, and for UKERC to better define its position in the UK's evolving energy research institutional landscape

> *'greater interaction between engineering and social sciences/economics'*
>
> '*more engineering please'*
>
> '*ESRC and EPSRC need to do more joint things or get better at interdisciplinary responses*'
>
> '*UKERC needs to develop (perhaps novel) mechanisms for interfacing with the natural science and engineering-facing projects within the changing RCEP landscape, i.e. the BBSRC Sustainable Bioenergy Centre, the EPSRC EUED Centres, the Supergen Hubs, and various energy-related Doctoral training Centres*'

Respondents also highlighted the way in which data gaps presented a barrier to interdisciplinary research:

> '*it should be mandatory that data and results from taxpayer funded research is … made available to all… to avoid re-inventing the wheel and to speed up … adoption of the results'*
>
> *'some … institutions and senior academics hoard and guard data as if it is their own, after it has been paid for by the public purse. This is a barrier to intra and inter disciplinary research'*

Finally, despite the many barriers and recognised need for improvement, some respondents reiterated the value and rewards of interdisciplinary research:

'*interdisciplinary work is very difficult (it usually defaults to multidisciplinary research), but can bring really new insights … all parties need to be prepared to concede some ground, listen to others and share their knowledge; then it is possible to move forward'*

'although it's a massive challenge to work in a truly interdisciplinary way, the final results are worthwhile'

4.2 Conclusions

The aims of this survey were threefold: to explore the experiences and views of the UKERC research community in relation to interdisciplinarity; to consider the strengths and weaknesses of UKERC's efforts to foster interdisciplinary energy research; and to identify opportunities for improved interdisciplinary collaboration.

The survey was well-received by many UKERC researchers, with responses from almost half of the entire UKERC research base, including past and present members of the Phase 2 programme. Inevitably, the survey reflects respondents' personal impressions, often based on limited experience and a partial knowledge of UKERC's activities.

The respondents made up a broadly representative mix of the UKERC research community, across disciplines, research roles, research themes and career stages. A slight imbalance was perceived by respondents in terms of disciplinary representation in UKERC research, with engineering and physical sciences seen as being more strongly represented than environmental sciences, economics and other social sciences.

UKERC Phase 2 has faced particular challenges in realising its interdisciplinary ambitions: a tension between *cohesiveness* and *flexibility* in managing its 'Core and Flex' funding model, which has resulted in a more diverse but less stable research community, and operating in a challenging wider institutional context for academic research in the UK.

Despite these challenges, UKERC members hold broadly positive views on UKERC's interdisciplinary efforts – while also indicating room for improvement. The clear majority of respondents agreed that UKERC had supported interdisciplinary collaboration through its content and structure. The Meeting Place was evaluated particularly positively, with more than half of respondents agreeing that it had been a highly effective means of fostering interdisciplinary energy research.

In addition to its direct achievements, UKERC is also recognised as helping to foster an interdisciplinary energy research community in the UK, with almost three-

quarters of respondents agreeing that UKERC had increased the likelihood of their future participation in interdisciplinary energy research.

While respondents acknowledged UKERC's efforts and impact, there were suggestions that more ambitious forms of interdisciplinarity were possible – for example, by designing the programme around 'big research questions', with interdisciplinarity more explicitly built-in from the start, rather than being introduced through mid-phase 'Flagship' projects.

Any successful inter-disciplinary research relies on committed and motivated individuals, and under any structure, UKERC's interdisciplinary ambitions will continue to depend on these. In a difficult context and challenging remit, UKERC has achieved some real successes. At the same time it has been less pioneering, in terms of its research methods and organisational make-up, than some other initiatives, and some respondents highlighted a tendency toward multidisciplinary rather than interdisciplinarity research.

The results suggest considerable researcher enthusiasm for interdisciplinarity, but also concerns about its practical challenges and professional implications, including academic career progression (particularly for the junior researchers) in an institutional context which has tended to privilege disciplinary expertise and reinforce disciplinary boundaries. Ultimately, UKERC's interdisciplinary achievements and limitations cannot be judged in isolation: there is a widely-shared perception that UKERC Phase 2 has operated in a challenging wider context for interdisciplinary research.

Another concern – and opportunity for improved future practice – was the persistent language barriers between disciplines. While interdisciplinary achievement ultimately relies on committed individuals prepared to engage with new perspectives, programme design and funding models which offer dedicated resources for interdisciplinary exchange and translation can enable more successful outcomes.

For many involved in UKERC, the benefits of interdisciplinary research outweigh the challenges, and the additional effort involved is seen as worthwhile. Above all, an interdisciplinary perspective is seen as essential to fulfilling UKERC's ambitions for whole-systems research, and addressing critical 'real world' problems in the UK and beyond.

Annex: Survey Questions

Q1. We would like to know a bit more about you. Providing your details is optional and all responses will be anonymised in any reports and publications.
Answered: 82 Skipped: 8

Q2. What is your current academic role?
Answered: 84 Skipped: 6

Q3. How would you describe, broadly, your current research disclipline?
Answered: 87 Skipped: 3

Q4. What is your current research role in UKERC?
Answered: 77 Skipped: 13

Q5. Which UKERC theme(s) are you involved with?
Answered: 82 Skipped: 8

Q6. Are you involved in Core or Research Fund projects?
Answered: 82 Skipped: 8

Q7. Did you have any experience of participating in an interdisciplinary centre or project before joining UKERC?
Answered: 87 Skipped: 3

Q8. If you answered 'yes' to the previous question, how well in general terms does UKERC's approach to interdisciplinary research compare?
Answered: 69 Skipped: 21

Q9. "The content and structure of the UKERC research programme supports interdisciplinary collaboration"
Answered: 86 Skipped: 4

Q10. Below is a list of ways in which UKERC supports interdiciplinary research. How do you rate the effectiveness of those that you've used?
Answered: 86 Skipped: 4

Q11. At what level(s) do you think effective interdisciplinarity has occurred in UKERC? Tick all that apply.
Answered: 84 Skipped: 6

Q12. How strongly do you think the following broad discliplines are represented in UKERC?
Answered: 84 Skipped: 6

Q13. How well have different disciplines interacted in UKERC?
Answered: 82 Skipped: 8

Q14. How well have different types of UKERC researchers engaged in interdisciplinary research?
Answered: 82 Skipped: 8

Q15. Where has the interdisciplinary approach fostered by UKERC made a difference?
Answered: 83 Skipped: 7

Q16. As a result of your participation in UKERC have you published in any journals that you had not previously published?
Answered: 78 Skipped: 12

Q17. My participation in UKERC has made me more likely to participate in interdisciplinary energy research.
Answered: 83 Skipped: 7

Q18. What are you main reasons for engaging in interdisciplinary research?
Answered: 82 Skipped: 8

Q19. What are the main barriers to engagin in interdisciplinary research?
Answered: 82 Skipped: 8

Q20. UKERC has helped develop an interdisciplinary community that will have an impact on future research and policy.
Answered: 85 Skipped: 5

Q21. Please suggest any lessons for future researchers, programme leaders/managers and funders.
Answered: 27 Skipped: 53

Q22. Do you have any other comments or suggestions?
Answered: 16 Skipped: 74

Q23. Please let us know if you would be willing to be interviewed as part of this work.
Answered: 83 Skipped: 7