UK Energy Research Centre

Whole Systems Networking Fund:

Project highlights

November 2019

Contents

Introduction

This part of the report offers summaries of the highlights achieved by each of the funded projects. These summaries have been developed by the project leaders and edited by UKERC HQ staff.

A total of 18 projects were funded that mainstreamed gender balance across a wide range of energy research topics.[1]

Below are highlights from the projects, which we have divided into four cross-cutting themes:

- gender balance in research;
- heat decarbonisation;
- citizens in the 'driving seat'; and
- UK industrial strategy.

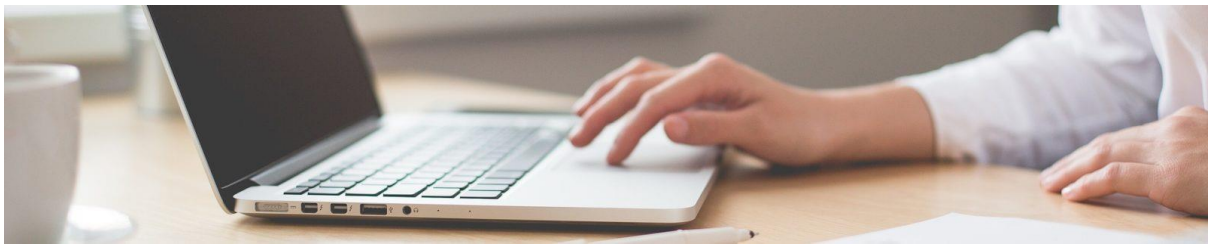
These reports demonstrate the diverse range of topics, stakeholders, and approaches (e.g., energy modelling, workshops, desk-based analysis, survey, conferences, gaming).

[1] The full list of projects is available online: http://www.ukerc.ac.uk/programmes/networking-fund.html. Due to contracting delays, three projects could not be concluded at time of press; we will publish a supplemental document on our website describing these projects when available.

Section 1: Gender balance in research

Gender balance in research

Basia Cieszewska, Dr Jess Britton, and Dr Julie Smith, University of Exeter



Power Shift: How to build Gender Balance in the Energy Research Portfolio

Unfortunately it's old news that women are significantly underrepresented in Science, Technology, Engineering and Maths (STEM) subjects, with the UK having the lowest proportion of female engineers in the EU. Across all academic disciplines women account for 58% of Postgraduate students but only 25% of Professors.

But there is a welcome renewed focus on equality, diversity and inclusion (ED&I) as UK Research and Innovation becomes established; we need to ensure that this opportunity is fully seized upon. The energy sector needs women and the current under-representation of women in energy research funding is a waste of talent and expertise. We spoke to 59 female energy academics from across career stages, disciplines and institutions to better understand the issues they face. We also analysed the available data on gender and energy research funding, though due to limited data availability we focussed our analysis on funds distributed by the Engineering and Physical Sciences Research Council (EPSRC).

The analysis of the available funding data confirms what has been long felt among the energy research community - gender balance is poor in the energy research portfolio. Our findings show the proportion of female Principal Investigators (PIs) and Co-investigators (Co-Is) remains low and grants awarded to female PIs tend to be of smaller value. There is also a significant drop-off between the number of female PhD students and funded female researchers, with energy research losing talent at an early stage. In the last two years there has been some progress in the gender balance of Peer Review Panel Members and the data suggests a small increase in awards granted to female researchers, however progress is slow.

Our interviews with female researchers unearthed a whole range of issues that are holding women back. Some of them relate to funding processes and structures but it quickly became apparent that progress in those areas needs to be accompanied by systemic change within the institutional structures and cultural environment of the universities. Systemic interventions are crucial and a piece-meal approach will not work.

Five ways to improve gender balance in research:

1. **Look at the data**

Understand the data and be transparent - there are significant difficulties in accessing meaningful data on gender balance in energy research. UKRI should publish data across thematic areas such as energy, set targets, monitor progress and provide annual updates.

Use quantitative and qualitative data to identify key intervention points. For example both data sets analysed in our study indicated that the trend towards large grants and big consortia bids disproportionately impacts female academics.

Speak to female energy academics - we need to know more about how researchers experience biases, barriers and wider academic life. The links between research culture and EDI issues also need to be acknowledged.

Continue to improve review panel gender balance while drawing on a wider pool of more junior academics. Involvement in peer review can play an important role in learning how to write successful applications.

2. **Fund more women**

Funding structures can be a barrier - get the basic right by ensuring timescales are realistic, events are accessible and EDI statements are effectively monitored.

Part-time working and career breaks are perceived to slow progress - the assessment of part-time working and maternity leave needs to be standardised across funder eligibility criteria and in the review process. The impact of over-relying on quantitative measures of academic esteem needs to be scrutinised.

A lack of diversity of funding types impacts on women - trial innovative approaches to allocating funding and support early career researchers.

3. **Stimulate career progression for female energy academics**

Acknowledge and take action on the individualistic, long hours culture of academia - the ability to work long hours should not be synonymous with productivity and commitment. Institutional structures and cultures need an overhaul - address the funding hierarchy and review criteria for research productivity: don’t assume everyone has an equal start point.

Publicise more widely what UKRI is already doing to fund female energy academics and raise their profile.

Build suitable training, mentoring and support networks to help more women progress and ensure the visibility of female researchers.

4. **Build on what is working**

Identify key points of engagement to build gender balance: combine specific targeted actions, such as legislation, UKRI and university frameworks and targeted funding initiatives with long-term action on structural issues that promote cultural change in our institutions.

Use a top-down and bottom-up approach – systemic solutions are the only ones that can work.

5. **Ensure equality of voice - women's voices must be heard**

The recommendations in our report serve as a starting point but there is a need for more research on gender balance, both nationally and internationally. Further research should also take account of the many intersecting characteristics that determine whether diverse voices in energy research are heard.

As a follow up to the data and insights offered by this project, UKERC organised a roundtable with POWERful Women (PfW), a professional network that aims to advance gender equality within the energy sector. The initiative provided a ground for further engagement with senior levels at BEIS regarding gender in the energy portfolio.

She is Sustainable: Energy Pioneers

Dr Caterina Brandmayr, Green Alliance

UKERC partnered with the She is Sustainable initiative to empower a group of early career women in the energy sector through a combination of network building, improving their awareness of opportunities and increasing their exposure and policy influence.

In late June 2017, we brought together a group of 30 early career women working in the energy sector for a kick-off event, with representatives from academia, NGOs, industry, policy, media and innovation organisations. The workshop established a forum for collaboration: it gave participants the opportunity to engage with other female energy professionals, discuss some of the emerging challenges in whole systems energy and learn about ways to engage in energy policy. Sessions were designed to be very interactive, putting participants centre stage, and the final session gave participants the chance to brainstorm on topics of common interest and expertise around which they could develop ideas for future collaboration and suggestions for policy events to be developed with Green Alliance's support.

Based on feedback from the participants, we organised four webinars on how to engage with decision makers. Led by Dr Rebecca Willis (Green Alliance), and Hazel Williams (Regen), the webinars discussed how to engage decision makers in parliament, national and local government. Sessions were hosted online, to enable participants to join remotely, and were recorded and shared with participants on an online platform, so they also could be viewed at a later stage.
Outreach events were proposed and developed by groups of participants, building on the ideas discussed during the final session of the kick off workshop, and were aimed at the wider energy community.

- ***How should we share the benefits of the energy transition*?,** co-hosted with UKERC in December 2018; developed by four participants, this event discussed what may be alternative and fairer models for energy policy in an increasingly decentralised energy system.

- ***Onshore wind: licence to operate?*,** co-hosted with PRASEG in January 2019; developed by two participants, this event aimed to move the debate forward from a simple 'for or against' exchange, towards a more sophisticated understanding of how developers and communities could collaborate on environmentally and socially appropriate renewable energy projects for their area.

- ***Energy innovation: How can local authorities maximise local value?,*** in March 2019; developed by three participants, this event provided a forum to discuss how local authorities can – together with energy innovators and others – maximise the social, environmental and economic value that comes from transitioning towards a low carbon energy system, and explore how low carbon solutions and their co-benefits can best be communicated to engage decision makers.

Participants had the opportunity, supported by Green Alliance and Dr Willis, to learn about developing content, tailoring messages to different audiences, and, in the case of the second and third events, showcase their expertise as part of the expert panel. Events were also designed to have majority female panels and to provide a combination of academic and policy insight.

To further raise their visibility, participants were also invited to showcase their reflections on the subject of the events in blogs that were posted on the Green Alliance blog (around 75,000 views per year).

The project was also featured in Energy UK's *Diversity & inclusion in energy* report, which was launched at a roundtable meeting with Alok Sharma MP, then (July 2018) Minister of State for Employment.

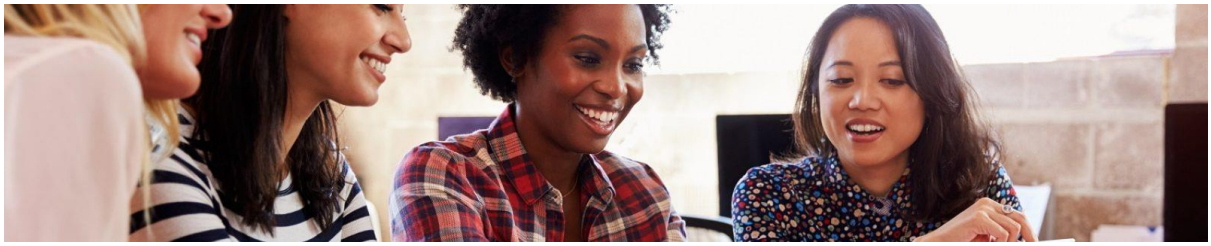
'Before taking part in the Energy Pioneers initiative I would not have imagined myself as willing and able to co-organise and take part in a House of Commons event seeking to influence government policy on onshore wind.

It was the Energy Pioneers workshop and follow up support that gave me the assurance and ambition to take part in this, and the after effect has been greater self-confidence in the impact I can have.'

– Sarah James, Rutherford Appleton Laboratory, Energy Research Unit; volunteer and trustee of Westmill Sustainable Energy Trust

Increasing Visibility of Underrepresented Groups in Energy Research (IVUGER)

Dr Zoe Harris, Dr Gbemi Oluleye, and Ana Laranjeira, Imperial College



The IVUGER network (Increasing Visibility of Underrepresented Groups in Energy Research) aims to increase participation and visibility of underrepresented groups within the energy research sector, targeting female researchers, and aiming to have a strong Black, Asian and Minority Ethnic (BAME) presence.

We hosted a free residential funding retreat for 30 female early career researchers (ECRs). This provided a unique opportunity for the successful applicants to apply for up to £12,000 to support collaborative research projects on energy systems decarbonisation. Other key objectives included:

- accessing training and networking opportunities
- raising their profile in the UK energy space and accelerate their careers
- building new collaborations
- improving their record in attracting research funding.

Project organisers received an extraordinary number of (brilliant) applications from all over the country, making the task of selecting the final list of participants a gruelling one. After much deliberations a group of 30 innovative female researchers from a variety of institutions, specialisms and backgrounds were selected.

The participants were grouped into six interdisciplinary groups, allowing for more holistic and impactful research. Over the two day retreat individuals were able to work on their specific projects, but also to access tailored training from Imperial College's Dr Liz Elvidge and Dr Karen Hinxman, this focused on accessing funding, writing for a lay

audience, working collaboratively, increasing research impact, and on how to improve their CV.

“The interactive exercises, the overall peer-to-peer support, and covering different aspects of the funding application process were some of the most useful aspects of the retreat. All good advice.” (IVUGER participant)

“Working in interdisciplinary team of researchers; having to find ways to collaborate together, and getting tips on how to work together” (IVUGER participant)

On the final day, each of the groups presented their research proposal to an expert panel from BEIS, Centre for Research into Energy Demand Solutions (CREDS), UKERC and Imperial College. The three winning proposals were collectively awarded £12,000 to fund their projects on:

- Heat as a service
- Predicting the uptake of air conditioning in UK households to 2050
- Social and political implications of delivering a low carbon heat future in the UK

So what next? The Funding Retreat was the beginning of a series of collaborations amongst this cohort. IVUGER is currently working alongside the awarded groups to take their research further, and all participants were keen to stay in touch and work collaboratively towards developing new research beyond IVUGER - using some of the lessons learned at the retreat.

Because IVUGER is all about visibility, we will also be showcasing the great work achieved by all of the participants at a third event later this year. This Showcase aims to demonstrate that when the right opportunities are in place for everyone to access, our energy sector as a whole can go so much further.

The jury is still out on whether the funding agencies are taking note. But with the right opportunities in place, we will for once and for all be able to say that we are effectively using the UK’s full capacity – in the best way possible.

IVUGER’s vision is to increase the participation and visibility of underrepresented groups within the UK energy sector - namely female researchers, from diverse ethnic backgrounds. Our aim is to build a network of unique and innovative women working in this field, and to provide the space and resources for them to establish long-term, meaningful collaborations.

Teach Energy

Dr Grant Wilson, University of Birmingham

The TeachEnergy project aims to establish a diverse network of people involved in teaching energy, initially at the Higher Education Institute level of the UK – but in time seeking a broader involvement. A survey of HEI energy researchers at the end of last year indicated a desire for a workshop to help with this, which took place at the University of Birmingham at the end of May.

This workshop provided an opportunity for over 20 academics from Manchester, Edinburgh, Leeds, Aberdeen, Oxford, Keele, Newcastle, Harper Adams, Birmingham and others to present, discuss and share ideas around teaching energy. There was a diverse mix across disciplines, across career experience, from those focussed on undergraduate and postgraduate courses, and those in the process of setting up new courses.

There was a feeling that the UK was a fantastic place to study an energy course, due to the quality, depth and breadth of energy research taking place, and the rate of decarbonisation. The increase of ambition to net-zero by 2050 means the UK will continue to be an internationally attractive place to study the energy transition.

The keynote speaker was Dr Bob Everett from the Open University, who provided a fascinating longer-term view of teaching energy (since the 1980s) and how challenges with this (and the technology) have changed. His passion for this included the need to provide high quality illustrations where possible – as this really helps with a greater understanding of the concepts underpinning energy supply and demand (and everything in between).

A session of 10-minute ‘lightning’ presentations provided a great way to share ideas for formative and summative teaching methods, and a basis for discussion. An online method to do this was also felt to be helpful in future, to encourage remote participation, and facilitate recording of presentations too.

The afternoon was a series of round-robin discussions to identify some of the areas the network could try to develop, and some insights from this include:

The network was a good idea – and should be encouraged and supported where possible but teaching and research workloads are such that members should be able to dip in and out of the network and contribute when they can, without a significant time commitment. Legal sharing of content should not be an area for the network to aim to provide rules around, other than to suggest that this is best clarified at each member's institution. Where content is able to be shared, its copyright should be labelled, preferably using a creative commons licence. A continued search for a platform to help facilitate discussion and sharing should be undertaken.

Diversity Awareness using Videos: As a follow on to the workshop, a summer student project helped to create an interview 'process' to allow short videos to be created and edited, so that these could be shown at the beginning of lectures. These would help to display the level of diversity that currently exists in the wider energy sector (rather than just energy teaching) and to encourage students to think why they might consider a career in the energy sector.

The aim is to continually increase the amount of interviews that are available through the YouTube channel (http://bit.ly/teachenergy)

Section 2: Heat decarbonisation

Heat Network: the Heat decarbonisation network

Dr Alice Bell, Neil Jones (10:10); Dr Richard Lowes (University of Exeter); Dr William Burns, David Stoker (UKERC); Dr Faye Wade (University of Edinburgh)

Building an inclusive and enduring network of people and organisations to decarbonise heat

The Heat Network, led by charity 10:10 Climate Action working in collaboration with University of Exeter and UKERC researchers, looked to support the UK's heat decarbonisation efforts through the development of a successful, inclusive and enduring network of people and organisations helping to decarbonise heat.

To this end, we piloted interventions that aimed to mobilise three groups: (1) the public; (2) people interested in research (put another way, we were seeking to use research as a topic around which to 'rally' people); and (3) installers.

The public

Our worry is that the public is actively disengaged from the bulk of the systems which provide them with heating and cooling, let alone a sense of the need to decarbonise heat. While investment in climate science communications is very important, more will be needed to alert the public to the particular concerns around the energy system.

A book and a game

We developed two resources that are often used to engage the public – an accessible and attractive book, and a game. Part of our audience for the book was journalists, according to our view that encouraging journalists to write about heat would have positive impacts on public awareness.

Book: We commissioned science journalist Sophie Yeo to write the book – *Stories of Heat from our warming world* – which also included beautiful illustrations by artists from around the world.

We've gathered stories of some low carbon ways forward and brought them to life with magical storytelling and stunning illustrations.

- Meet the US scientists inspired by astronauts to create clothing that adapts to the body's temperature.
- Dig into the story of the former coal village in south Wales now using the mines for clean heating.
- Take a dip in a swimming pool to explore the pitfalls of designing policy to encourage low carbon heating.

The book shows how much is already being done in battling climate change - and the inspirational potential for more. Faced with the huge challenge ahead, using art and storytelling to celebrate the options available to us is essential to keep us motivated.

But the book also explores the many challenges before us, and the decisions we must make, not only to make the low carbon world a reality, but to make sure it works for everyone.

Table-top game: As part of our work, we also created a card game, 'Carbon City Zero'. Players compete to become the UK's first carbon zero city, and in order to do so they must consider the short and long-term benefits and the cost (both financial and environmental) for developing certain aspects of their city.

Developed by 10:10 and professors at Manchester Metropolitan University, Dr Sam Illingworth, Lecturer in Science Communication and Paul Wake, Reader in the Department of English, specialising in games, a game based on the real life challenges involved in heat decarbonisation is on the horizon.

The game has been trialled with a number of people, including those who work in the heat and energy sector. The aim was to create something that would enable people to engage in dialogue around the subject in a fun, but also meaningful way.

"To begin with the topic seemed quite daunting, but after listening to several different audiences and stakeholders it was clear that there was definitely an enjoyable gaming experience to be found."

The game was launched on Friday 20th September on Kickstarter, following an event hosted by 10:10. This gave anyone with a special interest in the game, including those working on heat and energy as well people from the games industry to network and trial the game before its official release.

Within the first hour of Carbon City Zero going live on Kickstarter, the original pledge goal of £500 was smashed. With over £6000 currently pledged by a total of 272

backers, there's still time to order a copy before the crowd funder ends on 20th October. In place of stretch goals, profits from this Kickstarter will be used to buy additional sets of Carbon City Zero, which will be donated to schools and local climate action groups, including UK Youth Climate Coalition, UK Student Climate Network, Climate Outreach and Amos Trust.

Installers

A well-trained workforce of installers such as heating engineers will be critically important to build a decarbonised heat system. The sector comprises a large group of installers employed directly or as contractors by British Gas and other major firms. Alongside this group, there appear to be a large number of small businesses and sole traders.

One key problem in terms of beginning to mobilise this group lies with engaging a large number of small businesses and sole traders. Our attempts to organise a meeting with installers drew a blank, for example.

A second issue lies with seeking to diversify the installer workforce, in terms of gender and ethnicity, thereby drawing upon all available talents. This is a goal of enormous value in itself, of course, but also as a means to combat labour shortage & skills gaps (which could become substantial issues in some of the proposed post-Brexit immigration regimes).

There is limited academic research on the topic of installers, e.g., a conference paper by Banks (2001)[2]; and a PhD thesis by Wade (2016)[3]. Therefore, to tackle the issue of how to engage installers successfully, we convened a discussion with the two known UK academic experts on installers: Dr Faye Wade (University of Edinburgh) and Clare Hanmer (UCL).

The following practical recommendations emerged from that discussion:

- It is vital to be clear exactly what you are expecting from the installers you intend to engage
- Many installers are self-employed/sole-traders and time is money – this may mean paying them for their time.
- Engage through organisations such as Gas Safe Register (

[2] Nick Banks (2001), 'Socio-technical networks and the sad case of the condensing boiler'. In: Bertoldi P., Ricci A., de Almeida A. (eds) *Energy Efficiency in Household Appliances and Lighting.* Springer, Berlin, Heidelberg

[3] http://discovery.ucl.ac.uk/1476959/1/WadeF_Thesis_2016.02.11.pdf

- Identify and work with builders' merchants, who installers visit most day
- An online forum

The project intended to create a briefing that would make evidence-based suggestions on how to engage groups such as installers (comprised numerous small businesses that are dispersed, not on the internet, and/or time-poor). Successful engagement, and building of trust at a grass-roots level, might allow us to ask such questions around what type of interventions would mobilise this group. What types of additional training could be proposed, what challenges and complexities await us, and so on?

Regrettably, the BEIS staff member interested in our work transferred to another team, and so the key policy audience was lost. This made us reticent to write the planned briefing until a new audience had been identified. Nevertheless, ground-work has been laid for developing a practitioner guide to engaging small businesses in the energy sector.

Research as a point of focus

UK heat decarbonisation is primarily a deployment issue. Much of the technology to decarbonise heat exists; the questions for research will be around how we stitch it all together to deliver a decarbonised heat system.

There are open questions, therefore, about what government-funded research should do, or what problems it is seeking to remedy, in the heat sphere. This is perhaps both cause and consequence for the lack of an established and networked body of 'heat' researchers, such as a heat SUPERGEN.

Starting from scratch, we therefore sought to identify individuals and groups potentially interested in research on heat, in an open and transparent way. Following a stakeholder mapping activity that included universities, government departments, industry, environmental and fuel poverty NGOs – all of whom we felt might be concerned with research as an element of heat decarbonisation – we issued an online survey asking where they saw research priorities.

We received 94 responses; the following topics emerged as particularly important:

- Retrofit: costs, insulation requirements, heat pumps in domestic settings, supply chain
- Technology choice
- Improvement to heat pumps

- Engineering innovation required to prepare the grid for electrification of heat (alongside high penetration of renewables)
- Research on hydrogen (for groups who encourage continued use of the existing gas grid)
- Power system flexibility and how heat could support or affect that
- Smart (heat) system optimisation and what data and time of use tariffs can do
- Economic and social scientific research regarding:
    - Consumer protection & vulnerable groups
    - Heat services. The concept of heat as a service idea might be particularly important in terms of engaging the public with heat decarbonisation.
    - Understanding public needs, perceptions, value and attitudes
    - Impact of decarbonisation programmes on bills

There will undoubtedly be a need to 'fuse' cultural and social expertise with engineering to answer the above topics. At-scale demonstration and large scale trials may also be required.

Alongside interventions to support heat research, we will need to build a connected community of individuals and organisations motivated to undertake research supporting heat decarbonisation. The area is not currently well networked and therefore it is hard to get collaborative initiatives going and sustain them. Building this community will probably be initiated by funding a series of dedicated heat research projects.

We fed this information to UKRI and are exploring ways to engage further to impact on thinking within the funding agency. So far, the summary of ideas were fed into the development of a new heat research programme, and there may be further opportunities to influence the scope of future cross-Council programmes on heat if funding is secured for that by the Research Councils.

Micro research projects: heat as a service, UK air conditioning demand, industrial heat (these projects sprung out of IVUGER, see above)

Dr Inna Vorushylo (Ulster University); Dr Shivani Taneja (University of Surrey); Dr Oluwatobiloba Stephanie Ogunrin (Ulster University); Dr Xinfang Wang (University of Birmingham); Dr Jenny Crawley (University College London)

We undertook three pilot projects on topics related to decarbonisation of heat that looked interesting in terms of informing ourselves of evidence needs and research gaps.

Heat as a service: understanding evidence needs and research gaps

Heat as a service (HaaS) refers to concept of a company owning the heating system and covering maintenance costs within the price is a popular model in many European countries and highlight Best Green in Denmark as an example.

In terms of UK policy documents there are limited references to heat as a service models, however the recent call for evidence on 'A future framework for heat in Buildings', and the Government's subsequent response (BEIS, 2018a, 2018b, p. 26), highlighted the potential for HaaS and stated that 'the government is keen to build further evidence in this [heat as a service] area'.

Our project sought to explore Heat as a Service (HaaS), understanding evidence needs and research gaps, based on a literature review and a stakeholder workshop.

The literature specifically on HaaS appears extremely small and few examples of HaaS in practice were evident. This was also identified by Skovshoved and Sandqvist (2017) who highlight the rarity of HaaS business models across Europe. The vast majority of documents included in this review were in fact linked to two research projects, one in Denmark and one in the UK, and a study by Citizens Advice.

- ERA-Net Smart Grids Plus project "Markets, Actors and Technologies: A comparative study of smart grid Solutions" (MATCH)

- Smart Systems & Heat programme (SSH) run by the Energy Systems Catapult (ESC). Phase 1 of the SSH programme included a trial of a consumer orientated Home. 30 homes in 2016-17; 108 homes to test Heat as a Service during the winter of 2017/18.

- Citizens Advice commissioned a series of reports on how such changes may impact on different types of consumers, which were published in 2019. Their research on heat as a service revealed people had mixed views of this supply model. Consumers felt that homes need a high level of energy efficiency before this model can be viable. The fear of losing control was a recurring theme and long-term contracts were not popular. Participants were also concerned that consumers who are less digitally-savvy could be excluded from HaaS models and were unclear on how problems would be solved or routes to redress (Impact, 2019).

Following the literature review, we organised a workshop on 16th September in London, to facilitate face-to-face networking and knowledge-sharing between stakeholders, and help them network with other research organisations. We gathered 40 participants from academic, industry, civil society, and government sectors to discuss Heat as a Service and its potential as an energy delivery model.

Workshop - viability of HaaS models & the data

The workshop was divided into three sessions. In the first session we had speakers from Energy System Catapult, Bristol Energy, Citizens Advice, UKERC Heat Network, and EPSRC, discussing the smart system heat programme, the trial experience, consumer issues, and providing an overview of UKRI's heat decarbonisation priorities.

Questions raised in this session were mainly in relation to the viability of HaaS models for different customer segments, data collection and data interoperability issues and the role of policy in making HaaS models commercial. Speakers responded by saying these are key challenge and the ESC and Bristol Energy are considering this in their ongoing work.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Ambitions and opportunities for HaaS

The second session was a facilitated discussion session. Participants were divided into groups, focusing on what work is already happening in relation to HaaS, and what are the ambitions and opportunities for HaaS? What are the barriers and knowledge gap? And how might we overcome the barriers and knowledge gap identified in the earlier discussions?

In relation to the HaaS models for different customer segments, it was highlighted that granular segmentation of customer types is very important, as is a close relationship with each customer to ensure information provision and choice is clear. There seems to

be an underlying trust issue between customers and energy providers and HaaS can help overcome that.

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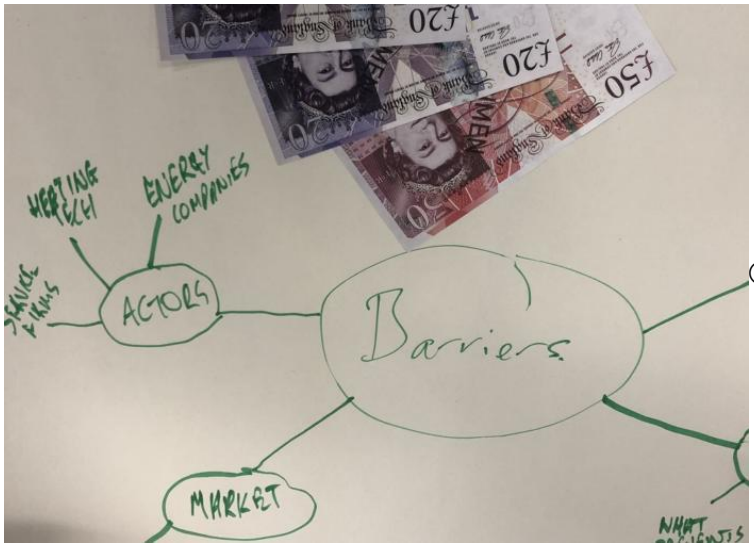
Pitching ideas for HaaS

The third session was a Dragon's Den activity, in which participants worked in groups to develop their ideas about a new HaaS research project. They were asked to develop a 1-minute 'elevator pitch' describing their proposed project, and then voted on their favourite project developed by other groups using bundles of imitation money.

In relation to the role of policy in making HaaS models commercial, the answer was: modelling risks across consumer propositions is challenging and varies widely depending on the segmentation of customer groups. There are challenges relating to tenure, length of contract, asset ownership, data/money flows and policy needs to recognise the need for both consumer and asset protection measures.



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Conclusions

We identified a number of challenges and opportunities for HaaS.

- More trials are needed to address consumer concerns and lack of understanding of HaaS
- HaaS requires supportive policies, especially for market regulation
- Open, interoperable and secure data are key to deploying HaaS
- Best practice energy services from other countries can inform HaaS development in the UK
- To facilitate HaaS, opportunities for consumers, experts, and industry to work together should be explored

Organisers:

- Dr Zoya Pourmirza, Newcastle University
- Dr Jess Britton, University of Exeter
- Dr Angela Minas, The University of Manchester
- Dr Catarina Marques, London South Bank University
- Dr Sarah Royston, Anglia Ruskin University

Pilot project: Domestic air conditioning in the UK: when, and how much?

The authors are Dr Inna Vorushylo (Ulster University), Dr Shivani Taneja (University of Surrey), Dr Oluwatobiloba Stephanie Ogunrin (Ulster University), Dr Xinfang Wang (University of Birmingham) and Dr Jenny Crawley (University College London).

Around 2% of English households are currently believed to have air conditioning installed [1]. How much, and when, might this proportion increase?

This project aims to provide an estimation of air conditioning uptake in order to flag up the existence of a future problem for the electricity grid.

Air conditioning uptake is a socio-technical question. The technical (or physical) dimensions are warming summers, increasing frequency of heatwaves and how these external temperatures translate to internal temperatures inside homes, given construction standards. However, temperature is not the only driver of uptake of a thermal comfort technology such as air conditioning – for example when central heating became popular in the UK from the middle of last century, the marketing strategy aimed to persuade the lower middle classes that it was a normal domestic amenity [2]. Therefore there also exists a crucial social dimension.

An important follow on issue concerns how much domestic air conditioning would add to demand on the electricity grid (and, if the use of gas-fired power stations continues, CO_2 emissions). This question is also socio-technical – depending on the temporal nature of air conditioning demand, which in turn depends on both the ability of the building to keep out heat and the priorities and schedules of the occupants.

We are constructing an air conditioning scenario model which will take some of these social and technical factors into consideration. Alongside, we are conducting engineering simulations of buildings to predict the electricity use at different times of day, before combining the estimated uptake with the electricity demand in an electricity market model. This will allow exploration of the grid impacts and CO_2 emissions under different supply scenarios.

A larger follow up study to this would seem like a good place to start to understand how the early adopters of air conditioning use their systems and what factors caused them to get air conditioning installed. We anticipate that an important outcome of our project will be suggestions similar to the above, regarding what further work is required to better understand cooling demand and its possible interaction with heating systems.

[1] Data from the Energy Follow Up Survey to the 2011 English Housing Survey

[2] Hanmer, C., & Abram, S. (2017). Actors, networks, and translation hubs: Gas central heating as a rapid socio-technical transition in the United Kingdom. Energy Research & Social Science, 34, 176-183. doi:https://doi.org/10.1016/j.erss.2017.03.017

Electric heat: similarities and differences between domestic and industrial

Our project will go beyond the technical, and summarise the politico-socio-economic barriers to decarbonizing and electrifying heat in the UK, identifying differences and similarities in barriers between the domestic and industrial sectors, providing a comprehensive understanding of the challenges around UK heat decarbonisation.

Zero-IN on NI Heat

Dr Caterina Brandoni and Dr Inna Vorushylo, Ulster University

This work sought to inform Northern Ireland's energy transition by building a network of people who have knowledge and experience on heat issues, and gathering a gender-balanced data set on the attitudes of Northern Ireland consumers.

Our work on heat decarbonisation in Northern Ireland was undertaken in a multidisciplinary spirit and was female-led. We investigated opportunities and barriers on the road towards zero emission targets in heat sector, with focus on the 'indigenous' features of Northern Ireland (NI). These indigenous features are political stalemate (all supporting mechanisms for energy decarbonisation and support of new renewable projects have ceased), predominance of oil heating (68 % of the domestic stock), high rate of fuel poverty (22 % In 2016), its abundant renewable resources.

Future visions for heat decarbonisation in Northern Ireland

Ulster University (UU) has been the lead partner on this project with a Steering Committee gathering women representatives from key organisations of NI heat sector, including Department for the Economy, Utility Regulators, renewable industry group (NIRIG), transmission and distribution system operators (NI Electricity Networks and SONI), charity (NEA Northern Ireland), Consumer Council, public affairs consultancy (Stratagem).

Four stakeholder engagement workshops and a final seminar were organised for this project. Workshops aimed at identification of barriers and opportunities with the involvement of the wide range of stakeholders and focused on the following topics: (i) domestic; (ii) non-domestic; (iii) infrastructure; and (iv) energy policy and regulation for heat decarbonisation in Northern Ireland.

The main opportunities and barriers identified during first two workshops within technological, economic and social strands were recorded. They were used for perception analysis using Q methodology (ranking by sorting cards printed with various options) to define stakeholders' visions towards future heat decarbonisation in Northern Ireland.

Six visions for the future heat decarbonisation strategy were identified with the different levels of support for various measures, such as: greater cooperation; the role of government and institutional investors; alternative and novel business models; role of consumers; or implementation of top-down strategy; protection of vulnerable consumers; and more strict measures for heat decarbonisation, among others.

All stakeholders agreed that 'indigenous' renewable technologies are the biggest opportunity for Northern Ireland heat sector; non-financial factors and motivation should play a major role in future decarbonisation strategy; and the lack of a long-term policy is the main barrier to heat decarbonisation in NI.

Furthermore, discussion groups were set up for consumers. Consumers with basic knowledge of sustainable heating systems expressed their opinions on adopting domestic low-carbon heating in Northern Ireland and the impact of their households on the environment. Five groups of visions for final consumers were identified. All consumers agreed that a central independent resource is required to provide education, support and advice about energy efficiency and low carbon heating for NI houses.

A gender-balanced perspective of Northern Ireland consumers

Our work was supplemented with workshops and a survey that explored decision on energy choices by householders in a gender-balanced way. The project conducted (i) a series of stakeholder workshops, (ii) focus groups with women to explore their role in investment decisions, knowledge of energy bills, and long term perspectives in their household, and (iii) a survey with 1,355 respondents (which included the mainland UK as well as NI) to elicit people's willingness to invest in low carbon technologies.

The survey indicated that

- In Northern Ireland

    - men are generally more interested than women in considering to purchase an electric or hybrid car
    - men seem to be more interested than women in insulating the roof of their house.
    - we found no statistical difference for gender in the intention to buy other low carbon technologies, such as double or triple glazing, floor or wall insulation, investing in heat pumps or smart meters.

- In Great Britain
    - women are more interested than men in purchasing solar panels for heating water,

The stakeholders' and focus groups (held in NI only) produced perhaps more detailed qualitative material on the gendering of roles. In focus groups, home-owners who were women explained that when it comes to invest in low carbon technologies in the house, the decision was generally jointly made with their partner, but that it is their partner that most often suggests the investments to make. Whilst women are mostly in charge of using many appliances in the house, several participants had no idea of the amount their household pays in electricity bills, as it is something that they believed their partners looked after.

Conclusion

Overall, we found that in general there is a low percentage of people (generally less than 20%) willing to invest in low carbon measures in the house (no significant difference across gender). It appears, at least based on our data, that neither males nor females are concerned about the long term consequences of not investing in low carbon technologies in their dwellings.

We believe more positively it also showed the potential role of women householders in taking a more active role in demand-side management of energy, as the dominant users of the appliances. This suggests that by examining how women use, understand, and manage energy, we can help them not only increase their awareness, agency and wellbeing, but also find ways to reduce energy demand and fuel poverty. Very few (/many) studies address this issue at the intersection of gender, demand-side.

Few studies[4] address the issue of gender in the use of energy, especially in industrialized countries, where energy is mainly seen as gender-neutral. Men and women should have equal opportunities to access energy or to make choices about

[4] Clancy, J. and Roehr, U., 2003. Gender and energy: is there a Northern perspective?. Energy for Sustainable Development, 7(3), pp.44-49.

energy. However, women, on average, have lower incomes and are disproportionally found as heads of households either as single parents or alone at a pensionable age[5]. Furthermore, women have been found to suffer more than men from energy poverty. [6]

Considering the challenging climate targets, the energy transition will affect everyone. Researchers[7] have recently started to take into account gender as an aspect to improve carbon mitigation measures and in particular when studying 'smart' household technologies and low-or zero emission vehicles[8]. Women Buying Green project has contributed to investigate the role of women in the low carbon energy transition.

Overall, we believe our projects had a significant impact on thinking in Northern Ireland on heat decarbonisation, drawing in new stakeholders from every walk of life. We hope to build on them – and also present it as a model for engaged university research on decarbonisation in other localities. There is an opportunity for Stormont to create an innovative, gender-balanced, and evidence-based new heat strategy with a comprehensive public communications framework built-in; that ambition is obviously currently blocked.

Feedback received from key stakeholders:

'I have been involved with this heat project from the outset from both a policy and regulatory perspective….The project has delivered many benefits including, for the first time, building a network of people who have knowledge and experience on NI heat issues and in facilitating discussions hearing different viewpoints and perspectives along with finding out what other organisations are doing in relation to heat decarbonisation. The networking and knowledge sharing aspects have been invaluable in progressing this important piece of work to inform NI's energy transition.'

– Orla Gray, The Utility Regulator

'We were particularly impressed by the level of the speakers from industry, the opportunity to engage with them during the discussions, and also for their willingness to take part in our own stakeholder engagement sessions in the North West.'

– Cirran McGrath, Regional Energy Co-ordinator, Derry City & Strabane District Council

[5] EU Commission, 20017. Gender perspective on access to energy in EU. Available at: http://www.europarl.europa.eu/thinktank/en/document.html?reference=IPOL_STU(2017)596816 (November 2017)
[6] EU Commission, 20017. Gender perspective on access to energy in EU. Available at: http://www.europarl.europa.eu/thinktank/en/document.html?reference=IPOL_STU(2017)596816 (November 2017)
[7] Anfinsen, M. and Heidenreich, S., 2017. Energy & gender-a social sciences and humanities cross-cutting theme report.
[8] Miralles-Guasch, C., Melo, M.M. and Marquet, O., 2016. A gender analysis of everyday mobility in urban and rural territories: from challenges to sustainability. Gender, Place & Culture, 23(3), pp.398-417.

Section 3: Citizens in the driving seat

Community energy resilience in the electricity sector

Dr Long Seng To (Loughborough University) and Simon Trace (Oxford Policy Management)

Our goal has been to develop a global, whole systems, picture of what community energy resilience looks like in the face of different kinds of disasters. The project grew from the observation that communities played a key role in accessing energy after the major earthquake in Nepal in 2015.

Our current project, while small in scale, aimed to build the diverse global links needed to take this work forward by bringing together perspectives on disaster risk reduction and energy systems. It focused on the technical innovations needed for more resilient electricity systems, linking resilient electricity systems with broader community resilience, and exploring the governance and planning processes required.

To this end we held a series of workshops with policy makers, practitioners and academics in UK, Nepal and Malawi. Participants shared their experiences working in Nepal, Bangladesh, India, Myanmar, Sri Lanka, Malawi, Kenya, Zimbabwe, Zambia, South Africa, Mozambique, USA and the UK.

The following topics emerged from the discussions as priority areas for further investigation:

- Short term disaster response & recovery and disaster prevention & preparation. Discussions focused on the opportunities for on-grid, mini-grid, and stand-alone systems and how they might interact.
- Role of community groups, the private sector, and government.
- Role of quality control guidelines in enhancing reliability (and therefore resilience)
- Integration of mini-grids into national grids (and how that might offer opportunities or challenges for energy resilience).

- Cost and benefits of renewable energy systems that include back-up (which might cost more, but might be more resilient).
- Actions required across operational, regional, and national planning to improve resilience.
- Role of energy efficiency in resilience.
- Role community organisations play in rebuilding infrastructure: including energy in reconstruction plans more effectively.
- Exposure to risks, including energy security.

We believe the project has built many of the personal and institutional connections needed to take this work to the next stage. It has also outlined a potential framework of topics for further investigation, comment, and analysis.

Subject to further funding, we can begin to develop a programme of research that could support resilience and recovery of energy systems in the face of disasters, as well as explore how more robust energy systems contribute towards community resilience more broadly. This work is vital for achieving the Sustainable Development Goals and addresses issues that are only likely to become more pressing for the international community.

This project is a collaboration between the Low Carbon Energy for Development Network and the applied research programme on Energy and Economic Growth. The authors would like to thank all workshop participants. With special thanks to collaborators at Mzuzu University & the Civil Society Network in Climate Change for co-hosting the workshop in Malawi.

The Solar Commission. A bright future: opportunities for UK innovation in solar energy

Kerry Hayes, Regen

Far from being a mature technology, solar PV is on the verge of a series of technological and business innovations that represent significant opportunities for UK.

Until now, these have been obscured by focus on China's domination of the manufacture of current generation crystalline solar PV panels.

The Solar Commission is a unique partnership of leading academics, system operators and industry, supported by UKERC and managed by Regen. The aim of the Commission is to examine areas where the UK could use its scientific and technical capabilities to play a leading role in the innovation and industrial strategy opportunities being created by the rapid, global emergence of solar PV as a major form of power generation.

Whilst the UK role in offshore wind is well known, the importance of the UK's role in the development of solar PV is less well understood.

UK researchers and businesses are at the forefront of developing innovative solar PV technologies, materials and applications including:

- New solar cell technologies that reduce costs per unit of energy generation and enable new applications.
- Development of storage systems that enable solar power to be stored off-peak and released at times of peak demand or system stress.
- Digital technologies that use algorithms and big data to maximise the value of solar PV to energy users and enable a smart more, flexible energy system.
- Building integrated technologies that enable solar to become ubiquitous in the built environment as part of the development of 'buildings as power stations'.
- New financing models that enable deployment of capital at the scale needed to finance a transformation of the energy system.

Despite the potential of solar PV and the UK strengths, the technology is not currently identified as an industrial priority by the UK government and its innovation agencies. The UK's Industrial Strategy makes only one mention of a technology that could be the key global energy source of the future.

The Commission's overarching recommendation, therefore, is that government and industry should work together on a sector initiative that:

- Recognises the role of solar PV as part of a smart, decentralised energy system.
- Invests in the UK's capabilities to play a key role in solar PV innovation across the value chain.
- Secures business investment in solar PV in the UK.

- Coordinates investment in innovation in solar PV with that in complementary technologies such as storage and digital technologies to maximise the value of public and private innovation spending.

The event organisers received positive feedback from BEIS representatives, that they enjoyed the event and would review the report.

The Just Transition

Prof Raphael Heffron, University of Dundee

‘Just transition’ is a concept emerging from legal scholarship that looks at climate change and the energy transition from a human rights perspective. How they align together, such as health, labour, industry, finance during the transition. In the energy transition, whatever the timeframe, the fundamental part of it is justice. Society needs this just transition.

Several countries are putting in place the first legislative steps. This is through the creation of a Just Transition Commission (or similar), and there are currently at least eight forms of such a commission in the following jurisdictions: Canada, Germany, Scotland, Australia, Ireland, New Zealand, US (Appalachia), and South Africa.

Such a commission will provide expert advice on the ways to achieve a Just Transition and also will monitor the effects of existing laws and policies to ensure they contribute to the delivery of a just transition.

Our UKERC grant on the Just Transition to a Low-Carbon Economy is the first to be awarded on this topic in the UK.

What is energy law and why is it significant?

By Prof Raphael Heffron (University of Dundee) and Dr Gloria Alvarez (University of Aberdeen)

The definition of energy law is contentious but broadly speaking it is defined as 'the regulation of energy related rights and duties of various stakeholders over energy resources over the energy life-cycle' (Heffron and Talus, 2016). It is found in contracts, regulations, and precedent, as examples.

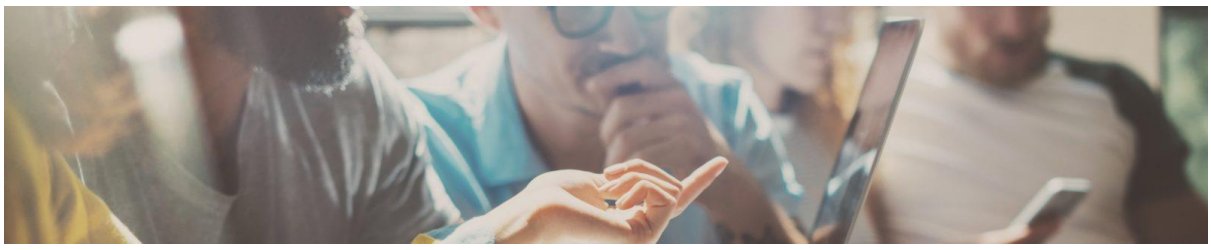
Energy law now plays a central role in defining what happens in the energy sector. It is only quite recently, however, that the academic world, outside a select band of legal scholars, has become aware of this phenomenon.

Within the practice of energy law, various principles can be discerned, such as national resource sovereignty; access to modern energy services; protection of the environment; and prudent, rational and sustainable use of natural resources.

This raises the need, in our minds, to incorporate analysis of energy law into interdisciplinary research. We would also argue that energy law itself provides a framework for interdisciplinary work between scientists, engineers, and social scientists (as well as legal scholars) that ought to be explored.

Energy-PIECES (Energy Policy Insights from Early Career Events and Secondments)

Dr Chris Foulds, Lauren Stabler (Anglia Ruskin University), Dr Rihab Khalid (University of Cambridge)



Secondments to UK Department for Business, Energy and Industrial Strategy: evidence to support policy development on heat decarbonisation

Anglia Ruskin secondment 1: The social dimensions of moving away from gas for cooking: lack of much-needed evidence base to support transitions to a low-carbon kitchen (Khalid)

How to eliminate cooking by burning natural gas? Obviously, people could (and indeed already do) heat food without combustion using a range of electrical appliances that include electric stoves, microwaves, rice cookers, kettles, toasters, and so on, all of which can be powered with renewable electricity.

Decisions on which appliance is used hinge on complex factors associated with socio-cultural norms, cooking and technical skills, work and mobility routines, building and infrastructural alignments and interrelations with intermediaries (like landlords, installers and suppliers). Compared to heat consumption for comfort, this is a more complex topic.

We identified a gap in the evidence that needs filling. There is scant academic evidence on these topics for developed countries – and an inadequate national data set on cooking appliances and their use. This makes the design of appropriate behaviour change interventions hit and miss. It suggests the need both for research to understand how people cook at home, but also evidence on the impact of potential interventions that could change behaviour, e.g., promoting more shared eating, cooking and social learning spaces; or how cooking is presented in the mass media (celebrity chefs, TV cooking competitions, etc.).

This would be a fruitful area to invest in future research to help decarbonise domestic cooking.

Anglia Ruskin secondment 2: Secondment with Électricité de France: the Section 106 (community fund) agreement for the construction of Hinkley Point C nuclear power station

Pip Roddis (University of Leeds) and Rosie Robison (Anglia Ruskin University)

Hinkley Point C nuclear project includes a £20 million community fund which is part of the £100m Section 106 Agreement for the construction of the power station. Projects must be for the benefit of one or more communities in the county of Somerset experiencing residual and intangible impacts* as a result of the construction of Hinkley Point C. It may be designed to remove or reduce impact and improve the social, economic or environmental wellbeing of communities and improve quality of life.

The key aim of our report is to understand how the impacts of the HPC community fund can best be measured. We examined the idea of Social Value, with a view to informing how it can be both evaluated and maximised in future spending.

Social Value is a rising policy agenda, and was formalised in UK legislation by the Public Services (Social Value) Act 2012. It refers to social, economic and environmental benefits whose value is not captured in financial flows. Measuring Social Value is useful for policymakers and public bodies who need to account for spending

decisions, funders who want to direct their money to the most beneficial projects, and funding recipients who wish to demonstrate positive impacts. Whilst multiple tools and methodologies are available to measure Social Value, there is little consensus on which method is best to use in different contexts, and how 'soft outcomes' such as quality of life can best be captured.

Key recommendations are as follows:

1. **Build consensus on how to measure Social Value**. A key challenge is that there are multiple ways to measure Social Value, and the array of available tools and approaches leads to fragmentation. Whilst there are reasons for this diversity, a common approach across major energy infrastructure would be helpful to developers, decision-makers and the public in understanding the costs, benefits and trade-offs of different projects.

2. **Use a framework that is flexible to circumstances**. Because what Social Value 'looks like' varies between contexts, measurement frameworks must be flexible and adaptable e.g. by having an open section where specific relevant measures can be added by stakeholders. A combination of qualitative, quantitative and financial measures will be appropriate in most cases.

3. **Involve stakeholders throughout the process, from planning, implementation to evaluation**. Value is subjective, relational, contingent and contested. It varies between contexts, and even within contexts. This means that all relevant stakeholders must have meaningful participation in all stages of the process, so that what is most valuable to *them* can be understood.

4. **Allocate sufficient resources for Social Value analysis**. A key barrier to Social Value analysis is the resource intensity of the process. Funders should provide adequate additional funding to cover the staff and resource costs of measuring and reporting Social Value. This would help to ensure that funds allocated to *delivering* Social Value are not diverted into measurement and reporting.

Anglia Ruskin secondments 3 a-c: citizens in the driving seat

Chris Foulds, Rosie Robison (Anglia Ruskin University), George Warren (Kings College London), Sioned Haf (Bangor University), Stephanie Hirmer (University of Cambridge), Pip Roddis (University of Leeds)

The energy sector to date has been led by deep-set relationships between traditional energy incumbents and governments, leaving some limited opportunities for citizens to

have their say about individual energy projects through the planning process. This, in our view, can be achieved through firstly understanding the ethics and importance of participation (energy justice and democracy, see above), and practically, through engagement with existing citizen led-projects and citizen-led activist movements.

We undertook secondments of academic researchers in three third sector organisations with deep interests in citizen engagement – Energy Saving Trust, Energy Cities, and Practical Action – with the goal of stimulating two-way dialogue on the ways we could 'put' citizens in the driving seat.

The topics covered were set by the receiving organisation. All the work was based on review of the literature (both academic and non-academic, e.g., policy reports), consultation with the receiving organisation, and conversations with individuals working in the community energy sector, with Local Authorities and/or organisations in the field of citizen participation in energy-related issues.

Anglia Ruskin secondment 3a: The role of public energy advice in transitioning towards a low carbon, decentralised energy system with lower levels of fuel poverty – Energy Saving Trust (Warren)

How to deliver advice on energy to the public?

Tailoring based on values and situation (socio-economic, current home ownership, fuel poverty) is vitally important to improve outcomes and energy scheme engagement.

Despite its usefulness, engagement with English householders should move past the passive website provision to include more active forms of engagement, especially at a community level.

Energy advice providers should consider complementing low-involvement advice provision methods (e.g. websites and telephone advice centres) with high-involvement approaches (e.g. face-to-face and in-home audits) that engage communities at a local level especially for three key groups: 1) vulnerable and fuel poor householders, 2) early adopters of new technologies, and 3) able-to-pay owner-occupiers. These groups require the greatest support and are more open to deeper retrofit options due to grant offerings, motivation, or available spending power.

Anglia Ruskin secondment 3b: How can local authorities support and promote citizens' involvement in energy systems? – Energy Cities (Haf)

Energy Cities (the European Association of Local Authorities in energy transition) is an organisation that aims to: (1) strengthen Local Authorities' skills in the field of sustainable energy, (2) influence European policy on behalf of Local Authorities; and

(3) create networking opportunities to share good practice of energy transition procedures.

Local Authorities have a specific role to play in ensuring that their citizens' views and hopes are fed into the National Energy Climate Plans that will be prepared for by the end of 2019 by all EU member states.

Working with Energy Cities, we developed a wish list of good practices and behaviours for Local Authorities who want to work more closely with citizen groups to advance the energy transition:

- Procurement of locally generated renewable energy from community/cooperative energy projects.
- Implementing a collaborative approach to delivering the energy transition by offering resources, officials' time, guidance and a more united relationship between communities and Local Authorities.
- Where community capacity and Local Authority capacity is low, cooperate on joint-ventures.
- Local Authorities can raise projects' visibility and recognition through raising awareness amongst their own members of staff. Normalising such projects and identifying citizen-led initiatives as key players in the energy transition could lead to their replication.
- A focus on justice can be a central guiding philosophy for the energy transition (being mindful of justice in both local and global terms) and can contribute towards a transition which is inclusive and fair. Citizen participation approaches should therefore seek out the underrepresented – and be inclusive of age, gender, race, minorities and geography.
- Community or citizen ownership of energy initiatives developed by Local Authorities means citizens are better able to engage with energy systems. Ownership can involve: financial stakes in community energy initiatives/projects and remunicipalisation movements and the co-design (and a sense of co-ownership) of energy visions and projects through deliberative processes.
- For an active and engaged citizenship, an active and engaged Local Authority is also needed. All members of staff within Local Authorities need to be literate around the challenges that the energy transition will entail, and the need for the transition to be just through adopting a collaborative approach.

- There is need for much more cross-departmental collaboration within Local Authorities, including an understanding of energy transition matters going beyond being an 'environmental' issue alone.

- Engaging with the many forms of participation - including citizen activism, protest and campaigns which reflect the concerns of citizens - is key to nurturing the relationship between local governments and the public, fostering trust between both parties and encouraging a more deliberative relationship between both.

- Following from this, Local Authorities need to be more approachable – adopting an open-door policy and allowing citizens to be able to engage with developments much more easily. This can be done through actively seeking out existing initiatives and movements and inviting more citizens to shape policies.

- Adopt participative governance strategies that allow for the input of citizens into all-city and/or all-region vision strategies. Although there are some examples of good practice, it is certainly not yet the norm.

Anglia Ruskin secondment 3c: Achieving inclusive rural electrification: policy and regulatory options for improving the effectiveness of mini-grids in developing countries – Practical Action (Hirmer)

Practical Action manage complex, multi-disciplinary international projects across Africa, Asia, Latin America with a focus on decentralized and off-grid energy. Actively integrate 'non-energy' energy policy (i.e. from other ministries) and energy policy.

Our goal in this project was to generate a preliminary evidence base around the limitations of the standard approaches that Practical Action takes. These standard approaches include:

Issue	**Change needed**
Policy alone is not enough for PUE Policy is a powerful tool for shaping the investment environment; for example it can reduce the potential risk for investors and drive systematic change. However energy policy alone is not sufficient to bring about the task of shifting the off-grid energy access	To operationalise the rhetoric of PUE, the energy sector must integrate policy that is commonly located outside the sector, including and most importantly financial policy, agricultural policy and environmental policy.

landscape to account for Productive Uses of Energy (PUE).	
Silos Working in sector silos often results in a failure to see the bigger picture, which is crucial for objectives that cut across many disciplines, such as the mainstreaming of PUE across policy areas. However key challenges of working across sectors are the coordination of action, assigning responsibility of outcomes, the lack of human capacity, and limited financial resources.	Establish cross-departmental working groups that are not coordinated by a specific sector. To overcome this there is a requirement for high level political sponsorship, commitment, and coordination. This may be achieved through the creation of committees or overarching agencies to coordinate different governmental departments to develop a framework for collaborative action (i.e., establish a benchmark of what is required), and to be accountable for progress towards specific objectives.
Understand the end user Understand end-user decision-making to enable PUE which meet local needs. The higher cost of PUE developments compared to basic levels of energy access (e.g., household lighting) is clear. Technology solutions which support PUE require additional capital investment relative to those which do not, and projects are further dependent on uptake and utilisation of technology if they are to achieve economic viability.	To achieve the necessary change it is essential to work to understand existing, context-specific, local community needs patterns of behaviours. These assessments need to be undertaken in addition to traditional needs assessments.
A just development of markets PUE is not about energy access but about just community and market development. The objective of rural off-grid energy access projects is to reduce	This requires the delivery of energy access projects that not only facilitate economic opportunities (i.e., PUE) but inclusively benefit all groups (and thus account for inequalities). Developers which better address local injustices and account for changing preferences and demand over time i.e.

local poverty levels and improve well-being.	accommodate market development, are likely to experience higher demand for generated power and thus improve the economic viability of their project. Markets, when well-managed, can be a tool to incentivise the supply of power to the marginalised and thus reduce inequalities. For more a detailed account of energy poverty and energy justice literature see subsections 3.1 and 3.2 respectively.
Mapping risks To increase private sector participation in off-grid energy access projects, risks that inhibit engagement must be better understood and reduced. This includes actual risks (e.g., the risk of grid extension to project communities which would create stranded assets; or the lack of uptake resulting from low financial capacities of customers); perceived risk (e.g., subjective judgement); but also, the risk perception by other actors (e.g., users' behaviour; practices and measures currently undertaken and accepted; existing knowledge that influences utilisation).	Map risks and develop risk mitigation strategies.

Women Buying Green

Caterina Brandoni (Ulster University) Lecturer in Energy and Alberto Longo Professor (Queen's University Belfast)

Our Women Buying Green project held a series of workshops and focus groups to learn about older women's interest in low-carbon technologies. Here Caterina Brandoni presents initial results.

Women have a growing role to play in demand-side management of energy. By 2050, one in five people worldwide will be over 65 years of age. Women, on average, live about four years longer than men, and older women are more likely to be poor, socially isolated, badly housed, and spend longer hours at home. Households' energy investment decisions, therefore, are going to affect women more heavily than men.

And, yet, energy investments decisions are often made by men. The uptake of low carbon technologies, energy-saving behaviours and "behind the meter" strategies for introducing renewable technologies in elderly households could help decarbonise the energy system - and allow the electricity network to defer grid investments.

This project explored how women's decision making role in the household related to energy choices. The project conducted

- a series of stakeholder workshops,
- focus groups with women to explore their role in investment decisions, knowledge of energy bills, and long term perspectives in their household, and
- a large survey to better understand people's willingness to invest in low carbon technologies.

"Energy bills are something my partner looks after"

In focus groups, women explained that when it comes to invest in low carbon technologies in the house, the decision is generally jointly made with their partner, but that it is their partner that most often suggests the investments to make. Whilst women are mostly in charge of using many appliances in the house, several participants had

no idea of the amount their household pays in electricity bills, as it is something that their partners look after.

Results: some gendered differences

A survey of 1,355 respondents in the UK showed that whilst men are generally more interested than women when considering to purchase an electric or hybrid car, there is no statistical difference for gender when considering other low carbon technologies, such as double or triple glazing, floor or wall insulation, investing in heat pumps or smart meters.

In Great Britain, we found that women are more interested than men in purchasing solar panels for heating water, whilst in Northern Ireland men seem to be more interested than women in insulating the roof of their house. In Northern Ireland, we also found that women tend to prefer to set a slightly higher average temperature in their house, about 20.4ºC compared to 19.5ºC for male respondents.

Conclusion: paths to increase women's energy awareness, agency and ultimately - wellbeing

From the stakeholders workshops it emerged that women have a growing role to play in demand-side management of energy. By examining how women use, understand, and manage energy, we can help them not only to increase their awareness, agency and wellbeing, but also to find ways to reduce energy demand and fuel poverty.

That would, in turn, offer a new and compelling approach to support whole energy systems by designing flexible market-oriented technologies and policy initiatives that promote greater demand response and reduce the current and future energy demand of houses with elderly inhabitants.

Section 4: UK Industrial Strategy

Co-producing the Electric Vehicles Bill

Andrew McLean, Environmental Defense Fund Europe

UKERC funded this project to apply research expertise and evidence to Environmental Defense Fund Europe's efforts to revise the Automated and Electric Vehicles Act 2018, successfully gaining amendments in the primary legislation.

Background: The Automated and Electric Vehicles (AEV) Act passed through Parliament last year. Environmental Defense Fund Europe (EDFE) saw a rare opportunity to influence primary legislation to achieve environmental goals. The aim of the AEV Act was to ensure adequate electric vehicle (EV) charging infrastructure in the UK, and we saw potential to strengthen the Act to accelerate the UK's transition to EVs and to better integrate the transport and energy systems.

EDFE and UKERC collaborated to run an ongoing series of stakeholder workshops looking at barriers preventing EV uptake and development of charging infrastructure, examining what amendments to the AEV Act could help overcome those barriers.

We drew upon the experiences of Frantzeskaki and Kabisch (2016)[9] in coproducing policy through workshops to ensure that the roundtables were open and inclusive, with extensive sharing of knowledge about how policy recommendations would be used and opportunities given to participants to engage in further advocacy.

"Immediate policy impact": We had an immediate policy impact – the first two roundtables led to the assembly and refinement of amendments to the AEV Act, which were then proposed in the House of Lords. Five of our amendments were accepted by the Government and written into law, as follows

1. Legal power for government to prescribe technical requirements for public charge points, including a requirement that charge points be capable of smart charging

[9] Frantzeskaki, N. and Kabisch, N., 2016. Designing a knowledge co-production operating space for urban environmental governance—Lessons from Rotterdam, Netherlands and Berlin, Germany. *Environmental Science & Policy,* 62, pp.90-98.

2. Giving metro mayors greater power to build charge point networks
3. Keeping legal options open on hydrogen fuel-cell technology, by ensuring reference to ‘charging’ in the initial draft was replaced with ‘refuelling’ in the final version
4. Ensuring that the government reports on progress
5. Requiring charge points to be maintained in good condition

The stakeholder workshops were supported by multiple peers throughout the passage of the Bill: Lord Brooke of Alverthorpe, Lord Broers, Baroness Worthington, Baroness Randerson, Lord Lucas, and Lord Tunnicliffe. Lord Broers, Lord Lucas, Lord Brooke and Baroness Randerson attended our workshops and gave valuable insights, and the amendments were discussed with them before they were tabled and supported. Lord Tunnicliffe also supported some of the amendments and the wording was discussed with him with regards to Labour support, as he is the Labour whip. Most amendments were tabled forward by Baroness Worthington and supported by other peers, but some were tabled by others such as the hydrogen infrastructure amendments which was tabled by Baroness Randerson.

The peers spoke in Parliament in support of the amendments, which was of great value in influencing the Government to table their own amendments reflecting some key aspects raised through this project.

We proposed a number of other amendments – on 10 or so topics – over sequential House of Lords sittings, some of which were proposed multiple times, while some amendments overlapped in effect but used different wording.

Understanding success: The reason five of our amendments went through was largely because they were in line with the Government’s definition of the scope of the Act (which we thought was too narrow, as it exclusively related to charging, but…); other amendments were deemed to fall out of scope by the government and were therefore rejected (but might well be included in other regulations).

A good example is seen in the recent consultation on charge point requirements in new buildings – the Government rejected our amendments for the AEV Act, but has introduced our ideas through the Building Regulations 2010. The Government was also unwilling at the time to consider more supply-focused amendments, and the clerks would not let us table them as they were too far out of scope.

Limitations: The government were very willing to listen, seeing the UKERC /EDFE project as a legitimate voice of industry and climate concerns, but were unwilling to stretch what they saw as the focus of the Bill.

Further roundtables: Two further roundtables looked at how best to harmonise the converging transport and energy sectors, and the final roundtable focused on how automation, shared vehicles and electrification would combine to shape the UK's transport and energy systems. Here we saw a particularly clear example of the value of our approach: during discussions of the potential value of using buses for on-demand services outside of peak times, representatives from the charge-point industry pointed out that bus charging-times are so long that they must be predictable, making more ad-hoc services difficult to run. Diverse stakeholder workshops produced unexpected insights.

Key success: One of the key successes of our work has been not just to get amendments to the text, but to help the government see the limitations of the scope of the Act itself and take action beyond it (as it largely focuses on fuel retailers). We are seeing this new approach take root with the proposed regulations for new and renovated buildings via the Buildings Regulation 2010. These regulations will ensure that there is a charge-point in the parking space of every new dwelling and every non-residential building with more than 10 parking spaces, as well cable routes in every space for dwellings with more than 10 parking spaces and one cable route in every five parking spaces for non-residential buildings with more than 10 parking spaces. There will also be regulation of existing non-residential buildings with more than 20 parking spaces requiring the provision of at least one charge point.

Though it is more difficult to show the line of influence (by definition, this is often the nature of policy work), it's nonetheless worth stressing as a major win from our workshops. The UK's energy and transport systems are undergoing rapid changes, and interacting with each other in complex ways. This complicates the development of policy enormously, as decisions can have unpredictable consequences, and policy must draw on cross-disciplinary and cross-sectoral knowledge.

A wide reach: We deliberately ran workshops that would elicit input from all sections and sectors of society, allowing us to develop policy in collaboration with academics, industry specialists, citizens and policymakers. Too often energy and transport policy discussions are dominated by men, and as part of our work we set out to significantly increase the participation of women. Through emphasising the need to have a gender-balanced perspective among our invitees, working with the Werin network (a network and support system for women working in research and industry on whole energy systems also funded by UKERC), and prioritising having women as speakers we had an approximately even gender split at every event that we hosted.

Policy Priorities: The key policy priorities that emerged from our discussions included: improving accessibility of transport data to ensure that monopolies do not form, ensuring that automated vehicles are both electric and shared, and how to replace fuel duty without impacting the energy system, as well as how to ensure that the benefits of

EVs are accessible to all. The latter is a topic we are exploring in an upcoming report with Frontier Economics.

A cleaner UK, managing risks: The United Kingdom's transport system is polluting both our planet and our streets. The response, a shift to electrified transport, will have huge impacts on the energy system: power for our vehicles will increasingly be supplied by the electricity grid. Done in an uncontrolled way, this could lead to spikes in demand for electricity and demand for more fossil-fuel resources. However, if done effectively, this shift could enable greater decarbonisation of the grid, cheaper transport for citizens due to low costs of charging, and pave the way for an entirely new model of transportation in the UK – one closely integrated with the energy system.

Environmental Defense Fund is an influential American NGO founded in 1967 that brings together science, economics, and law to impact environmental legislation. In 2016 the organisation opened a legal entity in London – Environmental Defense Fund Europe – adding to its existing network in USA and China.

Solar + Storage waste pathways

By Dr Britta Turner (Durham University) and Dr William Burns (UKERC)

Energy waste in a zero-carbon system: what ought we to be thinking about?

The waste associated with the extraction, distribution and burning of fossil fuels – including greenhouse gases (obviously!), inorganic compounds and metals, benzene, toluene, phenolics, polycyclic aromatic hydrocarbons, sulphur dioxide, CO, NO_x and so on – is well known. Similar can be said for nuclear, with the important proviso that radioactive waste is orders of magnitude more hazardous than anything else, but also comparatively localised.

Based on current evidence, renewable electricity devices such as solar, batteries, and wind turbines might appear less troubling both in terms of volume and level of hazard

What can be said with reasonable confidence is that end of life management for decommissioned renewable infrastructure should be taken into account, given the necessary expansion of the sector in a zero carbon scenario. There could also be

substantial profit from responding proactively to this forthcoming waste stream – financial, scientific, ecological, in terms of equity, and so on.

The focus of the project undertaken by one of us (BT) has been on solar and storage waste. As has been noted elsewhere, the two components (solar panels and batteries) can be thought of as integral to one another, in the sense that we are talking about a system that both harvests energy and stores it. It is also noteworthy that materials science and chemistry are core sciences applicable to both technologies.[10]

Funded through UKERC, BT ran three workshops in Kenya, India and the UK that brought together international and interdisciplinary researchers and stakeholders with the remit to explore what a future whole systems research agenda for solar and battery waste could look like.

Through the workshops a number of issues such as recycling, resource recovery, repair and maintenance, formal and informal waste and recycling infrastructures, supply chains and geopolitics were discussed.

- Conclusion

The above text highlights the interplay of local and global, business and economics, culture, supply chains, chemistry, engineering, and even geopolitics. We are not yet at the stage of drawing firm conclusions or making policy recommendations, beyond pointing out the existing discussions occurring on these topics. The current project was small in size.

But one question for the would-be analyst is what to ‘do’ with the intricate picture of evidence from various unconnected disciplines and literatures?

Good connections have now been made across disciplines, and internationally. Future research work could therefore look towards a whole systems analysis to fully understand how and where solar and storage waste can be prevented. This would include design for recycling, choice of energy materials, manufacturing and diffusion processes, repair, reuse and maintenance, and cross-border trade. Not to mention associated regulations and incentives.

The author acknowledges Kenyan and Indian colleagues.

[10] https://royalsociety.org/science-events-and-lectures/2018/09/low-carbon-future/

Decarbonisation of the UK Road Cargo Sector

Advanced Propulsion Centre, Energy Systems Catapult

Road freight is expected to become the most significant energy user from 2030 onwards as the UK economy evolves. Carbon emissions from road freight account for about 17% of the UK's emissions today are projected to increase in the next 30 years.

Our overall aim was to provide underpinning modelling that could help define a cost-effective pathway to decarbonise road freight across the UK's transport and energy systems in ways that are genuinely useful for the sector. This is going to be become an ever more pressing issue as the need for whole-economy decarbonisation in light of net zero calls for more granular understanding of all aspects of the economy, not just the energy sector.

Our current modelling environment, ESME, was not originally designed for road freight. In conjunction with road freight industry we uncovered areas where substantial and useful enhancement could be made, such as the fact that ESME vehicle categories were not recognised by industrial stakeholders.

This project laid the groundwork for further work.

We undertook a project to collaboratively through a series of workshops that brought new sets of stakeholders together to generate ideas, with discussions informed by insights from the Energy Systems Catapult's ESME modelling (including improvements to the model); and a literature survey.

<u>The trucker's quadrant</u>

Key pressure points in delivering a zero-carbon road freight sector – as identified by our industry focus group (a mix of truck manufacturers, hauliers, and logistics firms).

Policy	**Users**
Policy solutions could include applying a carbon tax to support the uptake low-carbon fuels as deemed this could be the easiest and quickest way to achieve	Understanding the user case as this impacts not only selection of vehicles but also understanding the ancillary technology that can support vehicles,

carbon reduction across the existing fleet. Examples were tabled of other European countries taking this approach supporting the uptake of lower-carbon fuels, e.g. hydro-treated vegetable oil (HVO). Scandinavia has fiscal benefits from introduction of paraffinic fuels; Finland and France with differential taxation on, e.g., E10 (ethanol-gasoline blend). However, none of these measures would 'cut-it' in terms of delivering zero carbon: central policy for freight decarbonisation is needed for zero emission vehicles to be adopted by operators.	e.g. telematics, autonomous functionality, geo-fencing to limit emissions of vehicles. In addition to the in-use phase, the importance surrounding costs of maintenance and servicing of new vehicle powertrains along with additional costs for infrastructure (e.g. installing charging points & retention/retraining of in-house maintenance teams). Alternative operation strategies like portable distribution centres, consolidation of services and freight also have the potential to reduce emissions.
Operating models Many larger organisations in the heavy duty vehicle (HDV) sector now operate on a leasing model. Currently electric vans that are being trialled are being given a longer lease compared to their diesel counterparts to ensure that the total cost of ownership (TCO) is comparable. There is an expectation that fleet transport managers and companies are having to meet carbon footprint initiatives. This provides an opportunity to look at the whole carbon cost of logistics taking to account the multi-modal and distribution networks. When adopting new solutions there is the challenge of having the right infrastructure to support these technologies, e.g. charging infrastructure. Due to rapid turnover of fleets, retrofit not a factor.	**Technology** 'Electric road'/catenaries (over-head wires) thought to be easiest option; installation costs on motorways/trunk roads large but not unreasonable for major national infrastructure. Battery kicks-in for 'off-catenary' roads; predictable usage and telematics available for HDVs makes them particularly suited to electrification. It was also noted that HDVs and buses could potentially share infrastructure at 'charging super-hubs'. Scepticism about carbon capture and storage (CCS) deployment in a reasonable time to facilitate low carbon hydrogen. The major issue with biodiesel is the emissions profile (unsuited to ultralow emission zones).

Developing the ESME model

Working primarily with Volvo we set out to investigate how to develop a vehicle selection model ESME to assess the energy system implications. Based on the workshop outputs the vehicle selection model will categorise vehicles based on their operation and size. Several scenarios and model features were developed, again based on the workshop outputs (summarised above in the trucker's quadrant). An assessment process was followed to prioritise and select the scenarios and features that will be included in the scope of the modelling work. Complexity, data availability and expected impact were among the criteria used in the process.

The features that will be included in the vehicle selection model are:

- Motorway catenary charging as a route to the electrification of HDVs
- Shifting relevant demand from larger vehicles to smaller vehicles
- Stricter regulations on emissions from HGVs or additional taxation will represent a form of central policy

The scenarios that will be explored with using ESME include:

- The ESME base case scenario will be set so it meets the Road to Zero targets
- Additional ESME scenarios will look at the deployment of CCS, looking at no CCS deployment or an option where deployment is delayed

Even though the modelling capabilities could be upgraded to include other areas of interest, due to the lack of data and complexity some of the features and scenarios that were formulated from the workshop outputs were not included in the project's scope of work. These will be part of the project's future work and recommendations sections. Recommendations will also be made on the data that would be needed to assess their viability and impact on the road freight sector and the wider energy system.