UKERC ENERGY RESEARCH ATLAS: SOCIO-ECONOMIC ISSUES

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1. Overview

Return to Top

Characterisation of the field

The UK socio-economic energy research landscape is a particularly broad and diverse field of research. In general, researchers in this area take the starting position that energy systems constitute complex systems, which are comprised of a multitude of inter-connected 'technical' (e.g. technology, infrastructure etc.) and 'social' elements (e.g. institutions, user practices, regulation, business models etc.) that together are capable of satisfying our energy needs. Socio-economic energy research typically examines the interplay between these technical components, emphasising the important role played by actors, institutions and networks, alongside technologies and infrastructure.

The socio-economic research community is a 'broad church' but primarily includes economists, social scientists, psychologists, human geographers, business study experts, historians and political scientists. Economics has traditionally been the most dominant discipline in this field. However, significantly more attention has in recent years been given over to the cultural and political underpinnings of energy generation and consumption. For instance, a growing number of research projects in the UK have begun to apply concepts from sociology, psychology, Science & Technology Studies (STS), innovation studies, business studies, geography, planning and environmental management in order to tackle key energy research challenges.

An important characteristic of the UK socio-economic research landscape is its focus on engaging with inter-disciplinary energy research projects. Whilst inter-disciplinary energy research is the focus for a stand-alone UK Energy Research Centre (UKERC) landscape report, it is important to note how commonly socio-economic researchers collaborate with researchers from the applied and formal sciences, most notably engineering and mathematics. This alliance has been forged in the understanding that without both incremental and radical technological innovation, delivering a whole-sale transformation of the energy system will be extremely difficult. Conversely, new technology alone will simply not be sufficient to deliver a timely transition to a sustainable energy system, where behavioural change, business models and energy policy will all be necessary to ensure these new technologies are adopted at scale. It is on this foundation that major consortia, such as the UK Energy Research Centre (UKERC), the Energy Revolution Research Consortium (Energy-REV) and the Centre for Research into Energy Demand Solutions (CREDS) have been borne.

This document is concerned only with UK research projects, funding programmes and institutes that are a) primarily concerned with energy issues and, b) which incorporate a significant focus on social science and/or economics research. Those that do not fulfil these criteria are excluded from this report.

Overview of Research Activity

The range of research challenges undertaken by the socio-economic energy research community is particularly broad given the variety of disciplines that operate in this area. However, the majority of research in this field is centred around improving our understanding of how we can deliver a more environmentally sustainable, affordable and secure energy system, given the emphasis on achieving these aims across both government and industry.

- **Dynamics of whole system change and innovation** – Analysis and modelling of the interplay between social and technical energy system components and how these characterise energy system change. A specific focus on the development,

uptake and potential impact of energy innovations, both technical and non-technical.

- **Energy economics** – The application of economics and econometric modelling to analyse the costs and associated benefits of different energy system interventions, both technical (e.g. new technologies) and non-technical (e.g. new policies). These may take a micro- or macro-economic focus, as well as examine up- (i.e. supply) or down-stream (i.e. demand) supply chain activities.
- **Energy system governance** – Exploration of existing and alternative governance arrangements for energy systems and analysis of their respective impacts upon the broader energy system (e.g. generation, supply, consumption etc.) and their potential to address key challenges (e.g. climate change, energy security). Areas of specific interest include governance frameworks for decentralised energy systems and the role incumbents could play in delivering transformational change.
- **Design and impacts of energy policy and regulation** – Examination of the effectiveness, costs and benefits of different policies and regulation designed to promote: competition within energy markets; uptake of innovative technologies; and sustainable energy consumption practices in order to address key energy challenges (e.g. energy security). An area of growing interest is 'co-benefits' of interventions both energy-related and otherwise (e.g. social, cultural, economic). Related to this is interest in the impact of non-energy policies on the energy system.
- **Energy use behaviours and decision-making in the home** – The factors responsible for characterising the type and level of energy demand, as well as consumers' engagement with energy technologies. Strong focus on the uptake and potential impact of smart technologies.
- **Energy business models and finance –** the range of potential alternative energy business models and how these might be financed, as well as the role they could play in addressing key energy challenges. Much of this work has looked beyond the dominant private sector model, to consider how local authority or community led organisations could implement change.
- **Equity, justice and acceptability –** how different interventions (e.g. technologies, business models and policies) impact upon different socio-economic groupings in different ways. It also explores the ethical implications of these impacts and how to deliver an equitable or 'just transition'. Complemented by research into the perceived acceptability of different energy interventions.

2. Capabilities Assessment

Return to Top

Not applicable

3. Basic and Applied Strategic Research

Return to Top

Socio-economic energy research does not neatly sit within a single UK energy research funding programme. Instead funding is split across numerous programmes, managed by different organisations. Even so the bulk of socio-economic energy research funding has been channelled through the Research Councils' Energy Programme (RCEP). Led by the Engineering and Physical Sciences Research Council (EPSRC), funding is also drawn from the Biotechnology and Biological Sciences Research Council (BBSRC), the Economic and Social Research Council (ESRC), the Natural Environment Research Council (NERC), and the Science and Technology Facilities Council (STFC).

The RCEP provides a common strategic framework for the different research councils to work together to plan, develop and deliver energy research and training. The current grant portfolio has committed £42m to end-use energy demand and £30m to whole energy systems research, together accounting for 21% of all energy theme funds committed.

Today, the RCEP concentrate most of its investment in large consortia. Most notable of these is UKERC, which since 2004 has acted as the central vehicle for socio-economic energy research in the UK. It has however recently been joined by other major consortia. Examples include the end-use energy demand focused CREDS, which was established in 2018. Some of the RCEP Supergen Hubs also include socio-economic work packages, despite primarily being technology focused.

Looking beyond RCEP funded consortia, other investments by individual research councils have also played a key role in supporting socio-economic energy research. Most notably, these include EPSRC's fellowships, such as the Innovation, Governance and Affordability for a Sustainable and Secure Economy (iGOV) project at Exeter, alongside a raft of other mid-career fellowship (Table 3.1). ESRC has also made important investments, such as the:

- Centre for Climate Change, Economics and Policy at LSE & Leeds
- STEPS (Social, Technological and Environmental Pathways to Sustainability) Centre hosted by SPRU, the University of Sussex.
- Centre for Climate Change and Social Transformations (CAST)

We also find that a host of techno-economic projects, mostly funded by EPSRC, also incorporate a strong socio-economic focus (e.g. policy, business models, consumer behaviour), such as the Centre for Energy Systems Integration (CESI), headquartered at Newcastle University.

One important development has been the formation of UK Research and Innovation, which is ostensibly an umbrella body that brings together the seven Research Councils, InnovateUK and Research England. It has become responsible for managing funding direct from the UK government's Industrial Strategy. For socio-economic energy research the most substantial investment has been the £10m Energy Revolution Research Consortium (Energy-REV) established in 2019 to explore the scaling up of smart localised energy systems. It is also important to note that the Energy Systems Catapult was provided funding of £50m by Innovate UK between 2018 and 2023 (see Table 3.2).

We also note that investment has not solely been delivered by the tax payer funded Research Councils. For example, the charity the Leverhulme Trust made a 10 year £10m investment in their Leverhulme Centre for Climate Change Mitigation (LC3M) in 2015.

Table 3.1 presents an overview of research programmes but of research projects with a strong socio-economic focus. We make clear who the funders are and we cover only major projects (>£1m) and those that are ongoing. Smaller projects below £1m, which have a very strong socio-economic focus, may be included under relevant research funding programmes (E.g. EPSRC Fellowships). Projects with a very strong techno-economic, systems oriented modelling orientation (e.g. IDLES) are excluded from our analysis, are assumed to be covered by the Energy

Systems landscape report. Table 3.2 outlines the organisations mostly responsible for leading delivering on these investments.

Table 3.1: Research Funding

Funding Stream	Funding Agency	Description	Funds (£m)	Funds per annum (£mpa)	Period
UK Centre for Research on Energy Demand (CREDS)	EPSRC and ESRC	A national Centre on energy demand research, building on the work of the existing six End Use Energy Demand Centres, for which funding ends in April 2018. Its research programme is inter-disciplinary, recognising that technical and social change are inter-dependent and co-evolve. Work is organised across three sectors and three cross-cutting themes: • Buildings & Energy • Digital Society • Flexibility • Materials & Products • Policy & Governance • Transport & Mobility CREDS also holds a Flexible Fund, which will be used to support research on emerging research questions, in particular through support for early career researchers. Its first call focused on the following themes: • Equity and Justice, • Decarbonisation of difficult sectors, and • Co-Benefits	19.4	3.9	2018-2023
UK Energy Research Centre	NERC/ EPSRC/ ESRC	UKERC was established in 2004 following a successful £14m bid to establish an organisation designed to bring together all researchers working on energy problems in the UK. UKERC was renewed for three subsequent phases and in 2019 it was invited to submit a	UKERC4 18.0	3.6	2019-2024

Funding Stream	Funding Agency	Description	Funds (£m)	Funds per annum (£mpa)	Period
		proposal for a fourth round of funding, which has recently been approved. UKERC's research and other activities will be substantially re-oriented in phase 3. The first two phases of UKERC focused on understanding what a decarbonised UK energy system will look like in 2050 and how the transition towards this system could be achieved. The third phase will recognise the increasingly contested and uncertain nature of energy system change. It will explore the UK energy transition in an uncertain world, and the synergies and trade-offs between the key drivers for this transition. Whilst the need to achieve deep emissions reductions will remain a driver for UKERC's research, phase 3 will analyse a wider range of potential energy system transitions in the UK. These include future energy pathways that do not achieve such deep reductions in emissions. In terms of research UKERC is currently undertaking work in the following areas: • Future Energy System Pathways • Resources and Vectors • Energy Systems at Multiple Scales • Energy, Economy and Societal Preferences • Decision Making • Technology and Policy Assessment A NERC-funded Grand Challenge Project Addressing the Valuation of Energy & Nature Together (ADVENT) has worked closely with the UKERC3 themes.			

Funding Stream	Funding Agency	Description	Funds (£m)	Funds per annum (£mpa)	Period
		Phase 3 also included a Whole Systems Networking Fund (see Section 7) and a Flexible Research Fund that has funded a broad range of socio-economic oriented projects. These include: • Incumbent energy systems and infrastructures • Equity and justice in energy systems • Financing community energy • Bioenergy with CCS (BECCS) • Accelerating emission reductions in transport • Flexibility and low carbon heat systems • The impact of non-energy policies on the energy system Beyond research, UKERC also engages in a number of other important activities. These include: • The UKERC Energy Data Centre (including the Projects Catalogue and Data Catalogue) • knowledge exchange networks for policy, business and academic communities, a substantial communications function, international engagement activities including EERA • Network for early career researchers.			
Leverhulme Centre for Climate Change Mitigation (LC3M)	Leverhulme Trust	Long-term programme of multi-disciplinary research is organized across four themes: Earth Systems Modelling, Fundamental Crop Weathering Science, Applied Weathering Science and Sustainability & Society. It is the last theme that has the strong socio-economic research focus. It covers the following: • Dynamic integrated assessment modelling (IAM) • Global Sustainable Supply Chain • Public perception of risks and benefits	10	1	2015-2025

Funding Stream	Funding Agency	Description	Funds (£m)	Funds per annum (£mpa)	Period
Energy Revolution Research Consortium (Energy-REV) Plus Projects A & B	UKRI's Prospering from the Energy Revolution (PFER)	EnergyREV will work with the Energy Systems Catapult to enable and inform demonstrators and demonstrator design projects (funded by the PFER programme) through their lifetime; undertaking analysis and evaluation, building and driving best practice and, leading knowledge exchange through national and international engagement with policy, academic and industrial communities. Further to this, EnergyREV has shaped and defined a strategic programme of applied interdisciplinary research which aims to achieve significant outputs in the areas of whole energy systems and smart local energy systems. This will inform future energy investment by companies and Government. It will coordinate and integrate existing UK world-class knowledge, research teams and facilities, and through this provide advice, research and innovation support to help ensure the success of the PFER programme.	9.8	2.5	2018-2022
Centre for Energy Systems Integration (CESI)	EPSRC and Siemens	CESI aims to reduce the risks associated with securing and delivering a fully integrated future energy system for the UK. This will be achieved through the development of a radically different, holistic modelling, simulation and optimisation methodology which makes use of existing high level tools from academic, industry and government networks and couples them with detailed models validated using full scale multi vector demonstration systems. CESI will carry out uncertainty quantification to identify the robust messages which the models are providing about the real world, and to identify where effort on improving models should be focused in order to maximise learning about the real world	5.4	1.1	2016-2021
Centre for Climate Change and Social Transformations (CAST)	ESRC	The CAST Centre will be a global hub for understanding the systemic and society-wide transformations that are required to address climate change. At its core, is a fundamental question of enormous social significance:	4.9	1	2019-2024

Funding Stream	Funding Agency	Description	Funds (£m)	Funds per annum (£mpa)	Period
		How can we as a society live differently – and better – in ways that meet the urgent need for rapid and far-reaching emission reductions? Its Research Themes recognise that transformative change requires: inspiring yet workable visions of the future (Theme 1); learning lessons from past and current societal shifts (Theme 2); experimenting with different models of social change (Theme 3); together with deep and sustained engagement with communities, business and governments, and a research culture that reflects our aims and promotes action (Theme 4).			
ADVENT (ADdressing Valuation of Energy and Nature Together)	NERC	It explores future UK low-carbon energy pathways and quantify what they would mean for natural capital and ecosystem services. The project applies economic valuation to estimate in money terms the value of the ecosystem service changes associated with different future energy pathways. These will include the kind of steps the UK will need to take in order to meet its energy policy goals of maintaining energy security, keeping energy affordable and cutting greenhouse gas emissions by 80 per cent by 2050.	2	0.4	2015-2020
Centre for Climate Change, Economics and Policy (CCCEP)	ESRC	The ESRC Centre for Climate Change Economics and Policy (CCCEP) brings together some of the world's leading researchers on climate change economics and policy, from many different disciplines. It was established in 2008 and its third phase began on 1 October 2018. The Centre is also a member of the Place-based Climate Action Network (P-CAN), which was launched on 31 January 2019. Phase 3 of the Centre consists of seven projects. They build on the five research themes during phase 2 and complement other projects carried out at the Grantham Research Institute on Climate Change and the Environment and the London School of Economics and	1.1	0.2	2018-2023

Funding Stream	Funding Agency	Description	Funds (£m)	Funds per annum (£mpa)	Period
		Political Science and at the School of Earth and Environment at the University of Leeds. The Centre is undertaking seven research projects during phase 3: • Low-carbon, climate-resilient cities • Sustainable infrastructure finance • Low-carbon industrial strategies in challenging contexts • Integrating climate and development policies for 'climate compatible development' • Competitiveness in the low-carbon economy • Incentives for behaviour change • Climate information for adaptation			
STEPS (Social, Technological and Environmental Pathways to Sustainability) Centre	ESRC	The ESRC STEPS Centre will link research with action in the exploration of transformative pathways to sustainability. The Centre is part of an emerging STEPS Global Consortium with six hubs across five continents. Work on energy/climate, food/agriculture, health/disease, water/sanitation and urban development will continue through affiliated projects. The STEPS Centre's conceptual and methodological perspective - the 'pathways approach' will continue to be extended, and will provide a focus for debate about what works for sustainability transformations across domains.	1	0.3	2018-2021
EPSRC fellowships	EPSRC	EPSRC have traditionally awarded fellowships to outstanding scholars to pursue their research agenda. They are typically multi-year fellowships that are well funded, often running up to £1m. A handful of ongoing fellowships with a strong socio-economic focus are listed below: • Co-creating visions and pathways for integrated urban heat systems	N/A	N/A	Ongoing

Funding Stream	Funding Agency	Description	Funds (£m)	Funds per annum (£mpa)	Period
		• Adaptive Decision Making for Urban Energy Transformation EPSRC • Measuring and Evaluating Time- and Energy-use Relationships (METER) EPSRC has also awarded established career fellowships in the past and provided one of these with an extension until 2019: Innovation and Governance for Future Energy Systems (iGov).			
Global Challenges Research Fund	UKRI and Research Councils	The Global Challenges Research Fund (GCRF) is a £1.5 billion fund announced by the UK Government in late 2015 to support cutting-edge research that addresses the challenges faced by developing countries. Two of its three core themes have a strong socio-economic energy research focus: • Equitable Access to Sustainable Development • Sustainable Economies and Societies Example projects that have been funded include: • TERSE: Techno-Economic framework for Resilient and Sustainable Electrification (2018-2021) • Humanitarian, Engineering and Energy for Displacement (HEED) (2017-2020)	N/A	N/A	Ongoing
SUPERGEN Hubs	RCEP SUPERGEN	The Supergen programme was set up in 2001 to deliver sustained and coordinated research on Sustainable PowER GENeration and supply, focusing on several key research areas, including bioenergy; energy networks; energy storage; fuel cells; hydrogen and other vectors; marine, wave and tidal; solar technology; and wind power. For phase 3, EPSRC supported seven Supergen hubs with £150	N/A	N/A	Ongoing

Funding Stream	Funding Agency	Description	Funds (£m)	Funds per annum (£mpa)	Period
		million of investment over a five year period (including a series challenge calls and Centres for Doctoral Training). Today there are the following SuperGen Hubs active, the first three of which were funded under Supergen latest phase 4: • Bioenergy (2018-2022) • Energy networks (2018-2022) • Offshore Renewable Energy (2018-2022) • Energy Storage (2014-2019) • Wind (2014-2019) • Hydrogen and Fuel Cells (2017-2021) Associated with the Supergens are a number of 'challenge' funds, from which a large number of sizeable projects have been funded, many of which with a strong socio-economic focus. See for example the project funded under the Supergen energy storage challenge. Funding has also been issued for networking and is covered in Section 7.			

Table 3.2: Key Research Providers in UK Universities
The below is not an exhaustive list of key research providers. Instead we highlight only those institutes with a significant concentration of socio-economic energy research capabilities.

Name	Description	Sub-topics covered	No of staff
3S: Science, Society and Sustainability University of East Anglia	3S was established in 2011 and is based within in the School of Environmental Sciences at UEA. It conducts research to understand, and potentially transform, relations between science, innovation and society in responding to the unprecedented sustainability challenges facing our world.	• Energy • Climate Change • Innovation • Hazards and Risk	12 researchers
Centre for Energy Policy University of Strathclyde	The Centre has particular expertise in the macroeconomic modelling of energy and it works with partners across the university to bring current research from a wide energy base into the public debate. The global energy landscape is changing fast. This presents challenges to society, industry, commerce and governments as they seek to develop relevant and appropriate strategies.	Economic impacts of changes in the system. Sub-themes include: • Macroeconomic modelling of energy policy • Energy efficiency • Energy supply	4 researchers
Centre for Energy, Environment and Sustainability (CEES) University of Sheffield	Centre for Energy, Environment and Sustainability (CEES) is a leading centre of excellence in multi-disciplinary research, development and deployment of innovative ways to advance the understanding of energy, environment and sustainability for a low carbon future. It operates primarily as an umbrella institute to bring together disciplines from across the university.	• Carbon footprinting, accounting and management • Low carbon technology and interventions deployment • Sustainable development • Social preparedness in climate change • Climate change, environment, resource poverty and security • Governance, policy and regulation for energy and low carbon futures • Low carbon supply chains and economy, energy supply chains, eco-logistics • Green IT and digital futures • Low carbon building and construction • Energy efficiency	28 researchers from across the university

Name	Description	Sub-topics covered	No of staff
Centre for Environment and Sustainability University of Surrey	The Centre for Environment and Sustainability (CES) uses inter-disciplinary approaches to the analysis of complex systems, integrating the engineering and science-based disciplines with insights from the economic and social sciences, and from this develop action-oriented, policy relevant responses to long-term environmental and social issues.	• Sustainable Systems: Tools for Analysis and Design • Social and Economic Research on Sustainability: Developing Concepts and Themes • Policy, Strategy and Governance	19 researchers
Centre for Integrated Energy Research, University of Leeds	The Centre for Integrated Energy Research was initiated in October 2010, designed to draw together expertise of around 50 leading researchers, from across the engineering, design, social and behavioural sciences. CIER's mission is to integrate energy science and technology with energy economics and policy to enable and support UK industry, and society more broadly, to achieve national, European and future global energy targets. It operates primarily as an umbrella institute to bring together disciplines from across the university.	• Energy-related technologies (e.g. advanced combustion science and engineering, renewable energy systems and future fuels, and tribology) • Energy economics and policy (e.g. the economics of low carbon cities, transition pathways to a low carbon energy system, business models and the use of ICT for demand reduction) • Socio-technical systems design for energy (e.g. the design of indicators for, and mobile applications to support, green behaviours) – in collaboration with the Socio-Technical Centre • Interdisciplinary and whole systems approaches to energy (e.g. a holistic review of energy storage technologies and possible pathways for adoption in the UK)	43 staff
Durham Energy Institute University of Durham	DEI was born in 2009 out of the realisation that energy challenges cross conventional discipline boundaries and that new ways of thinking about and conducting energy research are required. DEI has now grown into an internationally leading institution, recognised for its ability to apply new methods and perspectives to existing and emerging energy challenges. By unlocking research synergies between different disciplines and sectors, DEI aims to produce	Alongside a wide range of technology oriented research theme, two main socio-economic themes: • Economics, Regulation and Policy • Society and Energy	13 researchers (on Energy and Society theme)

Name	Description	Sub-topics covered	No of staff
	major breakthroughs in our understanding of how to best meet the energy demands of the future. We emphasise a 'Science and Society' approach to energy which tackles the societal aspects of energy technology as well as developing new energy technologies and solutions for the benefit of society		
Electricity policy Research Group University of Cambridge	The Energy Policy Research Group (EPRG) is based at Cambridge Judge Business School. EPRG's research team have broad expertise in economics, technology policy and political science. Their core research discipline is economics, within a framework that encourages collaboration between experts from different academic traditions, drawing on insights from engineering, political science and law.	• Regulation and Markets • Technology and Innovation • Governance and Politics • Climate Change Policy	15 researchers
Energy Academy Heriot Watt University	A pan-university initiative, where research excellence ranges from solar energy and energy-focused materials through to energy economics, use, policy and logistics.	An umbrella institute that covers expertise across the following institutes: • Institute for Social Policy, Housing and Equalities Research • The Centre of Excellence in Sustainable Building Design • Centre for Infrastructure and Environment • Institute for Life and Earth Sciences • Urban Institute • Institute for Petroleum Engineering.	33 researchers
Birmingham Energy Institute University of Birmingham	The Birmingham Energy Institute is an umbrella institute that brings together academics across the University of Birmingham engaged in energy and energy related research and development. It is a focal point for the University and its national and international partners, to create change in the way	Whilst BEI has various sub-themes with a strong socio-economic focus (e.g. Storage), it is the Birmingham Centre for Environmental and Energy Economics and Management that is most active in this space.	23 (directly involved)

Name	Description	Sub-topics covered	No of staff
	we deliver, consume and think about energy. The focus being		
Energy Futures Lab Imperial College	A pan-university umbrella initiative, the Energy Futures Lab is concerned with facilitating the move towards a more secure energy supply in the future. To achieve this aim, the centre provides a focal point for multi-disciplinary research across Imperial College London by facilitating and funding energy related research that brings together the university's different departments.	• Policy and Innovation • Energy Infrastructure • Sustainable Power • Low Carbon Cities and Transport • Clean Fossil Fuels • Research Networks	2 non-administrative researchers (excludes university-wide affiliates)
Energy Lancaster Lancaster University	Energy Lancaster brings together Lancaster University's world leading expertise in a wide range of energy related areas covering the demand and supply of energy Notable institutes include	Relevant areas of expertise: • Carbon management • Energy and behavioural change • Energy demand management and modelling • Energy policy and economics • Transport and transport usage	45 researchers
Energy Policy Group, University of Exeter	The Energy Policy Group at the University of Exeter provides an academic hub for the interdisciplinary study of energy policy. EPG focuses on applied energy policy research and practice change, within the UK and internationally, to inform industry, policy makers and wider society.	• Future directions for energy policy and governance; • Roles of social and technical change; • Interface between people and technology; • How politics, rules and regulations can and could shape the energy system; • Balancing affordability alongside carbon management and security.	14 researchers
Energy Research Partnership	ERP is a public-private partnership seeking to guide and accelerate innovation in the energy sector through enhancing dialogue and collaboration. With a diverse range of energy sector stakeholders it aims to provide a reasoned and independent view, underpinned by industry, government and academic insight.	• Research and Development – targeting of UK priority technology areas; • Innovation – developing partnership models to stimulate and deliver innovation; • Policy – providing the factual basis to inform decision making;	N/A

Name	Description	Sub-topics covered	No of staff
		• Delivery – promoting the role of social science in understanding consumer preferences for the deployment of new technologies and innovations.	
Energy Systems Catapult	The Energy Systems Catapult was set up to accelerate the transformation of the UK's energy system and ensure UK businesses and consumers capture the opportunities of clean growth. The Catapult is part funded through Innovate-UK and is an independent, not-for-profit centre of excellence that bridges the gap between industry, government, academia and research. It takes a whole-systems view of the energy sector, helping us to identify and address innovation priorities and market barriers, in order to decarbonise the energy system at the lowest cost. It is responsible for developing products and services to address the new commercial opportunities created by the transformation of UK and global energy systems (covering electricity, heat and combustible gases). As part of this work programme they have in-house research capabilities that are focused on providing a greater understanding of the risks and opportunities associated with transitioning to a low carbon energy system.	Capabilities include: • Modelling • Consumer insights • Systems integration • Infrastructure • Digital and data	N/A
Environmental Change Institute University of Oxford	The ECI was founded 20 years ago with a mission "to organize and promote interdisciplinary research on the nature, causes and impact of environmental change and to contribute to the development of management strategies for coping with future environmental change". It has a special research focus on both understanding change and exploring solutions for sustainable development.	• Energy systems and governance • Energy demand policy • Energy monitoring and analytics • Flexibility • Smart systems and everyday life • Buildings and buildings • Energy, organisations and society • Transport and mobility	18 researchers

Name	Description	Sub-topics covered	No of staff
Global Energy Research Network University of Warwick	Global Energy research arises from Warwick Business School's long-standing interest in understanding the role of business when society faces major challenges. We combine fundamental research into management practices with a topical view on their implications for businesses, policy and society.	• How are the evolving economic forces and new patterns of economic growth across the world leading to changes in industry structures, new business models and changes in management practices across the energy sector? • What is the evolving relationship between the industry and governments through policy-making, regulation, international relations and global frameworks?	9 researchers
Grantham Institute for Climate Change Imperial College	In 2007, the Grantham Foundation for the Protection of the Environment made the visionary decision to support an Institute at Imperial to provide a vital global centre of excellence for research and education on climate change. Today, the Grantham Institute is established as a leading authority on climate and environmental science. Its mission is to contribute to, and lead on, world-class research, training and innovation towards effective action on climate change and the environment.	Relevant themes include: • Energy and Low-Carbon Futures • Economics and Finance	8 researchers (mitigation team)
Imperial College Centre for Energy Policy and Technology, Imperial College London	ICEPT is a world class centre for research and policy advice at the interface between energy policy and technology. It addresses key policy challenges including climate change, energy security, affordability and energy for development.	• Biomass & Bioenergy • Renewable Energy & Low Carbon Generation • Energy in Developing Countries • Markets, Policy & Systems Transitions • Fossil fuels and resources for energy systems	18 researchers
Institute of Energy and Sustainable Development De Montfort University	The Institute of Energy and Sustainable Development (IESD) has been undertaking interdisciplinary research for more than three decades to develop knowledge, skills and technology to support sustainable living in communities through	• Low-carbon energy systems and infrastructure • Sustainable Communities and Sustainable Living	18 researchers

Name	Description	Sub-topics covered	No of staff
	low carbon energy systems and infrastructure as well as bringing solutions to the base of the pyramid population.	• Solutions for the base of the pyramid population	
Science, Technology and Innovation Studies (STIS) University of Edinburgh	Explores questions about how societies both influence and are influenced by science, medicine and technology.	Research theme on 'Environment, Energy and Sustainability', covering energy policy and politics, environmental monitoring, and sustainable food production.	12 Researchers (on energy theme)
Sussex Energy Group, SPRU, University of Sussex	The Sussex Energy Group undertakes academically rigorous, inter-disciplinary research that engages with policy-makers and practitioners. The aim of its research is to identify ways of achieving the transition to sustainable, low carbon energy systems whilst addressing other important policy objectives such as energy security. The Group has funding from a diverse array of sources. It is core partner in the Tyndall Centre for Climate Change Research and part of the UK Energy Research Centre.	• Energy innovation and transitions • Economics and finance • Energy justice • Energy demand and behaviour • Smart infrastructure • Energy supply technologies	47 researchers
Sustainability Research Institute University of Leeds	The Sustainability Research Institute's work on energy seeks to understand whole energy systems and how they might transition in order to mitigate climate change. It is involved it interdisciplinary research across the energy system, with a particular focus on local generation, distribution, storage and demand, covering both electricity and heat, and considering the wider relationship between energy, economy and society.	• Energy systems modelling • Understanding impacts and distribution of energy systems • Issues of scale • Transitions and development • Governance and policy of energy systems	20 researcher (Energy and Climate Change Mitigation theme)
Sustainable Consumption Institute University of Manchester	The Sustainable Consumption Institute (SCI) explores how reconfiguring consumption and production systems can contribute to less resource-intensive ways of life. Placing consumption in the foreground of our research allows us to better	• Everyday lives • System innovation and transition • The politics of unsustainability • Working towards sustainability	25 researchers

Name	Description	Sub-topics covered	No of staff
	understand human needs, values, practices and habits, informing the drive to create more sustainable societies. However, this focus is balanced with questions surrounding the production, supply and distribution of goods and services - these factors shape how people live their everyday lives, and are in turn shaped by consumption.		
The Centre for Energy, Petroleum and Mineral Law and Policy, University of Dundee	Research is undertaken in natural resources and energy law and policy, combining economics, financial and legal and policy issues. The broad aim of our research is to achieve originality, excellence and to stimulate informed debate. Our academics are working on projects concerning international development, financing renewable energy projects, Chinese investment in African economies and mineral law. In recent years, the focus of this research has moved to the challenges associated with a long-term transition to a low carbon economy and potential conflicts between the current carbon dependence of society and sustainability.	• Energy law • Energy economics • Energy diplomacy and climate politics	13 researchers

Name	Description	Sub-topics covered	No of staff
The Grantham Research Institute on Climate Change and the Environment London School of Economics	The Grantham Research Institute on Climate Change and the Environment was established by the London School of Economics and Political Science in 2008 to create a world-leading centre for policy-relevant research and training on climate change and the environment, bringing together international expertise on economics, finance, geography, the environment, international development and political economics. It brings together international expertise on economics, finance, geography, the environment, international development and political economy, with the aim of producing globally recognised, policy-relevant research.	• Changing Behaviours • Sustainable Finance • Governance and Legislation • Growth and Innovation • Policy Design and Evaluation • Sustainable Development Goals	40 researchers (not all focused on socio-economic energy research)
Tyndall Centre Universities of Manchester, East Anglia, Newcastle and Cardiff	The Tyndall Centre was founded in 2000 to conduct cutting edge, interdisciplinary research, and provide a conduit between scientists and policymakers. With nearly 200 members ranging from PhD researchers to Professors, the Tyndall Centre represents a substantial body of the UK's climate change expertise from across the scientific, engineering, social science and economic communities. The Tyndall Centre is a unique partnership between the universities of East Anglia (Headquarters), Cardiff, Manchester, Newcastle, Sussex and Fudan University in Shanghai.	• Accelerating Social Transitions • Overcoming Poverty with Climate Actions • Building Up Resilience • Reaching Zero Emissions	200 researchers (includes PhDs and not all focused on socio-economic energy research)

Name	Description	Sub-topics covered	No of staff
UCL Energy Institute University College London	The Energy Institute is part of the Bartlett of Environment, Energy and Resources: UCL's global faculty of the built environment. Its research spans the entire energy demand system, from consumer behaviour and household technologies to policy-making.	Its remit is broad but the most socio-economic research themes are the following: • **Energy Systems** - interactions of different energy system elements, across a wide range of geographical scales (UK, EU, the World), with different tools focusing on different elements of the system (technology, economy, environment & climate change) • **Energy Space Time** - research into the design and application of sustainable energy systems, whole system integration in space and time. • **Buildings** – Amongst other more technical research, consideration of socio-technical systems, which combine monitoring and data with the social sciences, look at how behaviour affects energy consumption	62 research staff (NOTE: some individuals may not work specifically on socio-economic research)
Undertaking Risk Research Group Department of Psychology, University of Cardiff	The Understanding Risk group is an interdisciplinary social sciences (psychology, sociology and technology studies, geography) research unit focusing on the impacts upon individuals and communities, and acceptability to people, of environmental and technological risk within everyday life.	• Psychology of climate change; • Public attitudes towards and acceptability of energy supply systems; • Sustainable behaviour change and energy demand reduction; • Social conflicts and siting of large scale energy technologies; • Risk perception, communication and public engagement	22 researchers

4. Applied Research

Return to Top

Not applicable

5. Development and Demonstration Funding

Return to Top

Not applicable

6. Research Facilities and Other Assets

Return to Top

Not applicable

7. Networks

Return to Top

The below explores networks that facilitate engagement and knowledge exchange across the socio-economic energy research landscape. It is worth noting that many of the large consortia outlined in Section 3 perform a key networking role by bringing together key institutions and researchers, as well as linking these with other stakeholders. International networks are covered in Section 9

Table 7.1 Networks

Network	Established	Description	Membership	Activities
British Institute of Energy Economics (BIEE)	1984	BIEE is an independent institute and membership organisation for business, finance, government and academic professionals from all parts of the energy industry. Its expertise is in energy economics and policy, with a focus on the UK energy system, world energy markets, climate policy and the future energy landscape. The UK is at the leading edge of many energy-related issues. It is home to some of the world's largest and most innovative companies and financial institutions involved in providing and financing energy. UK government policy in energy and climate change has many innovative aspects, (e.g., the Committee on Climate Change) and the UK academic research on energy issues has a high international profile. BIEE is the UK affiliate of the International Association of Energy Economics (IAEE).	Individual and corporate membership. Membership is drawn from universities, government, international agencies, regulatory bodies, industry and the financial sector.	• Convening a regular programme of meetings seminars and conferences held in London Oxford and Scotland to debate current issues in both the UK and world energy markets. • Publishing presentations, papers, and discussion summaries from our meetings. • Helping to develop the next generation of professionals, by offering students free membership, research prizes and financial support. • Contributing to wider international energy debates through association with the International Association for Energy Economics (IAEE) and its regional affiliates. The BIEE encourages its members to become IAEE members
DecarboN8 - An integrated network to	2019	The DecarboN8 project will develop a new network of researchers, working closely with industry and government, capable of designing	Led by the eight most research intensive Universities	• Funding of early career networking initiatives.

decarbonise transport		solutions which can be deployed rapidly and at scale	across the North of England (Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield and York).	• 12 research workshops which will bring new research interests together to better understand the specific challenges of the transport sector and develop integrated solutions • Interface with non-research stakeholders.
Energy Pioneers	2017	Networking and skills-building events for women in the energy sector, with a particular focus on connecting researchers with policy-makers.	N/A	• Increase the visibility of expert female investigators in policy discussions in a gender-balanced way to encourage new voices, new ideas, and new discussions. • 4 outreach events for the benefit of the wider energy community. • Designing and executing policy relevant discussions and share learning.
Heat Network: heat decarbonisation network	2017	The Heat Network, led by charity 10:10 Climate Action working in collaboration with UKERC researchers, looks 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.	N/A	• Survey work, workshops and publications to for the first time pull together those researching and innovating around sustainable heating. • Bursaries to cover travel and child care for events in order to encourage niche players, small businesses and diverse interests to attend the events • Document targeted at the research councils advising them on the current status of UK heat R&D and where more research and innovation may be of most value.
Low Carbon Energy for	2012	Expanding research capacity around low-carbon energy development in the Global South by	• Initially five academic	• Annual conferences • Build collaborative partnerships for projects which expand research

Development Network (LCEDN)		bringing together researchers, practitioners and policy-makers.	research centres: • SPRU at the University of Sussex • Energy Futures Lab at Imperial College • UKERC • Durham Energy Institute • Midlands Energy Consortium	capacity and find solutions relating to sustainable energy development in the Global South. • News and events dissemination
Nexus network	2014	The Nexus Network has worked to support transdisciplinary research at the food-water-energy-environment nexus and to create meaningful links between communities of researchers, policymakers, business leaders and practitioners.	Five core university partners	• Events to frame nexus challenges Insights into tools and methodologies for nexus thinking and practice • Flexible small grants programme and fellowship scheme • Stakeholder engagement • Built capacity in the UK research system for future investments • Provide strategic advice to ESRC, RCUK and other funding bodies.
Ripples Network	2016	RIPPLES is an interdisciplinary group of early career researchers whose work focuses on the interaction between government policy and grassroots practice in local and community-led sustainability initiatives.	15 early career researchers	• Blog • Publications list • Regular gatherings

UKERC Whole Systems Networking Fund	2017	Not explicitly a network but an initiative to build networks. The Whole Systems Networking Fund aims to improve equality, communications and collaboration between those working in the field of whole systems energy. The fund is helping to develop best practice around networking, fostering better representation of UK capacity in whole systems energy research, encouraging fresh voices and building new working relationships within the community.	18 projects stretching across numerous UK institutions.	List of associated projects here. Some are presented individually in this table.
Women's Whole Energy Systems Research and Industry Network (WERIN)	2017	A project to identify women working in energy and whole systems energy research, and to run a series of online and offline networking events to highlight the capacity of women in the energy sector.	N/A	The project will build a user-friendly, online platform that will highlight the skills and research interests of each of the members. Once a network group has been established, the project will host a number of virtual and physical networking events throughout the UK.

8. Uk Participation in EU Framework Programmes

Return to Top

The below is not an exhaustive list of EU Horizon2020 funded socio-economic energy projects, with UK participation. However, it does provide an overview of the major ongoing projects.

Table 8.1: EU Framework Programmes

Project	Objectives	Action Line	Type of Action	UK Participants	Co-ordinator and partners	Duration	Total Funding (€m)	EU Funding (€m)	Total annual spend (€mpa)
ENERGISE European Network for Research, Good Practice and Innovation for Sustainable Energy	ENERGISE is an innovative pan-European research initiative to achieve a greater scientific understanding of the social and cultural influences on energy consumption. ENERGISE develops, tests and assesses options aimed at transforming the quality and quantity of energy use among households and communities across Europe.	H2020-EU.3.3.6.	N/A	Kingston University	National University of Ireland, Galway	2016-2019	3.7	3.2	1.2
Auctions for Renewable Energy Support II (AURES II)	Building on the insights of the recently finalized AURES project, AURES II investigates auction design options in more detail to determine their policy performance depending on different of policy objectives and give recommendations on their use. We apply a multi-methodological approach, including literature review, theoretical analysis, case studies, surveys, and	H2020-EU.3.3.2. H2020-EU.3.3.7. H2020-EU.3.3.3.	N/A	The University of Exeter	Fraunhofer, Germany	2018-2021	2.6	2.6	0.9

Project	Objectives	Action Line	Type of Action	UK Participants	Co-ordinator and partners	Duration	Total Funding (€m)	EU Funding (€m)	Total annual spend (€mpa)
	empirical and quantitative methods such as econometric analysis and model simulations.								
end-users Tools to Empower and raise Awareness of Behavioural CHange towards EneRgy efficiency (E-TEACHER)	eTEACHER concept consists of encouraging and enabling energy behaviour change of building users by means of continuous interventions displayed through a set of empower tools to drive informed decisions in order to save energy and optimise indoor environment quality. These empower tools are a set of ICT solutions that ensures friendly connection in between end-users and building systems, implement continuous behavioural change interventions and provide tailored advice.	H2020-EU.3.3.1.	N/A	De Montfort University Nottingham City Council	Centro De Estudios De Materiales Y Control De Obra	2017-2020	2.4	2	0.8

Project	Objectives	Action Line	Type of Action	UK Participants	Co-ordinator and partners	Duration	Total Funding (€m)	EU Funding (€m)	Total annual spend (€mpa)
New Buildings Energy Renovation Business Models incorporating dual energy services (NOVICE)	NOVICE will develop and demonstrate a new business model in building renovation to better monetize energy efficiency by consolidating services and subsequent revenue streams from both energy savings and demand response. In order to do so NOVICE introduces new actors (aggregators) in building energy upgrade projects and fosters their collaboration with ESCOs, financing institutions, facilities management companies, engineering consultants to facilitate the roll out of the dual (grid services and energy efficiency) energy services model.	H2020-EU.3.3.7. H2020-EU.3.3.1	N/A	Kiwi Power Ltd	University College Cork, Ireland	2017-2020	2	2	0.7

9. International Initiatives

Return to Top

Table 9.1: International Activities

Name	Type	Description	UK Contact Point
Clean Energy Transitions Programme	IEA programme	Launched in November 2017, the IEA Clean Energy Transitions Programme (CETP) is an ambitious effort to accelerate global clean energy transitions. The programme provides independent, cutting-edge support to governments whose energy policies will significantly influence the prospects for – and the speed of – the global transition towards more sustainable energy production and use. The CETP is supported by 13 IEA Member governments. Within the IEA Secretariat, the CETP is set up horizontally, with each work stream led by the respective IEA division with subject matter expertise, along with support by respective IEA country officers. A central CETP co-ordination team helps to ensure efficient and effective operation across the entire programme.	N/A
Climate Technology Initiative (CTI)	IEA Technology Collaboration Programme	The Climate Technology Initiative (CTI) was a multilateral initiative, operating as an Implementing Agreement under the International Energy Agency (IEA). CTI's objective was to enable countries to work together to foster international co-operation for accelerated development and diffusion of climate-friendly and environmentally sound technologies and practices. CTI participating countries implemented a broad range of co-operative activities in partnership with developing countries and countries in transition, the United Nations Framework Convention on Climate Change (UNFCCC), in particular the technology mechanism of the UNFCCC, relevant IEA Implementing Agreements, other international organizations or initiatives and the private business and financial communities.	n/a

		CTI's activities were: • Facilitation of private financing for technology transfer • Application of Clean Energy Technologies • Support assessment of Developing country technology needs • Capacity building • Outreach activities • CTI collaboration with TEC and CTC&N	
Demand-Side Management (DSM)	IEA Technology Collaboration Programme	The TCP's mission is to provide evidence from socio-technical research on the design, social acceptance and usability of clean energy technologies to inform policy making for clean, efficient and secure energy transitions. Decarbonisation, decentralisation and digitalisation are embedding energy technologies in the heart of our communities. Communities' response to these changes and use of energy technologies will determine the success of our energy systems. Poorly designed energy policies, and technologies that do not satisfy users' needs, lead to 'performance gaps' that are both energy and economically inefficient. User-centred energy systems are therefore critical for delivering socially and politically acceptable energy transitions.	David Shipworth Samuel Thomas
Energy in Buildings and Communities (EBC)	IEA Technology Collaboration Programme	The EBC TCP, created in 1977, carries out research and development efforts towards near-zero energy and carbon emissions in the built environment. Activities under the EBC TCP focus on the integration of energy-efficient and sustainable technologies into healthy buildings and communities.	Malcolm Orme, AECOM
European Council for an Energy Efficient Economy (ECEEE)	International network	ECEEE, the European Council for an Energy Efficient Economy, is a membership-based non-profit association. As Europe's largest and oldest NGO dedicated to energy efficiency, we generate and provide evidence-based knowledge and analysis of policies, and we facilitate co-operation and networking. Its members are found among private and	N/A

		public organisations, as well as among all those professionals from all sectors who share ECEEE's goals.	
Energy Technology Systems Analysis (ETSAP)	IEA Technology Collaboration Programme	The ETSAP TCP, established in 1977, is among the longest running TCPs. Its mission is to support policy makers in improving the evidence base underpinning energy and environmental policy decisions. This is achieved through energy systems modelling tools and capability through a unique network of nearly 200 energy modelling teams from approximately seventy countries. The ETSAP TCP develops, improves and makes available the TIMES (and MARKAL) energy systems modelling platform. It also provides training to energy modellers to use this platform to build national, regional and global energy systems models. In addition, ETSAP supports policy makers in undertaking and interpreting energy technology assessments and scenario analysis to inform policy decisions.	Kenneth Karlsson
European Forum for Studies of Policies for Research and Innovation (EU-SPRI)	International network	The "European Forum for Studies of Policies for Research and Innovation" (Eu-SPRI Forum) aims to strengthen the vibrant but dispersed interdisciplinary community of researchers focusing on interdisciplinary dimensions related to policy and governance in the field of knowledge creation and innovation.	Debbie Cox, University of Manchester
International Association of Energy Economics (IAEE)	International network	The IAEE is a worldwide non-profit professional organization which provides an interdisciplinary forum for the exchange of ideas, experience and issues among professionals interested in energy economics. To achieve this goal, it publishes The Energy Journal – a quarterly, academic publication, and holds International American and European Energy Conferences each year.	Benjamin J. Klooss, BP
LCS-RNet	International network	LCS-RNet is a practical platform of researchers/research organisations that are making close contributions to individual countries' low-carbon policy-making processes. The basic nature of LCS-RNet is a platform to support and encourage information sharing and voluntary cooperation among research institutions, specifically in the field of LCS research. LCS-RNet also facilitates interactions between researchers and various stakeholders and delivers its findings to policy-makers to assist in science-based policy making during transitions to low-carbon societies.	lcs-rnet@iges.or.jp

International Smart Grid Action Network (ISGAN)	IEA Technology Collaboration Programme	The programme will consist of efforts to improve understanding of smart grid technologies, practices, and systems, to accelerate their development and deployment, and to promote adoption of related enabling government policies. It will create a network of national stakeholders to facilitate dynamic knowledge sharing, technical assistance, and project coordination, where appropriate, across five topic areas: • Policy, Standards and Regulation • Finance and Business Models • Technology and Systems Development • User and Consumer Engagement • Workforce, Skills and Knowledge	John Baker, EA Technology
Sustainability Transitions Research Network (STRN)	International network	STRN is an international network of more than 1,500 scholars interested in sustainability transitions. Sustainability transitions are long-term transformation processes of established industries, socio-technical systems and societies to more sustainable modes of production and consumption. STRN is an entirely independent, research-driven network. Membership is open to anyone who is interested and involved in research on sustainability transitions. Mission is to deepen the scientific understanding of sustainability transitions through a program of networking, research coordination, education and synthesis activities. Towards this end it provides a meeting place and a platform, where researchers can engage in a vibrant intellectual exchange on the challenges of sustainability transitions. It is also a hub for practitioners in policy making, civil society, and business who are working to advance societies into more sustainable directions.	
Transformative Innovation Policy Consortium (TIPC)	International network	The Transformative Innovation Policy Consortium (TIPC) is a group of policy makers and funding agencies working together to give substance to a new framing for Science, Technology and Innovation (STI) policy	Johan Schot, Utrecht University

		that aims to contribute to addressing global societal challenges, as encapsulated in the United Nations' Sustainable Development Goals, including climate change, inequality, employment and pathways to economic growth and development. Co-ordinated by the Science Policy Research Unit (SPRU) at the University of Sussex in the UK, the current members are innovation ministries and funding agencies from Colombia, Finland, Mexico, Norway, South Africa and Sweden. There are additional associate programmes in China, Brazil, Panama, Netherlands, Senegal, Ghana, and Kenya. For more details, please see our members' page. TIPC is underpinned by recent work on the Three Frames of Innovation with Frame 3 being 'Transformative Innovation Policy' (Schot, Steinmueller 2018). Frame 1 refers to policies aimed at generating social benefits through R&D investment. While Frame 2 takes account of the systemic relationship between these investments, and the industrial and institutional framework of a country, the so-called National Systems of Innovation.	