THE BARTLETT
ENERGY INSTITUTE
ANNUAL REVIEW 2019

UCL

UCL Energy Institute 2019 Review

The UCL Energy Institute delivers world-leading learning, research and policy support on the challenges of climate change and energy security. We are part of The Bartlett: UCL's global faculty of the built environment.

> ucl.ac.uk/energy
> @UCL_Energy

Director’s Introd ction

Prof Neil Strachan re ects on the relevance of our work helping to build a globally sustainable energy system in the current climate of energy research.

Our Annual Review gives us an opportunity to look back and appreciate how far we have come.

UCL Energy Institute celebrated its 10th anniversary on 21 May 2019. In ten years we have grown from a cadre of 5 staff to over 100 faculty, staff and PhD students, plus a further large and vibrant cohort of MSc students. We continue to meet our goal to be the UK’s leading research and teaching centre on energy demand and energy systems, and a leading international player in these elds.

We have now truly completed the target setting process for the energy transition. The UK’s game-changing decision in June 2019 to legislate a Net Zero emissions target by 2050 (becoming the rst G20 economy to do so) emphasises that every interlinked sector in the energy system must decarbonise, and that fundamental change in energy service demands is essential to meeting such deep reductions.

Now, we are in the fast-moving, high-stakes and path-dependent implementation phase of the energy transition. The UK formally left the EU on 31 January 2020, and now with a new stable government it must adapt to the risks and opportunities this creates, including balancing energy decarbonisation, security and costs while trying to help UK energy companies win the races for the new technologies, services and business models in a low carbon energy system

The role of consumers and society in the energy transition is increasingly coming to the fore, with energy and the environment becoming a top tier issue in the UK general election for the rst time. The Extinction Rebellion protests remind us that many in our society are pushing hard for even more radical changes in the way we supply and consume energy, producing a very real shift in the debate and media framing. And with the UK hosting the critical COP26 conference in Glasgow, the eyes of the world will be looking for evidence based and practical action to enable a step-change in the pace and scale of energy decarbonisation.

With this exciting, challenging and sometimes unnerving backdrop in mind, our vision - to observe, analyse, interpret and in uence energy use and energy systems to help to build a globally sustainable energy system - could not be more relevant and important.

This review outlines our key roles in major UK energy research collaboration centres and our presence in key EU funded research consortiums, as well as our major outputs.

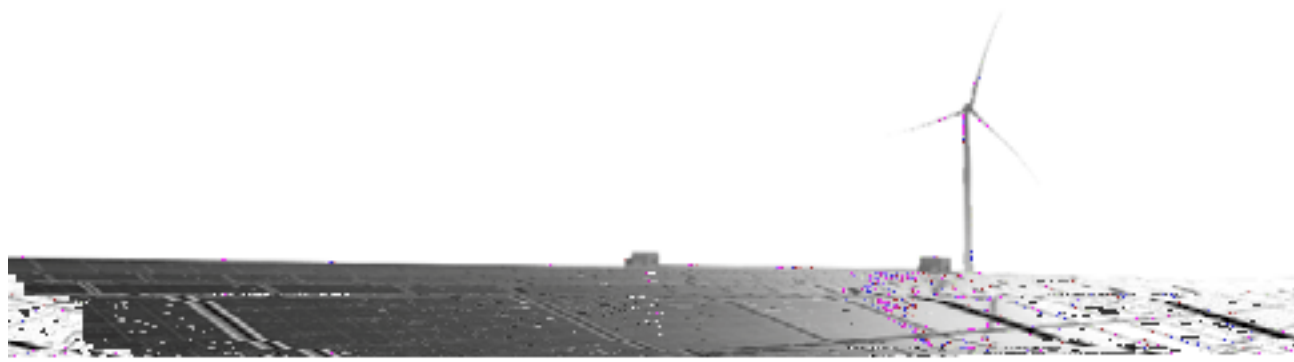
Our teaching programmes also continue to go from strength to strength - our students are diffusing into key positions in industry, government and international organisations as they make it their careers to drive this decadal energy transition challenge.

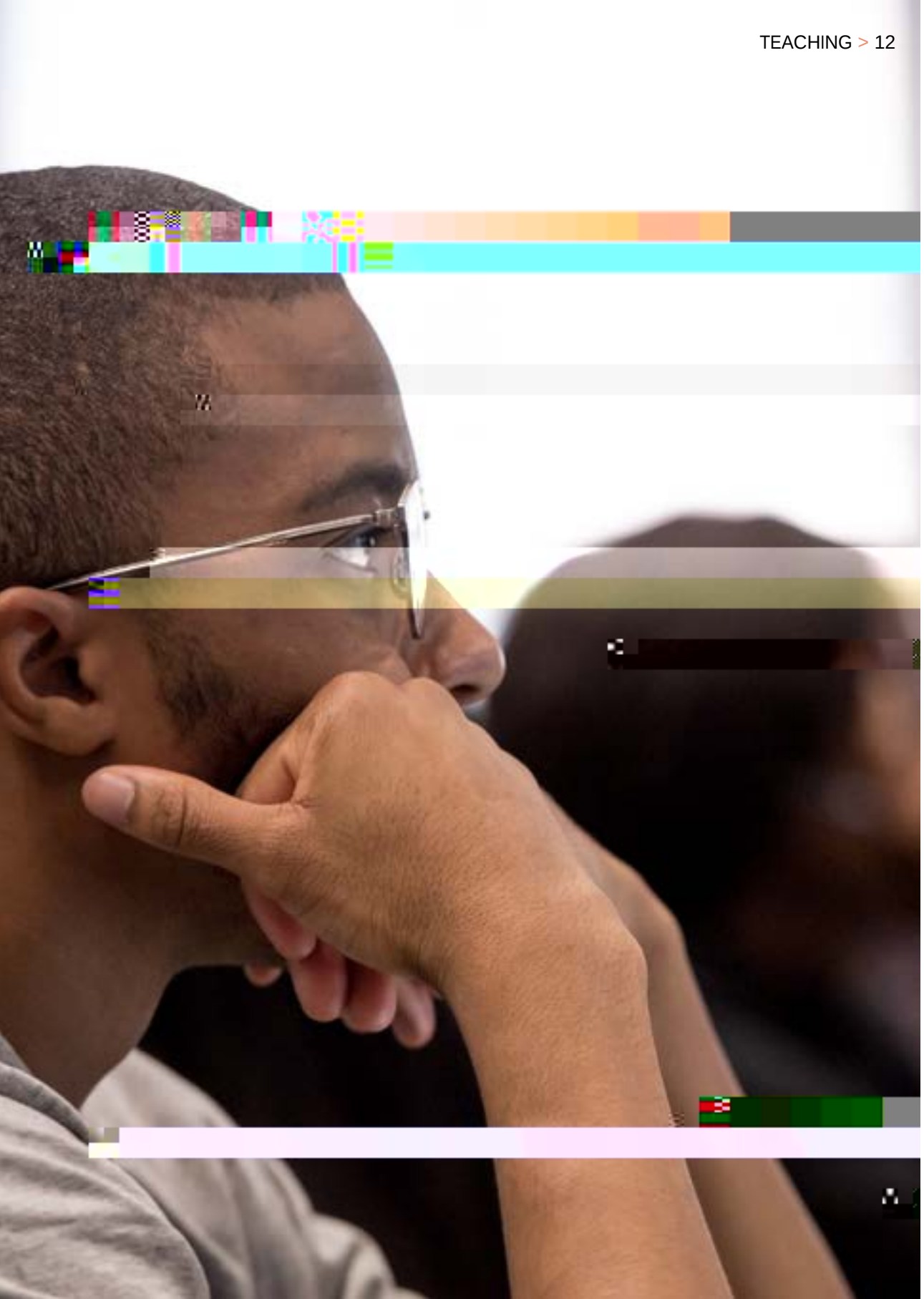
P utUns

CO and cogniti e performance

Researchers from our Building Research theme won the Napier Shaw Bronze Medal, awarded by CIBSE (Chartered Institution of Building Services Engineers) for the best research paper published in their journal.

The paper, entitled ‘Possible future impacts of elevated levels of atmospheric CO_2 on human cognitive performance and on the design and operation of ventilation systems in buildings’ was published in the CIBSE journal in July 2018. Its authors





Energ S stems and Data Anal tics MSc

Abo t the programme

Energy Systems and Data Analytics (ESDA) MSc is the rst programme of its kind in the UK, combining the study of Energy Systems with Data Science. Through this programme, we aim to equip students with a multi-sector, multi-vector understanding of Energy Systems, while developing advanced statistical and machine learning skills and getting practical experience of data analysis.

The programme is aimed at students with

St dent insight

We talked to Ayrton Bourn, Energy Systems and Data Analytics Alumni 2019, about what brought him to study this Master's at UCL, his experiences on the programme and what he plans to do next.

What as o r academic backgro nd before coming to UCL and joining the Energ S stems and Data Anal tics MSc?

I studied Chemical Engineering at the University of Shef eld, focusing on the application of carbon capture in heavy

Doctoral research - MPhil / PhD

Abo t the programme

UCL Energy Institute delivers world-leading

Energ Resilience in the B ilt En ironment CDT

The ERBE Centre for Doctoral Training trains future leaders and innovators in the eld of energy and the built environment.

The energy system is undergoing a major transition. Low carbon energy sources have an increasing role to play, accommodating them requires new exibility in the system, and the relationship between energy supply and demand is no longer one-way.

This interaction of people, buildings and energy systems will transform the relationship between supply and demand. Our domestic and non-domestic buildings will no longer be passive consumers of heat and power; instead, our homes and businesses will participate actively in a exible, integrated, low-carbon supply and demand system that includes buying, selling and storing heat and power. To implement this vision, we need people with a deep understanding of building physics, low-zero carbon technologies and the socio-technical context, to lead and drive change in government, industry, NGOs and academia.

The new EPSRC CDT in Energy Resilience and the Built Environment (ERBE) brings together established energy research centres at Loughborough University (LU) and University College London (UCL) with the Marine and Renewable Energy Ireland (MaREI) Centre. Loughborough and UCL will train at least 50 PhD students through a programme of energy demand research in a whole energy system context.

We build on a decade of experience of high-quality doctoral training to provide a bespoke new PhD programme, including: opportunities to work with leading researchers, projects integrated with industry and a comprehensive skills and development programme. We are centred rmly within the UK's energy research landscape and so all PhDs will have the opportunity to undertake signi cant, impactful research.

After a successful recruitment process, the aforementioned projects will be running during the 2019-20 academic year. For news about projects running in 2020-21 visit erbecdt.ac.uk.

Research

Transport

A iation

The Air Transportation Systems Laboratory explores the interaction between air transportation, the economy, and the environment.

What e do

Air transportation is a vital enabler of growth in the economy and quality of life through empowering trade and tourism. At the same time, its large and still growing scale generates undesirable effects, such as air traf c delays and environmental impacts at the local, regional, and global level.

The Air Transportation Systems Laboratory explores the interaction between air transportation, the economy, and the environment. Our work is data-driven, using physical science, econometric, and operations research-based methods. The integrating mechanism is the Aviation Integrated Model (AIM), a unique tool consisting of interlinked modules simulating current and future levels of global airport-to-airport demand, ight schedules, arrival delay, technology uptake, aircraft performance, local and global emissions, aircraft noise, and the related environmental costs and economic bene ts under a wide range of policy conditions.

Most recently, our work has focused on the local and global implications of airport capacity expansions.

Electric Aircraft

Ever since the Wright brothers' rst powered ight in 1903, commercial aircraft have relied on liquid hydrocarbon fuels. However,the need for greenhouse gas emission reductions along with recent progress in battery technology for automobiles has generated strong interest in electric propulsion in aviation.

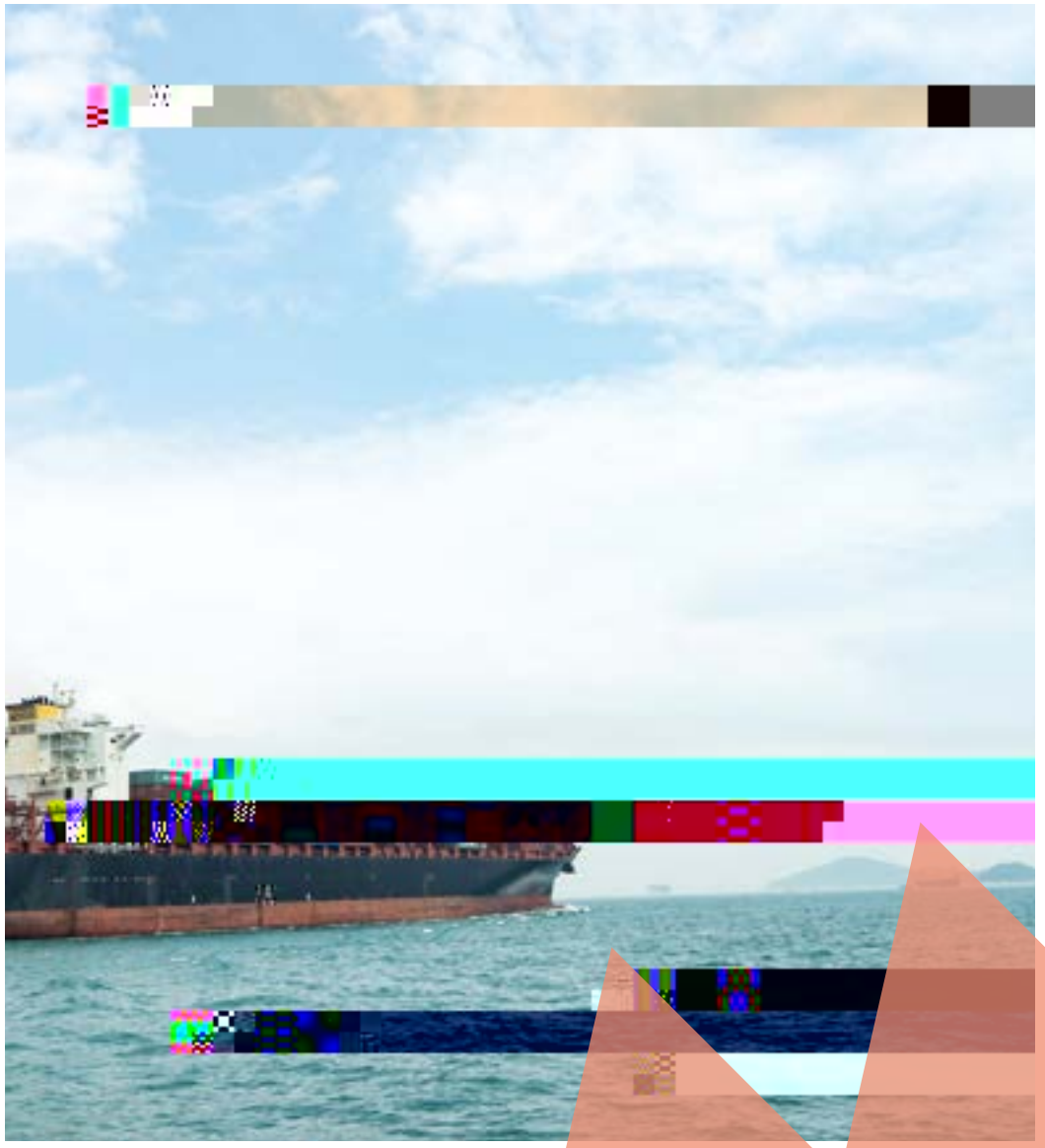
Our paper in Nature Energy provided a rst-order assessment of the energy, economic and environmental implications of all-electric aircraft. We showed that batteries with signi cantly higher speci c energy and lower cost, coupled with further reductions of costs and CO2 intensity of electricity, are necessary for exploiting the full range of economic and environmental bene ts provided by all-electric aircraft. A global eet of all-electric aircraft serving all ights up to a distance of 400–600 nautical

an equivalent of 0.6–1.7% of worldwide electricity consumption in 2015. Although lifecycle CO2 emissions of all-electric aircraft depend on the power generation mix, all direct combustion emissions and thus direct air pollutants and direct non-

This research, carried out jointly with the MIT Laboratory of Aviation and the Environment and the University of Southampton's Institute of Sound and Vibration Research, received broad media attention, with extensive coverage in newspapers, e.g., Financial Times, and other media outlets.

Shipping

Our shipping research activity is centred on understanding patterns of energy demand and emissions in shipping and how this can be applied to help shipping transition to a low carbon future.



Our research group consists of around 15 researchers and PhD students. They work on grant-funded and consultancy projects using using models of the shipping system, shipping big data and qualitative and social science analysis of the policy and commercial structure of the shipping system.

We are world leading on two key areas; using big data to understand trends and drivers of shipping energy demand or emissions and using models to explore what-ifs for future markets and policies.

Through the consultancy vehicle, UMAS, we've delivered analysis to clients from globally in the public and private sector, including UK government

> UN International Maritime Organisation (IMO)
> European Commission
> European Bank of Reconstruction and Development (EBRD)
> Committee on Climate Change (CCC)
> Carbon War Room and Danish Shipownrstase/GS2 tn

As a follow on study, in collaboration with Lloyds Register, the study examines three key energy pathways to help identify the actions required for the shipping industry to transition to a zero-carbon future by 2050.

The study indicates that all pathways explored with the study will achieve the IMOs ambition of at least 50% reduction in GHG emissions by 2050 and go beyond to show that zero-carbon is possible, that 2020 – 2030 is the most signi□cant decade stressing the urgency for early action. The evolution of shipping's fuel mix is closely linked to the evolution of the wider energy system, so a clear signal needs to be given to the potential fuel producers.

To □nd out more visit:
u-mas.co.uk/Latest/Post/407

Mobilit as a Ser ice

MaaSLab is an enthusiastic multidisciplinary research team at the forefront of the ever-changing transport sector.

What e do

We focus on urban and inter-urban transport exploring new mobility services, such as shared-mobility, on-demand services, automated vehicles, drones and ying cars, and new mobility concepts, such as Mobility as a Service in developed and developing countries. Our expertise is in transport and behavioural models, survey design and innovative data collection techniques, big data handling, GIS, data visualization and new mobility service design.

MaaSLab has several research projects on the aforementioned topics, while it works closely with the industry and public authorities to make sure that the innovative solutions and methods are utilized in real-life and have an impact on society.

HARMONY

2019 saw us launch the new HARMONY project funded by the European Commission through Horizon2020.

Against the background of expanding urbanisation and evolving transport challenges, HARMONY will support public authorities and service providers in transport and spatial planning. HARMONY envisages the development of a new generation of harmonised spatial and multimodal transport planning tools which comprehensively model the dynamics of the changing transport sector and spatial organisation, enabling metropolitan area authorities to lead the transition to a low carbon new mobility era in a sustainable manner.

Islands Lab

The Islands Laboratory studies innovative solutions to tackle climate change and assess possible scenarios for disasters risk reduction and resilience

We are a unique group, providing information alonside an electronic toolbox to analyse and interpret islands data and assess sustainable solutions through innovative integrated complex systems modelling. oup, p0es0.002tial

Energ &
Arti cial Intelligence

We focus on the application of arti□cial intelligence methods to solve problems in the energy system.

What e do

Recent advances in the □eld of AI, combined with the greater availability of data in the energy system, have opened up a promising new research area: developing and deploying algorithms that learn through repeated simulation and experience, and have the potential to outperform human decision making, to accelerate the transition to a decarbonised energy system.

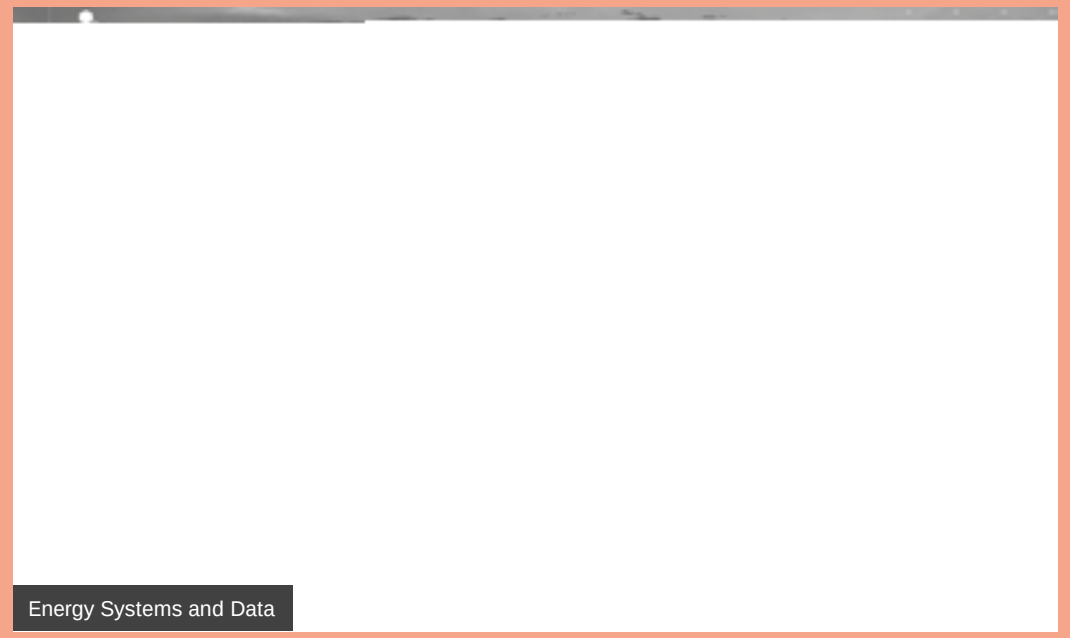
We recently established Energy & AI as a research theme, hosting 10 staff and doctoral researchers tackling projects across a range of applications in the energy system, from Arti□cial Intelligence agents that learn how to schedule grid scale generation assets, to collaborations with energy suppliers developing AI capable of providing individually tailored recommendations at the customer level.

We are strongly method-focused, naturally aligning with the Energy Systems and Data Analytics MSc, with the theme leader, Dr Aidan O'Sullivan, serving as programme lead and running two modules which translate the research going on in the theme to teaching. A number of dissertation projects were supervised within the theme involving collaborations with industrial partners such as Octopus Energy, assessing the impact of their new Time of Use Agile Tariff, and a large project on Industrial Energy Forecasting with Astral Tech.

This year we were awarded a large grant to work with the energy supplier Igloo Energy as part of the BEIS Smart Energy Savings project, conducting what is expected to be the largest customer trial involving smart meter and smart thermostat data, as well as a Grand Challenges Research Fund grant to explore the application of AI to support the Sustainable Development Goals.

We have been very active in the community, giving talks at the Slush tech conference, OFGEM and ENTSOE as well as the International Keynote Address at Australia Energy Week. We launched and ran the Energy Innovators talk series which invited CEOs and founders from startups in the energy space to share their experiences of launching innovative companies in the energy sector.

The theme has also provided advice to the newly established government advisory body, the Centre for Data Ethics and Innovation, while working as part of the design team on an ongoing proposal for an International Centre for AI Energy and Climate Change, which has led to a position paper and a workshop involving government and industry stakeholders.



Energy Systems and Data

Sa ing energ ith AI

The use of AI in healthcare has been championed for some time with personalised medical recommendations tailored to the unique characteristics of individual patients the holy grail of research in the area. Within the energy supply sector, building up an understanding of customer energy consumption patterns (which vary considerably - not just from customer to customer but also from day to day of an individual customer), tailored to the myriad complexities of the individual, is a challenge which AI combined with high resolution data offers the potential to solve.

This collaboration between Igloo Energy and the Energy and AI theme under the BEIS Smart Energy Savings grant is focused on developing an AI agent that takes in disparate information about a customer through an app interface, and, combined with smart meter data and smart thermostat data, makes recommendations tailored to the individual as to how they could better manage their energy consumption.

For example, a customer with an EPC A rated home who has their heating on timer from when they wake up to when they leave the house may be recommended that due to the well-insulated nature of their home they could schedule their heating to turn off half an hour before they leave for work with no noticeable change in thermal comfort.

The AI agent will learn through experience and the effectiveness of responses which recommendations produce the most positive results. The project involves a large scale customer trial of 3000 participants.

The interdisciplinary team conducts research focusing on the interactions of different energy system elements, across a wide range of geographical scales, using different tools to focus on different elements of the system, such as technology, economy, environment and climate change. Led by Dr Ilkka Keppo, the team has four academic and 15 research staff.

Several major projects concluded during the past year, including UKERC Phase III, where the team worked on the potential roles of different energy vectors in the future energy system, and the UKERC funded BECCS project focuseding on the analysis on the use of CCS with bioenergy.

Contributions to UKERC Phase IV started in May, and work on greenhouse gas removal technologies will also continue under the NERC funded GGR project. RESTLESS, an EPSRC funded project focusing on understanding how energy storage technologies can best be integrated into the UK energy system, was also finalised during the past year, while another project focusing on storage technologies, SPOT-RES, is still ongoing. A large, one year long project ICE, which studied the value of interconnection to the UK energy system, also finished during the year.

We have continued to work on a number of EU funded projects. Under INNOPATHS, activities of the Energy Systems theme have focused on building an EU wide, spatially and temporally detailed electricity system model. DEEDS, in turn, contributed heavily to the highly visible Final Report of the High-Level Panel of the European Decarbonisation Pathways Initiative, and RIPPLES continued its work in studying the energy system transformation required to implement the Paris Agreement. A new Horizon 2020 project, NAVIGATE, will kick off in September, with the aim of improving the state of the art European integrated assessment models in a range of different ways.

During recent years the work within the theme has extended to cover the modelling of socio-technical elements of energy transitions. The scope expanded this year, with several new projects starting. O-STET is a research initiative aiming to bring socio-technical energy transition ideas into use within real world decision-making. Similar tools will also be developed and used in ERRC Plus, which looks especially at local energy systems in the whole systems context. In a slightly different context, the DFID funded PATHWAYS also focuses energy system development pathways, but this time for a large developing country, namely Ethiopia.

The systems theme and partners recently concluded a 3.5 year long Horizon 2020 funded project REEEM that focused on trying to model in more detail specific elements affecting the transition, in addition to assessing what specific transitions might mean beyond the energy system. The assessment covered a range of aspects, including impacts of transitions on water demand and air pollution, macroeconomic consequences and lifecycle emissions related to the manufacturing of the technologies critical for the transitions.

In addition to contributing to various other tasks, systems theme led a work package focusing on consumers and how they may affect, or be affected by, the energy system transition. This work aimed to understand the preferences of individuals when making certain energy related decisions on the one hand, while assessing the distributional impacts of specific transitions on a subnational level on the other.

The findings indicated that there's heterogeneity across and within countries for these both, suggesting that the related policy measures are also likely to require carefully tailored approaches. Several journal papers are under preparation

Staff list

Management & Administration

Neil Strachan