Centre on Innovation and Energy Demand

The UK's climate goals are ambitious and challenging. Achieving an 80% reduction in GHG emissions by 2050 will require near complete decarbonisation of the electricity sector; the rapid and widespread deployment of innovative technologies such as heat pumps and battery electric vehicles; dramatic improvements in energy efficiency in all sectors of the economy; and far-reaching changes in individual behaviour, social practices and cultural norms. The anticipated rate and scale of emission reduction is without historical precedent and presents an enormous policy challenge.

The Centre seeks to contribute to this challenge by developing an interdisciplinary understanding of the *emergence, diffusion* and *impact* of ***low-energy innovations*** - defined as new technologies, organisational arrangements and/or modes of behaviour that are expected to improve energy efficiency and/or reduce energy demand. While many low-energy innovations represent relatively incremental changes to existing arrangements, large emission reductions will require more radical innovations involving far-reaching changes in technologies, infrastructures, institutions and behaviour. The Centre will use a *socio-technical* and *co-evolutionary* approach to understand how different types of low energy innovation emerge and diffuse in various end-use sectors; to identify how more rapid diffusion can be achieved; to quantify the corresponding impacts on energy demand and carbon emissions; and to provide practical recommendations for UK energy and climate policy.

The Centre's will take an interdisciplinary approach, drawing upon ideas from economics, innovation studies and human geography and combining case studies, surveys, econometric analysis and modelling. Individual projects will investigate a range of incremental and radical innovations in the industrial, buildings and transport sectors, with the aim of identifying common themes and drawing context-specific lessons. The Centre will also collaborate with stakeholders to develop practical ideas and recommendations, as well as providing interdisciplinary training, capacity building, networking and international collaboration in the area of innovation and energy demand.

Rationale

The dominant approaches to understanding energy demand and informing policy focus upon the technical and economic potential for improving energy efficiency, the economic barriers to technology adoption and the psychological factors shaping energy-related behaviour. While these perspectives provide essential insights, they tell us little about how low-energy innovations emerge and diffuse, or how they both shape and are shaped by the broader process of socio-technical change. They also systematically overestimate the impact of such innovations on economy-wide energy consumption.

Innovation and diffusion is driven by multiple positive feedback mechanisms, such as scale economies, learning economies and knowledge spillovers that act to drive down costs, increase market size, encourage investment and trigger further technical improvements and cost reductions. These processes combine with co-evolving infrastructures, skills, institutions, policies and lifestyles to make technological change non-linear and path dependent. Once established, 'socio-technical systems' have considerable inertia, leading to sectors and economies becoming *locked-in* to energy-intensive systems and making it difficult for new, low energy innovations to become established. For example, our car-based transport system comprises multiple, interdependent elements (e.g. fuel supply, vehicle manufacturing, road infrastructures, land-use patterns, government regulations, individual behaviours, social norms) that make any radical shifts towards public transport or alternatively fuelled vehicles extremely challenging.

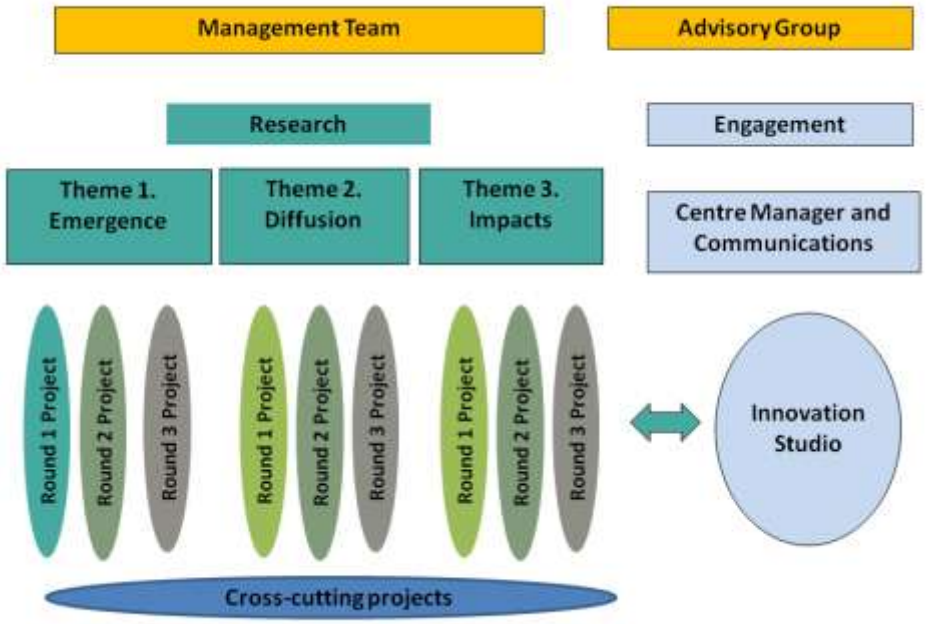
Even when established, low-energy innovations may not deliver the anticipated energy and carbon savings. Estimates of the economic impact of such innovations frequently neglect how individuals, organisations and economies respond to cheaper energy services. For example, energy efficient

lighting encourages people to illuminate larger areas to higher levels over longer periods of time. If carbon targets are to be met, these mechanisms need to be anticipated and addressed.

The Centre sets out to address these weaknesses in the existing research and policy approach. We will use insights and approaches from innovation studies to understand how low-energy innovations emerge and diffuse, together with quantitative techniques to explore their effects.

Approach

The Centre combines a number of research projects organised within three research themes, alongside cross-cutting research projects and a variety of communication and engagement activities.



The research themes are:

T1. ***Emergence***: Innovation is an uncertain process in which emerging technologies struggle against existing socio-technical systems. To succeed, new innovations need to be 'sheltered' from prevailing selection pressures to provide space for development and learning. This theme will study a limited number of emerging and promising low energy innovations with the aim of better understanding the mechanisms and processes involved and the conditions for success.

T2. ***Diffusion:*** Diffusion is driven by a combination of market and non-market mechanisms and involves interactions between consumers, businesses, policymakers and civil society. Low-energy innovations offer environmental benefits, but are unlikely to diffuse widely without changes in policy and socio-cultural support. This theme will investigate the enablers and obstacles to diffusion for both incremental and radical low-energy innovations, focusing on those that offer significant potential for demand reduction.

T3. ***Impact***: Economies are complex systems, making it challenging to estimate the historical or possible future impacts of low-energy innovations. In particular, the causal linkages between income growth, efficiency improvements and energy consumption are poorly understood. This theme will use econometric and other techniques to estimate the historical energy savings from low-energy innovations, to explore future energy savings and to identify how they may be increased.

Projects

Each research theme will include two or three substantive research projects during the life of the Centre, alongside cross-cutting projects to integrate the emerging findings.

Seven projects will be launched in year 1, as follows:

T1. ***Decentralised manufacturing***: Rapid advances in open-source, small-scale digital design and fabrication technologies (such as 3D printing) are being hailed as a third industrial revolution, but their energy and environmental implications are unclear. This project will explore the activities and narratives of grassroots groups experimenting with digital fabrication, assess the future prospects of these technologies and identify potential synergies and conflicts with demand reduction.

T1. ***Innovations in urban transport:*** City-regions are important locations for novel, low carbon transport initiatives such as car clubs, mass transit and congestion charging. This project will use comparative case studies of multiple bottom-up and top-down initiatives of varying types and scales in four city regions (London, Liverpool, Brighton and Oxford) with the aim of explaining variations, exploring the implications for energy use, identifying the factors that facilitate or obstruct success and assessing the potential for transfer to other regions.

T2. ***Learning about diffusion from experiences in other countries***: There are multiple examples of successful low-energy innovations, but factors contributing to their success may not translate to other regions, time periods or innovations. This project will use a series of case studies (e.g. district heating systems, passive houses, intermodal transport) to investigate how and why the relative importance and interaction between different diffusion mechanisms varies with context and type of innovation.

T2. ***The diffusion of energy service contracting***: Energy service companies offer an attractive means to deliver energy efficiency investment and may potentially provide the basis of a more sustainable, service-based economy. This project will identify the factors underpinning the success of energy service business models, assess whether, how and under what conditions these (and other) models could diffuse more widely, estimate their market and energy-saving potential and develop practical policy recommendations.

T3. ***Rebound effects in UK transport***: Technical improvements in vehicle fuel efficiency may encourage the adoption of larger and more powerful vehicles as well as increased transport activity, re-spending of cost savings on other goods and services that also require energy to provide and broader changes in economic structure. Such 'rebound effects' will offset the potential energy savings. This project will use econometric techniques to quantify different types of rebound effects in UK road passenger and freight transport, and will extend the analysis to shipping and aviation.

T3. ***Evaluating energy efficiency policies for households:*** The energy savings achieved by household energy efficiency policy are uncertain owing to the scarcity of rigorous, ex-post evaluations. This project will conduct a systematic review of the existing evidence base, focusing upon quasi-experimental or econometric studies that control for selection bias and free-riders. The project will identify the energy savings achieved, draw conclusions for 'what works' in this area and recommend effective and practical approaches to policy evaluation.

X1. ***Policy synergies and trade-offs***: This will the synergies and trade-offs between policies to encourage low-energy innovations and other overlapping energy policies in multiple empirical domains.

The research portfolio will be developed iteratively in consultation with stakeholders and an Advisory Group and will be responsive to changing priorities and opportunities. The projects will seek to provide a balanced coverage of methodological approaches, innovations and empirical domains. Several

projects will be conducted in collaboration with non-academic partners, and opportunities to obtain co-funding and instigate associated projects will be pursued. Currently planned future projects include:

- *Low-carbon non-domestic buildings*: case-study investigation of the obstacles to innovative designs and the organisational and policy initiatives that may allow them to become the norm.
- *Electric vehicle diffusion*: development of a systems dynamics model to explore the determinants of successful diffusion of hybrid-electric and battery-electric vehicles in the UK.
- *Contemporary success stories*: case studies of the diffusion of successful, incremental innovations in the UK, such as CFLs, white goods, efficient motors, and industrial process innovations.
- *Energy productivity and economic growth*: investigation of the long-term relationships between energy efficiency, economic output, and quality-adjusted energy consumption.

Innovation Studio

The Studio will be the Centre's engagement hub. It will carry out a range of activities that will be designed to work with external stakeholders – particularly non-academic practitioner organisations. This will include hosting visitors, organising research and policy workshops, holding a final conference in year 5 and hosting a PhD summer school. The Studio will also make available research staff time to work with non-academic organisations on specific low energy innovation questions and problems. This will include short (1-2 month) placements of Centre researchers in these organisations. This should have advantages for both parties: it will provide additional resources to organisations with limited budgets such as Local Authorities; and it will help the Centre gain a deeper understanding of the issues facing these organisations.

Organisation and People

The Centre is a collaboration between the Sussex Energy Group (SEG) at SPRU, University of Sussex; the Transport Studies Unit (TSU) at the University of Oxford; and the Sustainable Consumption Institute (SCI) at the University of Manchester. The Centre will initially work with several non-academic organisations including energy utility SSE, Brighton and Hove City Council, Oxfordshire County Council and The Discovery Mill. Further collaborations will be developed during the life of the Centre.

The Centre will be led by Dr Steve Sorrell, in collaboration with Professor Frank Geels, Dr Tim Schwanen and a new Senior Fellow and supported by a Centre Manager.

- **Steve Sorrell** is co-director of the Sussex Energy Group and has over 20 years experience of energy and climate policy research, with a particular focus on energy efficiency. Steve is an internationally recognised expert on the 'rebound effects' from efficiency improvements.
- **Frank Geels** is Professor of System Innovation and Sustainability at the Sustainable Consumption Institute (SCI) and a world leading scholar on socio-technical transitions. Frank is widely known for his conceptual work on the 'Multi-Level Perspective' and for his historical and contemporary case studies of socio-technical transitions within multiple domains.
- **Tim Schwanen** is a Departmental Lecturer in Transport Studies and Human Geography at the Transport Studies Unit (TSU), University of Oxford. Tim's research focuses on the relationship between transport and climate change and he is internationally known for his work on the intersection of human geography and transport studies.

The other contributing researchers are: David Banister (Director, TSU), Adrian Smith (Senior Fellow, SEG), Florian Kern (Research Fellow, SEG), Sabine Hielscher (Research Fellow, SEG), Mari Martiskanen (Research Fellow, SEG) and Rebecca White (Research Fellow, SEG). The Centre will recruit one Senior Fellow, four Research Fellows and a Centre Manager, as well as funding five PhD studentships to deliver a total of 60 researcher-years.