

EPSRC National Centre for Energy Systems Integration (CESI)

Interdisciplinary Research for Energy Systems Integration: Understanding and promoting good practice

Project FFC1-022:

Executive Summary and Recommendations

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Executive Summary

Introduction

This is the final report on the National Centre for Energy System Integration (CESI) Flex Fund Project *Interdisciplinary research for energy systems integration: understanding and promoting good practice* (FFC1-022). The project has undertaken original research on the practice and outcomes of energy systems integration research. It has also developed good practice recommendations for interdisciplinary research on energy systems integration, both within CESI and the broader whole energy systems research community in the UK, including research funders, stakeholders and assessors. Research carried out for the project has included:

- A desk-based international *literature review* of energy systems integration (ESI) research design and methods, including peer-review journal papers and grey literature (Silvast et al., 2019).
- Three researcher and stakeholder *workshops*. The first workshop (n=13) was an internal event to discuss experiences within CESI. The second workshop (n=25) involved researchers drawn from both CESI and the UK's wider interdisciplinary energy research community to discuss and compare experiences. The third and final workshop (n=c.50) reported early project findings, and engaged more widely with stakeholders and researchers on energy systems integration research in the UK.
- Semi-structured *interviews* with 15 senior researchers and stakeholders involved in interdisciplinary energy systems research in the UK. The interviews provided insights on the detailed experiences and views of those involved in developing and using interdisciplinary research on energy systems in the UK

In terms of its analytical approach, the project was informed by the interdisciplinary studies research field (e.g. Frodeman et al., 2010). In particular, it addressed two related concepts in interdisciplinary energy research: 'whole energy systems' (WES) research and 'energy systems integration' (ESI) research. This drew on the 3-fold characterisation of WES research devised by Winskel (2018):

- *intellectual diversity*: WES and ESI research initiatives typically include diverse academic disciplines, spanning different theories, data, methods, and forms of evidence. Working across these diverse knowledge bases is a defining challenge interdisciplinary initiatives.
- *integration*: unlike more loosely coupled 'multidisciplinary' research, WES and ESI research initiatives typically aim at integrating and synthesising the work of academics from different disciplines to develop shared research outputs. In interdisciplinary studies research, this integrated form of interdisciplinarity is seen as particularly challenging.
- *transdisciplinarity*: WES and ESI research initiatives may have a strong level of engagement with non-academic stakeholders, including businesses, policy makers and wider publics. For more 'transdisciplinary' oriented research initiatives, non-academic stakeholders are viewed as active research collaborators, co-designers and co-producers, rather than passive research users or less deeply engaged advisors.

Research Findings

Definitions and scope

Interviews and workshop research carried out for this project suggests that a broad distinction can be drawn between ESI research and WES research, in terms of their research scope and foci. Typically, ESI is seen a more technical research framing, oriented towards engineering and physical sciences perspectives, and aimed at understanding how different parts of the energy system may be integrated, without necessarily addressing broader issues. By contrast, WES research tends to take a wider view, encompassing societal and behavioural factors, and perhaps with a greater emphasis on social science.

This suggested distinction means that ESI research agendas can be understood as a subset of WES agendas, able to offer a more detailed, focussed analysis of particular issues:

‘Energy systems integration effectively is a subset of whole energy systems ... integrating different parts of either systems or different vectors, or looking at ... regional or local ... energy systems.’

A senior manager in a UK Government research funding body

There are also suggested complementarities between WES and ESI research, with ESI analysing detailed system interactions while WES research provides a broader, contextual framing. At the same time, there are concerns about the risk of weak links between more focussed ESI research and broader WES research.

Research Designs and Methods

Research aims and designs

For effective interdisciplinarity in ESI and WES initiatives, overall research aims need to be open enough to meaningfully engage different disciplinary perspectives, but also well-focussed enough to enable useful outcomes. A Centre-wide integrative initiative such as a major scenarios exercise or a collaborative writing project can help resolve interdisciplinary problems in a pragmatic, productive way.

The role of modelling

Modelling is often seen an essential feature of interdisciplinary research on energy systems because it enables integrated analysis of a complex system, helping to identify key research or strategy issues. At the same time, models – particularly the use of several different models in a large interdisciplinary research initiative such as CESI – can obscure understanding and create barriers to integrated analyses.

One concern is that modelling for ESI research tends to reflect engineering and economic research frameworks, and marginalise other disciplinary perspectives. Another concern is the abstractions involved in modelling, and the need for strong feedbacks between system modelling and ‘real world’ data from implementation trials:

‘The UK’s almost been modelled to death ... we need the learnings from delivery built back into academia.’

A modelling expert in industry

Research scope and disciplinary range

There are risks that a technical and engineering emphasis within ESI research may lead to a rather narrow research scope, possibly overlooking important social, behavioural and political aspects of change (for example, in personal transport, or rescaled power systems). Fully addressing these societal issues may require broad disciplinary participation:

'My fear would be that the energy systems integration approach just takes where we are today and says, how do we adapt what we've got today?'

A former senior manager in an energy research organisation

Research integration

ESI research faces the challenge of combining qualitative and quantitative research from different disciplines into an effective 'mixed methods' overall design. Although quantitative methods are a critical part of ESI research, a sole emphasis on quantification can lead to research biases and omissions:

'If we always only put into scenarios what we can quantitatively describe ... with our models ... we ... put into the background things that we know to be very important.'

A senior interdisciplinary energy system researcher

Novelty and Consolidation

One challenge for developing integrative designs is that research funding and publication incentives tend to favour novelty – for example, encouraging the building of new models rather than model integration, consolidation and verification by improving links between existing models, updating or archiving data, or reviewing past findings:

'Working to help somebody else improve the quality of the data in their model, or make sure that models ... or researchers interact with each other just isn't rewarded.'

A modelling expert in industry

ESI research in practice

ESI research faces a number of practical challenges, many of which reflect the challenges of interdisciplinary research in general, rather than whole systems energy research specifically. These challenges include: persistent institutional and professional barriers; disciplinary-based research commissioning and assessment procedures; and a tendency to spread funding very thinly across a large numbers of investigators and researchers ('salami-slicing'), especially for senior staff.

Another widely agreed issue is the extra time and effort involved in developing cross-disciplinary understandings. In practice, effective interdisciplinary collaborations often rely on pre-existing relationships, or be seen in the later stages (or second phase) of a 5-year research centre. In addressing this challenge, one suggestion is to focus on developing interdisciplinary relations at an early stage of the research cycle:

'Often planning of collaboration doesn't happen at an early enough stage ... you want to have that in mind and have good relationships between people before the proposals even goes in.'

A senior CESI academic

Early career researchers

Interdisciplinary research presents a dilemma for early career researchers: while they are often productive and enthusiastic interdisciplinarians (because they are less entrenched in disciplinary structures and are more able to devote the time and effort needed), they also face particular risks, given the professional and institutional barriers involved.

‘For early career researchers, there are higher risks ... [once] you’re already established ... you can ... put on hold the need for fundamental progress or original research in your own discipline to some extent.’

A senior manager in a UK Government research funding body

Leadership, facilitation and participation

Leadership in interdisciplinary research needs to invoke confidence in the researchers that cross-disciplinary collaborations will pay off in a valuable way. There is also a key role for non-specialists who can work across disciplinary boundaries. A frequently encountered challenge in WES and ESI research is fostering constructive interdisciplinary relations across the physical and social sciences. One reported issue here is that engineers and physical scientists may see the role of social scientists in rather limited terms – for example, as helping achieve social acceptance – rather than contributing to research designs, methods and practice on a more equal basis.

Non-academic stakeholders can play important and varied roles in WES and ESI research projects – for example, in terms of asking challenging questions, and helping ensure that academic research has wider societal relevance and value:

‘You’re more likely to ask and answer interesting questions if you get challenged from people who see the world in different way.’

A Professor in energy policy

The need for improved cross-centre learning

In responding to the challenges of interdisciplinary WES and ESI research, and developing good practice, there are untapped opportunities for different research initiatives to draw on each other’s experiences. There is also scope to translate research and demonstration findings from particular initiatives such as CESI for learning across the UK’s whole energy system research community:

‘I haven’t ... [seen] any evidence to suggest that there’s been any kind of deliberate kind of learning, cross-consortium learning’

A Professor with expertise in energy system modelling

Overall assessment of CESI’s interdisciplinary achievements

Introduction

Winkel (2018) offered a framework to comparatively assess whole systems interdisciplinary research centres, using four characteristic elements of such research: diversity, flexibility, integratedness and transdisciplinarity. Using these criteria, assessments can be made of different centres on a broadly consistent basis, so that a ‘high’ flexibility rating

indicates that a substantial proportion of the overall centre funds are allocated on an open and competitive basis; a ‘high’ integration rating indicated research processes and outputs that encompassed the majority of the research staff involved; and a ‘high’ transdisciplinarity rating indicates that non-academic stakeholders are significant contributors to the research programme

Research undertaken for this project in 2019, and follow-up discussions with senior CESI staff in 2020, suggests that by mid-2019 (around mid-way through its five-year research programme 2019) can be tentatively assessed as having a relatively medium level of transdisciplinarity and flexibility, and a relatively low level of diversity and integration. By late-2020, reflecting developments in the CESI work programme, these had shifted to a relatively high level of transdisciplinarity and medium level of diversity, flexibility, and integratedness. It should be noted that these assessments are provisional because they apply to an evolving, incomplete research programme.

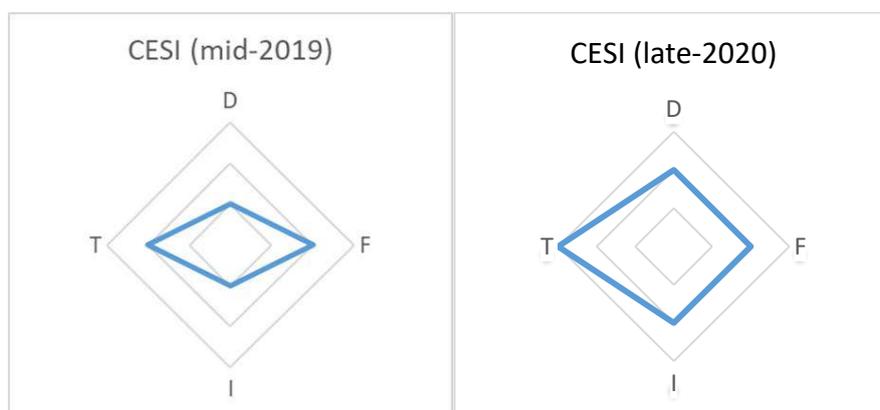


Figure 1: Provisional assessment of CESI's interdisciplinary research status
(T=transdisciplinarity; D=diversity; F=flexibility; I=integratedness)

Transdisciplinarity

CESI places a strong emphasis on involving business and local stakeholders. This reflects the Centre’s strong relationships with the business sector (a distinctive feature of the CESI research proposal), and a developing emphasis on local demonstration and pilot projects in the CESI research programme. However, there were some suggestions that CESI is less well connected to some stakeholders (such as national policymakers) and also that the Centre’s advisory groups could include more diverse stakeholder perspectives. The work of CESI’s advisory bodies could also be disseminated more fully across the consortium.

Diversity

CESI was established with a relatively low level of disciplinary diversity compared to some other WES initiatives in the UK. In early 2019, over three quarters of the CESI consortium had a broadly engineering or physical sciences disciplinary background. This is consistent with an understanding of ESI as a particular form of WES research, oriented to engineering and physical sciences. There has since been a broadening of the disciplinary base, with early rounds of the Flex Fund used to encourage this. At the same time, encouraging greater disciplinary diversity will present additional challenges for research integration.

Integration

As has also been seen in other similar centres, CESI has faced challenges in establishing Centre-wide integrative working. Despite some successful initiatives at project and workshop scales, establishing integrative working within and across workpackages has taken longer than anticipated; varied levels of workpackage efforts at integration, geographic dispersion and thinly spread resources with short term contracts for some research staff have all contributed to these challenges. CESI has taken steps to promote more integrated working across the centre, including directing later round Flex Funds to integrative research driven by existing consortium members.

Flexibility

Funding in CESI core and flex activities are spread thinly, and like other similar centres, limited resourcing means the Centre has faced a trade-off between openness and integration. At the time of our project fieldwork in 2019, CESI had commissioned one round of Flex Fund projects, and the emphasis in Round 1 was on bringing in new research teams and disciplines. Later Flex Fund rounds have placed greater emphasis on existing members of the CESI consortia and strengthening research integration. However, CESI Flex Fund projects are relatively small and short term, raising additional challenges for the coherence and integratedness of the research programme.

References

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Good Practice Recommendations

Recognise ESI research as a distinctive form of WES research

Energy Systems Integration (ESI) research is a distinctive form of WES research, with particular aims, scope and intended contributions. To date, much ESI research internationally has tended to reflect a predominantly techno-economic and engineering-based disciplinary view of whole energy system change, although more recent ESI initiatives such as CESI have taken steps toward greater diversity in terms of disciplinary participation and research strategy.

Recognising this distinctiveness is important in judging the effectiveness of ESI research strategy and outputs, yet research for this project suggests that this distinction is poorly understood among energy researchers, stakeholders and funders. The relationship between ESI and WES research in the UK needs to be more clearly defined and articulated. There is also a need for greater clarity on the contribution of individual initiatives within UKRI's whole energy systems research portfolio.

Decide on interdisciplinary ambition and participation

While there is no single best practice blueprint for effective interdisciplinary research, it is useful for interdisciplinary research centres to be explicit about their interdisciplinary ambition, in terms of developing centre-wide integrated research output and the extent of co-design and/or co-production with non-academic stakeholders. Collaborations across disciplinary boundaries take time to nurture, and different levels of ambition imply different research designs, effort and time commitment from researchers and managers, and different resource needs. Centre-wide research integration requires a significant commitment of resources and leadership effort.

Perceived failings in interdisciplinary initiatives may relate to unrealistic expectations. It is useful to set out, early on, the nature and extent of interdisciplinary ambition, drawing on wide experiences, while also allowing some flexibility given that research programmes develop and change over time.

More explicit consideration should also be given to what is an appropriate disciplinary balance for CESI, in terms of its ability to deliver its research programme. Disciplinary make-up will condition the forms of whole systems interdisciplinary research that CESI can undertake. For example, as a form of whole systems interdisciplinary research oriented towards the engineering and physical science disciplines, it may be seen as less appropriate for ESI consortia to aim for an even balance of broad disciplinary representation than seen in some other WES initiatives in the UK.

Draw on wider experiences and expertise

Devising, implementing and regularly reviewing interdisciplinary progress should be an explicit part of CESI's overall research strategy. CESI's International Scientific Advisory Board (ISAB) currently offers some guidance for interdisciplinarity in CESI, but consideration should be given to strengthening the advice and support from those with similar experiences of co-ordinating large interdisciplinary research programmes in the energy systems research community, and also more widely across the interdisciplinary studies research field.

Recognise the trade-off between flexibility and integration

A strong emphasis on flexibility, openness and diversity in research centre strategy can erode capacity for more ambitious forms of interdisciplinarity which rely on close understanding, familiarity and trust. Research for this project and elsewhere (e.g. McDowall, 2014) suggests that energy system integration research can involve different disciplinary and strategic approaches: either a relatively limited disciplinary spread with an emphasis on research integration, versus a more diverse disciplinary mix, with less tightly coupled interdisciplinary relations. It is important that this trade-off is recognised and anticipated by interdisciplinary research leaders and managers – and also research funders and assessors. For example, CESI has shown an awareness of this issue in the way it has designed different rounds of its Flex Fund, with an emphasis on openness and diversity in early rounds, and consolidation and integration in later rounds.

Allow for the extra time and resources involved

As is now widely acknowledged in interdisciplinary studies research, successful interdisciplinary research requires additional time, effort and resources. This needs to be acknowledged in the design and funding of ESI research initiatives, especially in the early stages. As well as disciplinary experts, there is an important role for interdisciplinary leaders and translators – and dedicated effort on integrative knowledge production across specialisms. While there

may be less capacity to respond to these challenges in the later stages of research programme, it may be possible to direct flexible funding to support integration – as CESI has shown, and it is important that funders allow use of flexible funds to support integration as well as diversity.

Develop a systemic interdisciplinary research strategy

CESI should maintain an interdisciplinary research strategy across *researcher, project, theme, and programme* levels. The overall interdisciplinary research strategy should be regularly reviewed. Suggested elements in this strategy are:

- At the *researcher level*, offer interdisciplinary publishing opportunities by negotiating interdisciplinary special issues of high-impact journals. Researchers also value CESI-run events and networks which create a protected space for interdisciplinary exchange.
- At the *project level*, devise and commission projects which deliberately and explicitly combine together different methods and perspectives, with dedicated review processes for assessing the interdisciplinary credentials of proposals.
- At the *workpackage level*, each WP should be designed have senior involvement from different disciplines. Meetings should be regular within WPs, with occasional initiatives across WPs to share best practices. WP progress in interdisciplinary research should be regularly reviewed.
- At the *programme level*, fostering interdisciplinary capacity through ‘seed-corn’ funding, and running workshops and conferences designed can promote centre-wide interdisciplinary exchange. However, developing centre-wide research integration requires a significant commitment to ‘flagship’ projects aimed at involving the majority of the centre’s researchers, disciplines and methods.

Conventional research metrics, such as journal prestige or citation patterns are less appropriate for assessing interdisciplinary research. Other forms of assessment should also be used, such as impact case studies, interdisciplinary output counts, and evidence of follow-on funding.

Develop best practice across the energy research community

Alongside senior researchers, research funders and assessors have a critical role in shaping interdisciplinary practices and outcomes. Different forms of research commissioning, funding and design have been adopted for different initiatives within the UK’s WES research portfolio, and there is now a considerable body of experience of operating WES and ESI research centres and initiatives. There is an opportunity to review the effectiveness of these different forms, and facilitate regular exchange between different initiatives.

Research carried out for this project suggests that many of the challenges faced by CESI closely resemble those confronted other interdisciplinary centres – reflecting the similar aims of such centres, and the wider structural origins of the challenges they face. Recent steps have been taken to establish links across different initiatives, but these are not yet well embedded in the strategies and practices of the UK’s interdisciplinary energy research community.