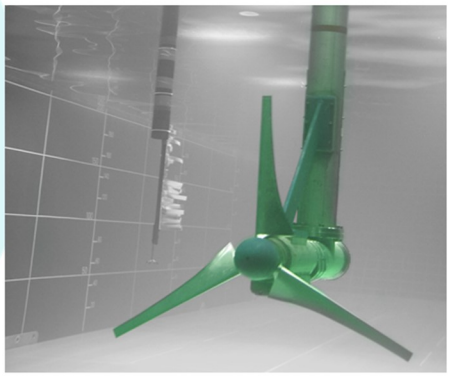
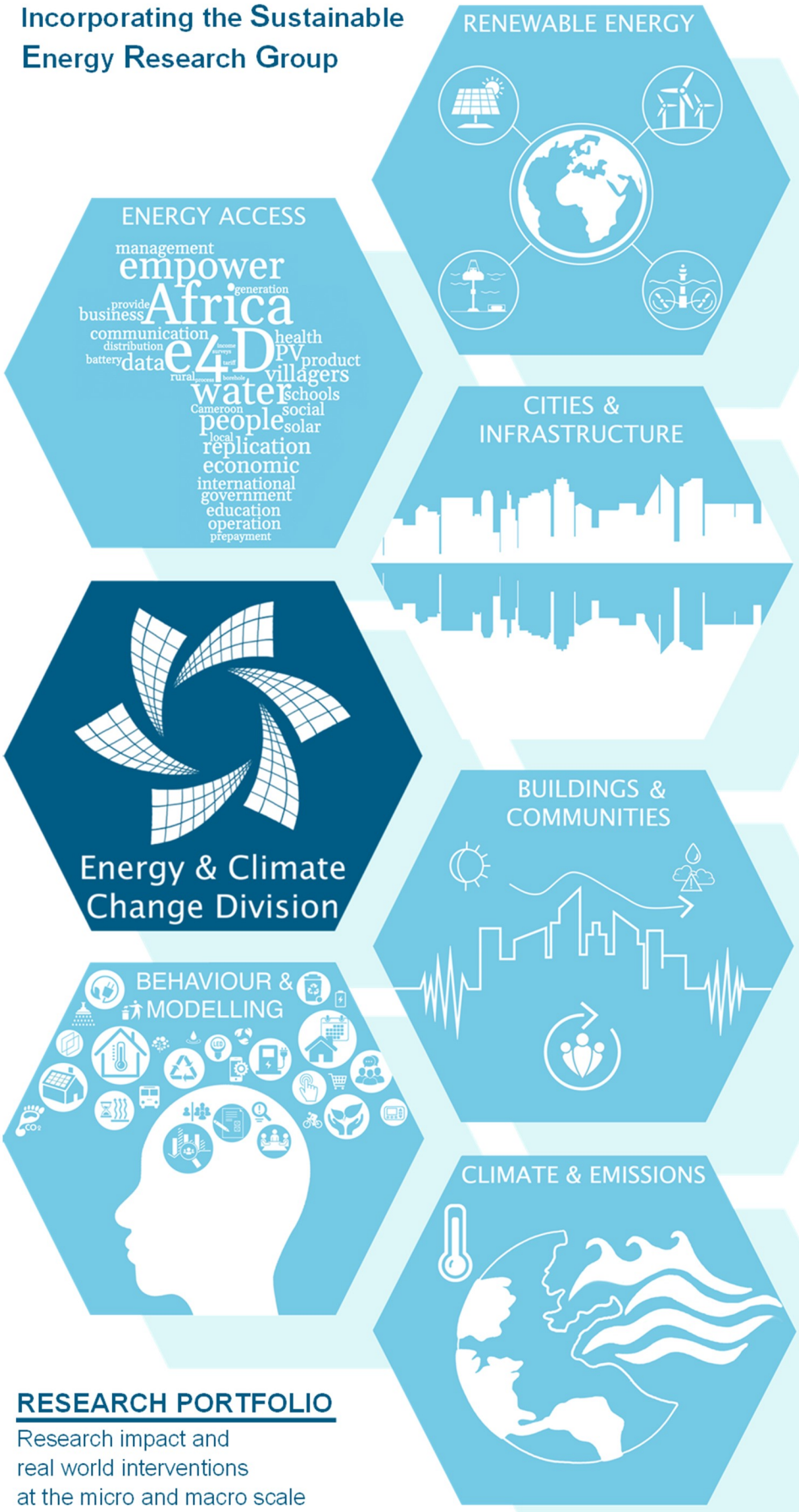
University of Southampton

Energy and Climate Change Division

Incorporating the Sustainable Energy Research Group





RESEARCH PORTFOLIO

Research impact and
real world interventions
at the micro and macro scale

Context

This document summarises the activities of the Energy & Climate Change Division and Sustainable Energy Research Group (SERG) and forms part of the Sustainable Energy Research Series. SERG was established thirty years ago with the aim of promoting and undertaking fundamental and applied research related to the efficient use of energy in the built environment. The content of this book gives a snapshot of the collaborative work undertaken by academics, researchers and PhD students at the University of Southampton, United Kingdom.

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Energy & Climate Change Division

University of Southampton

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Preface

The University of Southampton's mission is '*to change the world for the better*' by building on its global reputation in delivering world-class education, research and innovation that makes a real impact on society's biggest challenges. The University is one of the founding members of the prestigious and research-intensive UK Russell Group, an organisation that brings together the knowledge and resources of the top 24 UK Universities to: protect and improve the quality of University teaching, support and enable innovative research projects, and build stronger links with business leaders and policy makers. The University is a member of the World Universities Network (WUN), comprising 19 research-intensive institutions spanning six continents, a member of the Association of Commonwealth Universities and attracts students from over 130 different countries benefitting from a wide and varied culture.

The University's income in in the 2018 financial year was £583million, with a research grants income of £117million, from the UK Research Councils, UK based charities, the EU, UK Central Government/local authorities/health authorities and hospitals, and from UK public corporations/ industry and commerce. The University has internationally leading experts in designing, conducting and managing research programmes. The current value of managed research contracts is over £150M spanning multidisciplinary including engineering, social science and health. Such leadership is attained through first class researchers, developed knowhow, management and processes to deliver projects to the highest standards and required deadlines.

According to the Times Higher Education (THE) World University Rankings by Subject 2020, published 16 October 2019, the University of Southampton is ranked 6th in the UK, 18th in Europe and 76th in the world for Engineering & Technology.

Within the University of Southampton, energy research and development are conducted within the Energy & Climate Change Division (ECCD) encompassing the Sustainable Energy Research Group; (SERG, www.energy.soton.ac.uk), established and led by Prof AbuBakr Bahaj since 1990. ECCD/SERG research profiles addresses the University's mission focusing on fundamental understanding applicable to renewable energy studies, energy efficiency and energy for development. At the centre of ECCD/SERG research are the UN Sustainable Development Goals. This booklet in combination with the current information contained in the website www.energy.soton.ac.uk provides information on the activities undertaken. This document provides a snapshot and brief details of some of the current research and development areas within ECCD/SERG. These encompass (i) Renewable Energy, (ii) Energy Access, (iii) Cities & Infrastructure, (iv) Buildings & Communities, (v) Behaviour & Modelling, (vi) Climate & Emissions and (vii) a sample of PhD fundamental research undertaken by the ECCD cohort and their supervisors.

The document contains web links and details of our contact. If you need, further information on the topics covered or in general, related to sustainable energy and energy efficiency please get in touch. I hope you find the provided information useful and please check for further details on our website www.energy.soton.ac.uk as well as all the publications available there.

Prof AbuBakr S. Bahaj

Head of Energy & Climate Change Division | Professor of Sustainable Energy, University of Southampton

Renewable Energy

Engineering solutions for reliable, affordable and sustainable energy stemming from renewable resources

Solar photovoltaics (PV)

Solar photovoltaics (PV) convert sunlight to electricity and is now the most utilised renewable energy technology globally. PV research focuses on buildings as power generators at city scale, the supply of power to invigorate rural villages in Africa (*Fig.2*), as well as unique examples of building integrated PV (BiPV) deployed at the University of Southampton (*Fig.1*), with linkage between power generation from PV and behaviour in housing.

PV for refrigeration is an important application for PV not only in shaving off peak power in supermarkets and stores but also for cooling perishable foods during transportation. PV system was deployed on a Sainsbury's working articulated trailer for the delivery of perishable food, a world first (*Fig.3*).

In addition, we work on the utilisation of PV on carports shading in the Kingdom of Saudi Arabia (KSA), in collaboration with the King Abdulaziz University. Car parking footprints in many institutions in KSA represent more than 50% of their area, creating possibilities for large power production at point of use. One of the research foci is understanding appropriate combination of cleaning options to mitigate dust accumulation which reduces energy yield of such PV arrays (*Fig.4*).


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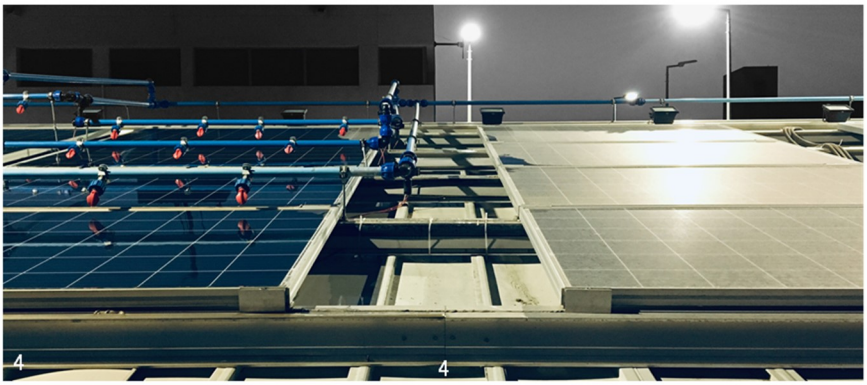
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Marine energy (wave and tidal)

Our research focusses on wave and tidal energy, encompassing resource characterisation, device fundamentals & array planning. It also addresses device interactions & array siting for optimised energy yields. The conversion of marine currents (tidal) is a relatively new area of engineering & our work is providing pioneering fundamental understanding of the hydrodynamics applicable to the converters (turbines) & arrays.

Experimental approaches investigate the fundamentals of scaled tidal turbines for a range of conditions (tip speed ratios, pitch and yaw angles). Results provide insights into operation of: (a) single turbines in straight/yawed flows, (b) performance changes due to rotor tip immersion (bathymetry), (c) cavitation inception and (d) interference between multiple rotors. Experimental results validate and complement numerical models including the wake effects & impacts of turbulence using RANS and LES approaches in addition to more basic but tried and tested BEM and actuator disk models.

Resource assessment analysis, array effects & energy yields were obtained for the Channel Islands, Portland Bill & the Isle of Wight. Sediment transport studies were carried out for hypothetical large tidal turbine arrays close to the Channel Island of Alderney. In wave energy, resource assessment through satellite altimetry were conducted, as were the hydrodynamic performance of the Owel & Anaconda devices.


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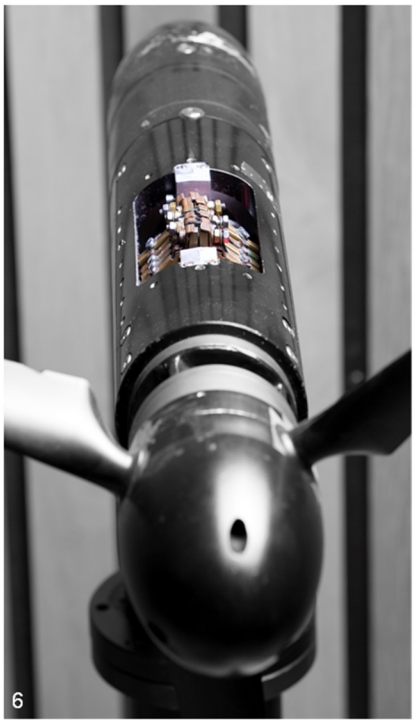
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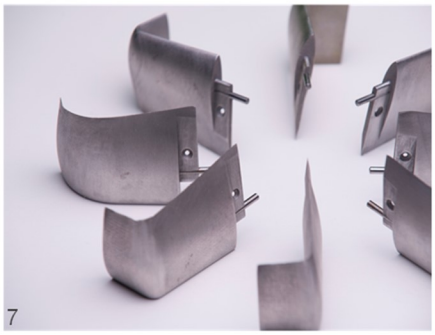
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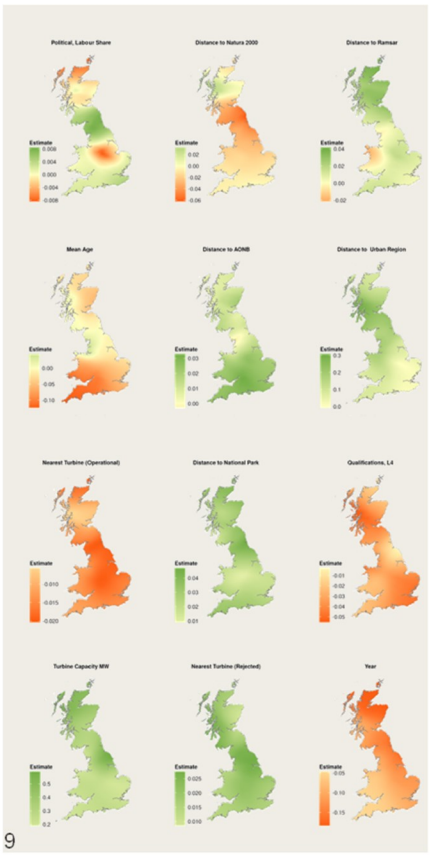
Wind energy

Research in wind energy is undertaken at various scales – urban, onshore and offshore. The first addressed UK field trails with small scale turbine of capacities >5kW (micro wind turbines), the 2nd was geared to identify factors that may influence the planning acceptance of onshore wind, whilst the latter mapped offshore wind energy resources and energy yields in the Middle East providing a blue print for sites development in the region.

In the UK national trial on micro wind turbines, the Energy and Climate Change Division team played a pivotal role in the monitoring and analysis of the results from 75 test sites (*Fig.10*) across the UK. This has resulted in guidelines for such turbine utilisations.

In onshore wind, research undertaken aims at identifying factors that may influence planning acceptance, integrating the results into a spatial model of onshore wind energy providing the most likely suitable locations for "least resistance" development (*Fig.9*).

In offshore wind, research addresses wind energy potential with a particular focus in the Middle East, where there is a paucity of information around the resource, its locations and infrastructure needs. This seminal research is based on the development of new, more accurate estimates of available resources and predicted energy yields, taking into account appropriate constraints such as shipping lanes, nature reserves, electrical grid etc, presenting the first mapping of the potential for offshore wind energy in the region (*Fig.11-12*).



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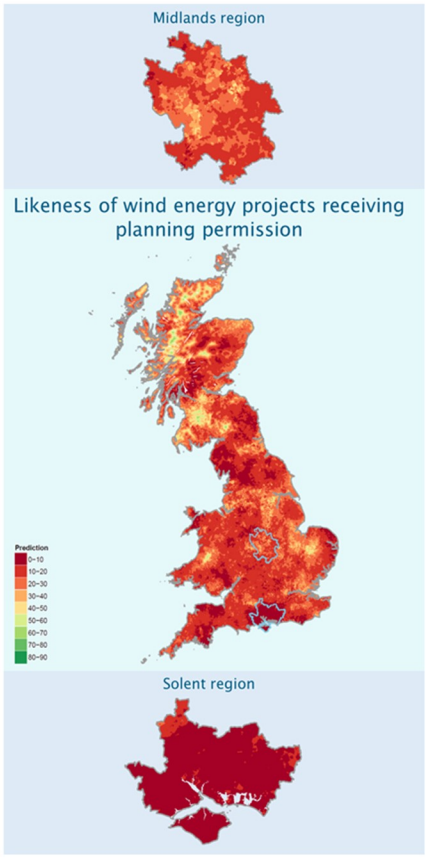


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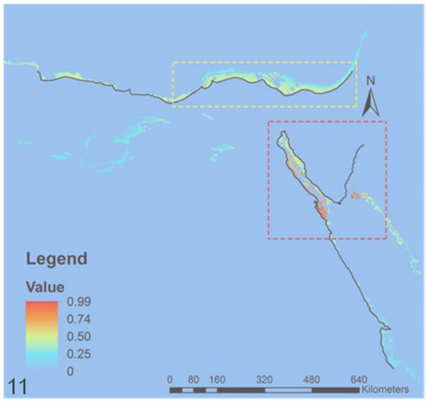

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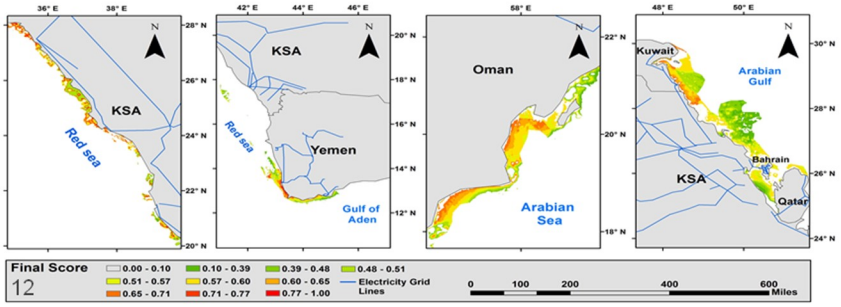

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Energy Access

Fundamental research in energy (electricity) access coupled with implementation of exemplar rural electrification projects as learning entities in rural communities

Mini grids, operations and networks

To date six community managed solar photovoltaic (PV) mini grid systems in Kenya, Uganda and Cameroon have been installed with more in the planning. The e4D research and development programme has been extended to study and explore the operation and resilience of local mini grid networks, including their appropriate transition to the national grid connectivity. The modular solar PV driven mini grids are used to supply power to village centres where connected consumers also act as conduits to provide services including electrical charging facilities for non-connected consumers. Our studies include consumption profiles, optimisations and cost of energy at different community applied tariffs.

These mini grids act as learning vehicles to explore their resilience in lone operation and how to optimise them. The work also addresses strengthening mini grids' capacity by studying two mini grids connected together as a network to form localised grids, supporting top tiers of electricity access. In addition, work also addresses connecting mini grids to the national grid studying their in-situ operation. This work is conducted under the 'FORTIS UNUM (Stronger As One): Innovation in Mini Grids and their Networks' project.


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Solar home systems (SHS)

Solar Home Systems (SHSs) have been proven widely as a solution for off-grid electrification at the household or single consumer level. To date, about 180 million standalone solar products have been sold in this market. SHSs range from few watts (pico-solar) to hundreds of watts (W) systems. However, smaller systems in the range of 10-30W dominate the market. Larger systems, however, now go to 200W providing flexibility to some level of productive use. The e4D research studies on the SHS sector focus on 'how these can be optimised with efficient appliances' to benefit the end user.

The e4D studies include quality aspects of PV modules, components (power electronics, charge regulators, batteries) and appliances (LED bulbs, refrigerators, TVs, cooling fans). Furthermore, we have developed our laboratory capacity to test small modules and components by mimicking the real environment of the products to be marketed and used.

The above research is augmented by studying water pumping for irrigation, ICT uses and small-scale refrigeration. Recent projects include the '**Low cost, graduated PAYG solar home systems for Africa**' with the objectives of designing and developing an affordable, upgradeable pay-as-you-go (PAYG) solar home system (SHS) product line for off-grid households in Africa.


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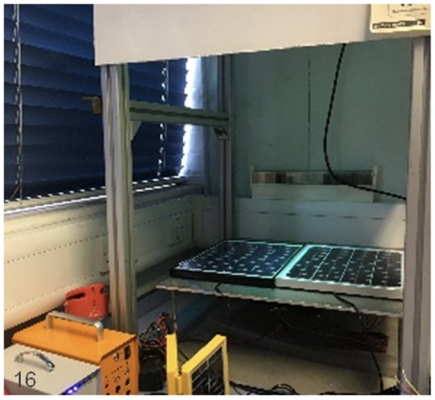
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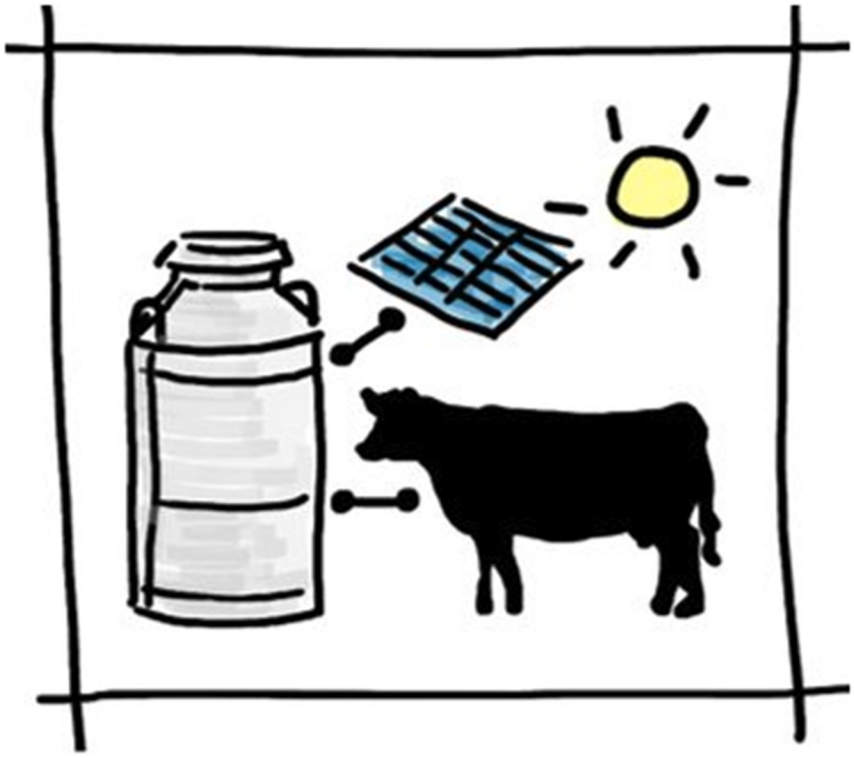
Productive use of electricity and efficient appliances

Benefits of electricity access cannot be attained without coupling it to productive use underpinned by efficient appliances and other socio-economic requirements. Research continues with a focus on inclusive growth in villages societies ranging from an individual entrepreneur in a small scale trade/business (e.g., phone charging) to bigger productive use (e.g., refrigeration), while emphasising energy efficiency.

Understanding gained through efficiency in generation, distribution and consumption are very important for both on-grid and off-grid electrification and their roll out.

In the case of the latter where capacity is constrained, efficiency measures can deliver extended benefits for the users of SHSs and mini grids as well as the other actors in the electricity access supply chain. Hence, e4D research encompasses both areas of DC mini-grids, DC appliances and efficiency in conventional remit of AC mini grids.

Recent projects include 'Efficient VERsatile Energy Services Solution Through DC' studying potential of DC PV mini grids for rural electrification. Also, 'Demand Side Renewables for Agricultural Base Load Energy (DeSiRABLE)', an ongoing project to explore the potential of PV powered cold chain in dairy processing in Africa



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Capacity building

Developing capacity in electricity access is crucial in providing energy to rural communities and enhancing their development. The e4D programme and the ECCD team have provided such capacity building in Africa, Asia and the Middle East covering the above research areas as well as energy efficiency in buildings. The thrust of such capacity building is geared to transition energy use to low carbon. In-county capacity of researchers, engineers and professionals in energy access and energy efficiency will fast track the Sustainable Development Goals.

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The ECCD team provided support to partners in Africa, Asia and the Middle East to address capacity gaps in delivering their national targets in rural electrification as well as being on track with the Nationally Determined Contributions (NDC) to reduce GHG emissions. The team developed course materials related encompassing the above research areas, enhanced through different analytical tools design methodologies, practical examples and site visits.

Examples include capacity building programmes in the areas of renewable resource mapping, energy efficiency, PV power generation from buildings and PV/ PV-hybrid power system modelling in the Philippines (Newton Fund Capacity Building Project) and in Saudi Arabia (Solar Shaded Car Park Project) and the Solar Housing Project. Also we are continually helping capacity building of partners in Kenya and Uganda within the areas of mini grid design, operation and maintenance through our flagship Energy for Development Programme.


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Cities & Infrastructure

Engineering solutions for sustainable, resilient and inclusive cities

Energy studies in cities

Research encompasses engineering analysis, developing evidence and providing advice to a number of city and district councils. The work includes citywide analysis of building stock performance, providing evidence on required investment for building refurbishment as well as potential solar PV power production from all buildings. The work resulted in new tools to assist UK's local authorities for future investment planning and carbon target setting.


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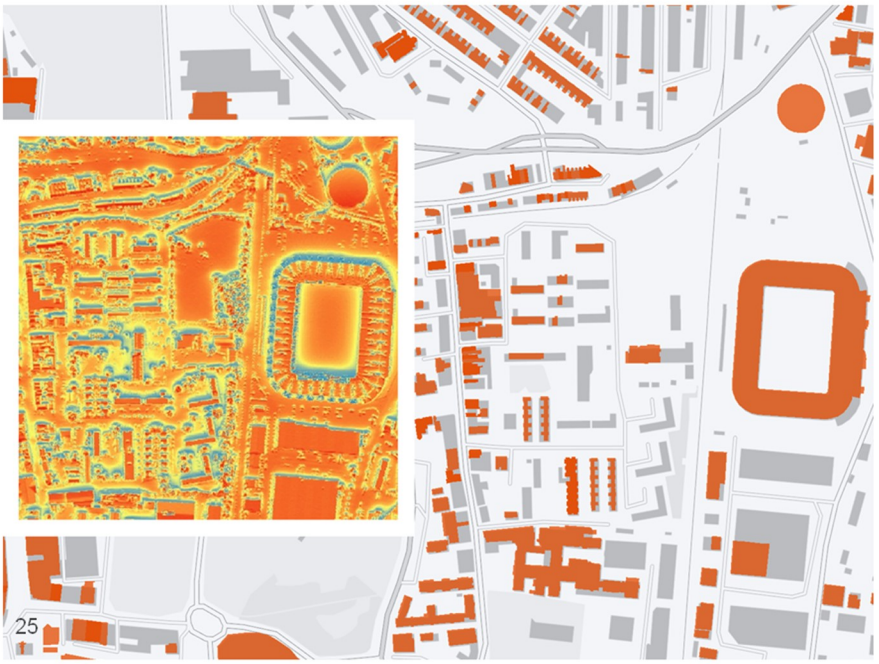
Engineered on geographic information systems (GIS), a building physics model was developed to allow refurbishment options to be applied and modelled, providing estimates of energy savings as a result of specific interventions. Furthermore, the model automatically identifies suitable roof areas for deploying solar systems – photovoltaics, or thermal, using high-resolution raster data collected by remote sensing. The result is a highly detailed 3D model of the entire city (*Fig.24*), rebuilding constructions and trees on a virtual environment. The model is able to accurately simulate solar radiation of building surfaces, taking into account factors such as shadows on roof surfaces at different times of the year to combine multi-layer analysis and then identify suitable buildings that are feasible for installing solar systems (*Fig.25*).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Demand modelling and infrastructure resilience

Demand for networked services such as energy and water vary with changes in household and dwelling characteristics and can be inferred using spatial data. ECCD has developed tools for estimating aggregate demand for services across heterogenous geographical areas or populations providing enhanced planning capabilities for resilient future infrastructure.

By combining household (micro) data from both small sample experimental studies and large sample randomised control trials with spatially disaggregated household and dwelling characteristics, this modelling technique can be used to estimate 'baseline' consumption and consumption under a range of intervention scenarios. An example of this work is the £10.3M Ofgem Low Carbon Network Fund (LCNF) project – Solent Achieving Value from Efficiency' (SAVE) primarily focused on the Solent region and the key output from the project was the Network Investment Tool: a suite of models to improve the simulation of low-voltage distribution networks, informing future investment strategies of operators across the UK.

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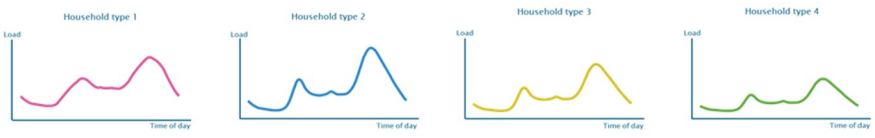
The SAVE project created a large-scale, representative sample of households and their electricity consumption (*Fig.25-29*). The industry leading sample underpins spatial microsimulation modelling, used to predict residential demand profiles for small geographical areas. Another example is the modelling of residential water demand conducted for the IMPETUS project. This work provided estimates of UK residential water demand under a 'baseline' scenario and a range of water efficiency interventions, to model demand response to drought conditions and inform response measures.



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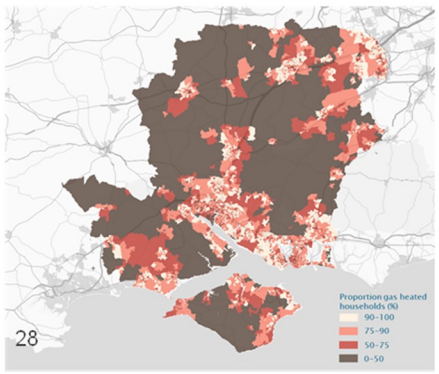

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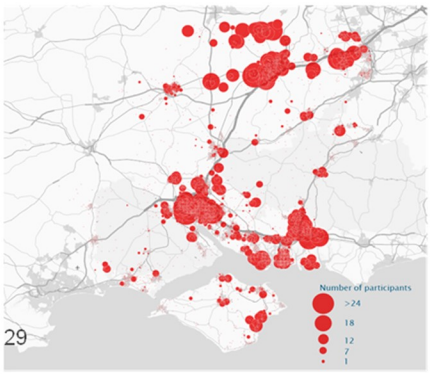

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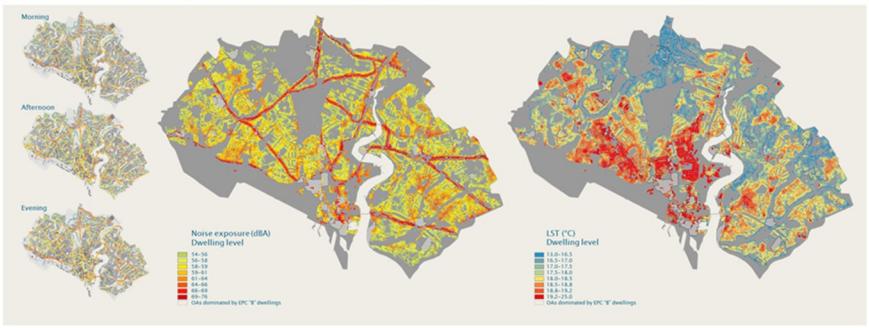
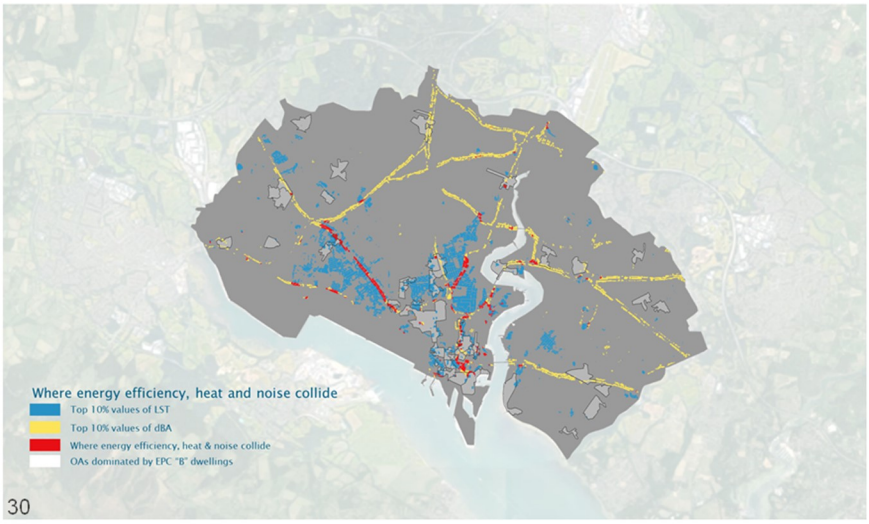
Master planning and environmental impact

This research considers the opportunities for change that exist within urban, city-scale infrastructure. It is concerned with future pathways to address negative conditions such as sound and air pollution, fragmentation, ghettoization and impoverished areas.

ECCD utilises both active and virtual monitoring of cities along with modelling of factors such as noise, land surface temperature (LST), accessibility and density (*Fig.30&33)*. Rezoning offers an opportunity to regenerate and revitalise an area of a city, where ECCD established 12 priority future city principles for Southampton City to provide a metric for city policy makers to evaluate areas.

Once key research areas have been identified, solutions are formulated and presented to local authorities with real world interventions being deployed and tested (*Fig.31-33*). Research is able to map city weaknesses and visualise city challenges in a manner which leverages investment. This assists local government in formulating sustainable future city plans to deliver city wide benefits.





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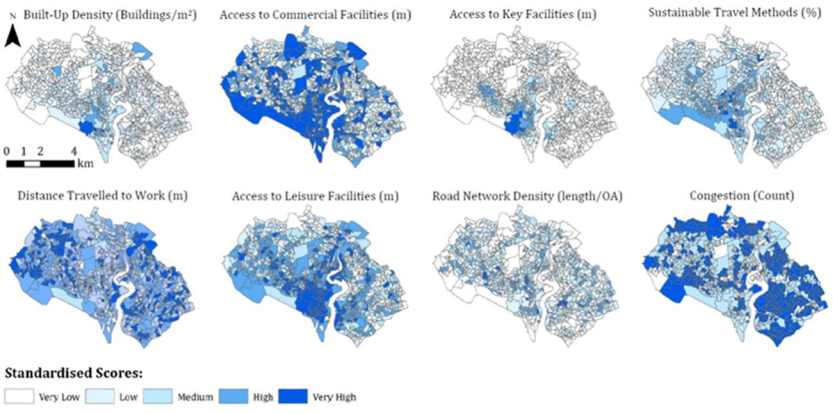

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Buildings and Communities

Evaluating indoor and outdoor environments for healthier human settlements

Energy studies in buildings

Urban power generation technologies such as PV, micro wind turbines, micro combined heat and power (μCHP) and ground source heat pumps are termed "micro-generation systems" which are likely to contribute the UK's emission reduction targets in cities at scale. The concept of implementing microgeneration technologies in the built environment is only worthwhile provided that (i) the resource availability is considerable to warrant investment; (ii) the generator to be used can provide sufficient output to significantly impact upon the energy load of a building/household and (iii) the investment can be justified within the scope of a reasonable payback period. Microgeneration research encompasses solar PV and microwind turbines installed on buildings.

ECCD research has shown that occupants' thermal preferences can adapt to prolonged high indoor air temperatures, raising their expectations. It also has identified that in the absence of communal heating charges, proportion of UK households are unlikely to be able to afford to heat their homes to the recommended healthy standards.


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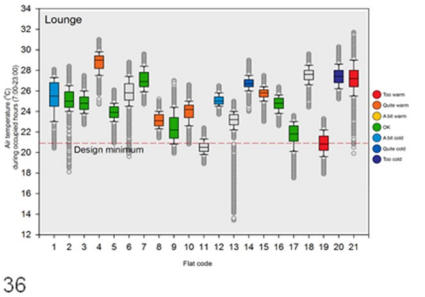

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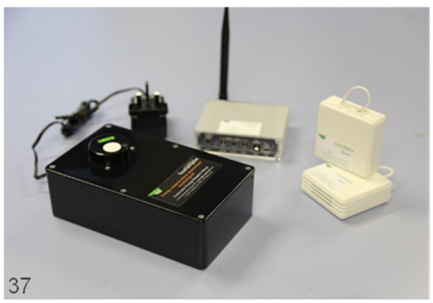
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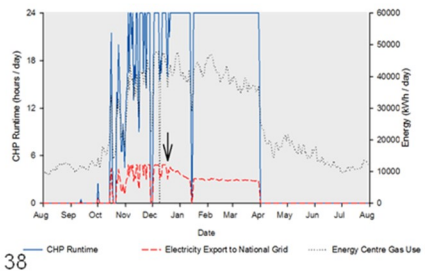

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Liveable spaces and communities

Research encompasses engineering, urban design and behavioural studies to develop evidence and provide advice through engagement with local authorities and communities to create liveable spaces for cities ensuring areas meet the needs of inhabitants on a micro and macro scale.

The work includes modelling of factors such as air quality, noise, accessibility, density and deprivation in order to inform regeneration strategies. Engagement events are held in person and virtually to further understand the needs and requirements of communities including surveys, interviews, focus groups and workshops covering issues ranging from energy services, electric vehicle charging and retail.

Communities can play a central role in enabling (or disabling) low-carbon interventions. ECCD undertake research that aims to understand the interaction between households, communities and developments or local initiatives. The work has included research into the impact of community-based energy saving initiatives, evaluating 'bottom-up' community approaches to mitigating daily peak demand on the electricity network, and others in order to better understand the opportunities and barriers presented by communities to the transition to zero-carbon.


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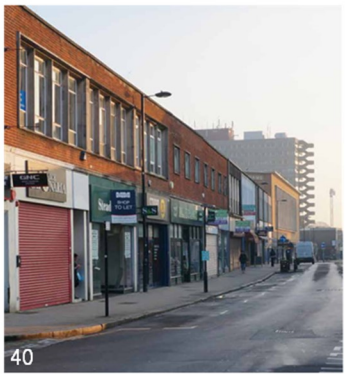
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Thermal comfort and indoor environments

Heating, is the main component of energy demand in dwellings in the UK and is often associated with thermal comfort. In order to achieve thermal satisfaction, occupants may interact with the building systems and controls to adjust their living environment.

Post occupancy evaluation (POE) and continuous feedback can provide some of the tools required to design and manage low-energy buildings with controls and occupants as direct actuators of adaptation. The interpretation of data within the context of specific building properties and occupancy can inform design and policy regarding domestic building retrofits.


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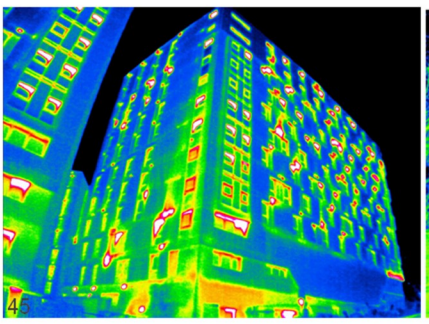
Smart buildings are seen as key in reducing energy consumption and emissions due to their improved operational efficiencies. The prevalence of the Internet of Things and reduced costs of modern sensing technologies heralds the application of such systems to provide real-time, dynamic control and automation in buildings. Clearly, such transformative approaches will also need to be augmented with building occupants' perception of comfort and space functionality to succeed.

Part of our thermal comfort studies are contributing to the activities of the International Energy Agency's Energy in Buildings and Communities Programme.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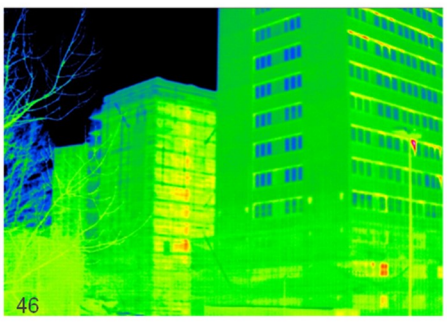
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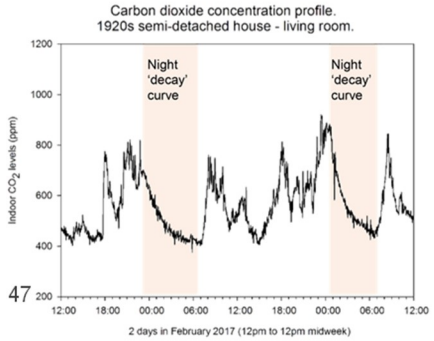

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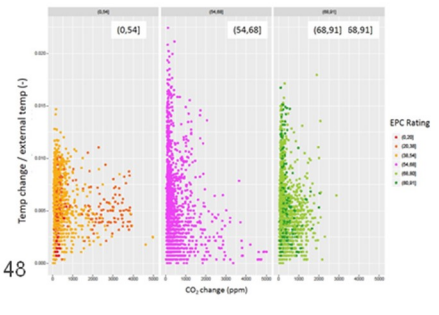

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Behaviour and Modelling

Understanding individual and community perceptions and behaviours to advance adoption of sustainable energy and energy efficiency

Energy demand and behavioural change

We conduct monitoring and analysis of users' energy related behaviour to establish patterns, motivations and constraints to inform energy efficiency strategies in all forms of housing and commercial buildings. This is a pathway to securing their thermal comfort needs, reduce consumption as well as tackling with fuel poverty.

As an example, through the EU €5.5M (THERMOSS) project (*Fig.17*) we are monitoring social housing residents, particularly their heating usage and the reasons behind it.

With a combination of monitoring sensors (*Fig.49*) and social surveys, we can infer energy usage patterns and their determinants, as well as understand user's motivations and constraints (*Fig.50*) .

In the Ofgem-funded £8.3m SAVE project we have used similar methods to analyse residential electricity consumption in 4,000+ households in the Solent region and tested a range of demand reduction interventions.

In addition ECCD are researching the role of solar energy systems in reducing demand in residential buildings, contributing to Saudi Arabian low carbon pathway aspirations.

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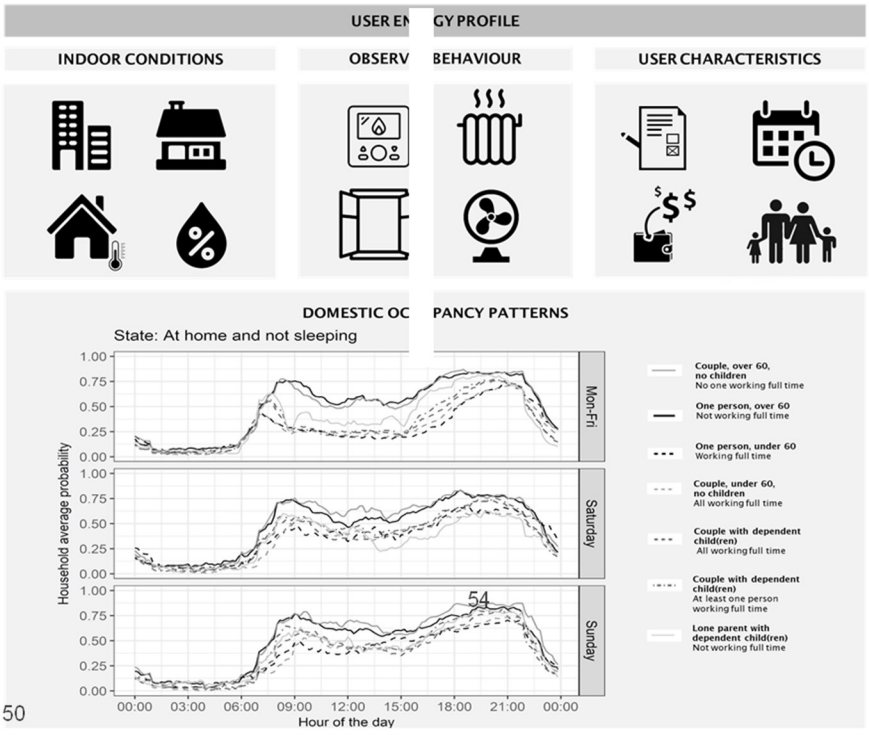

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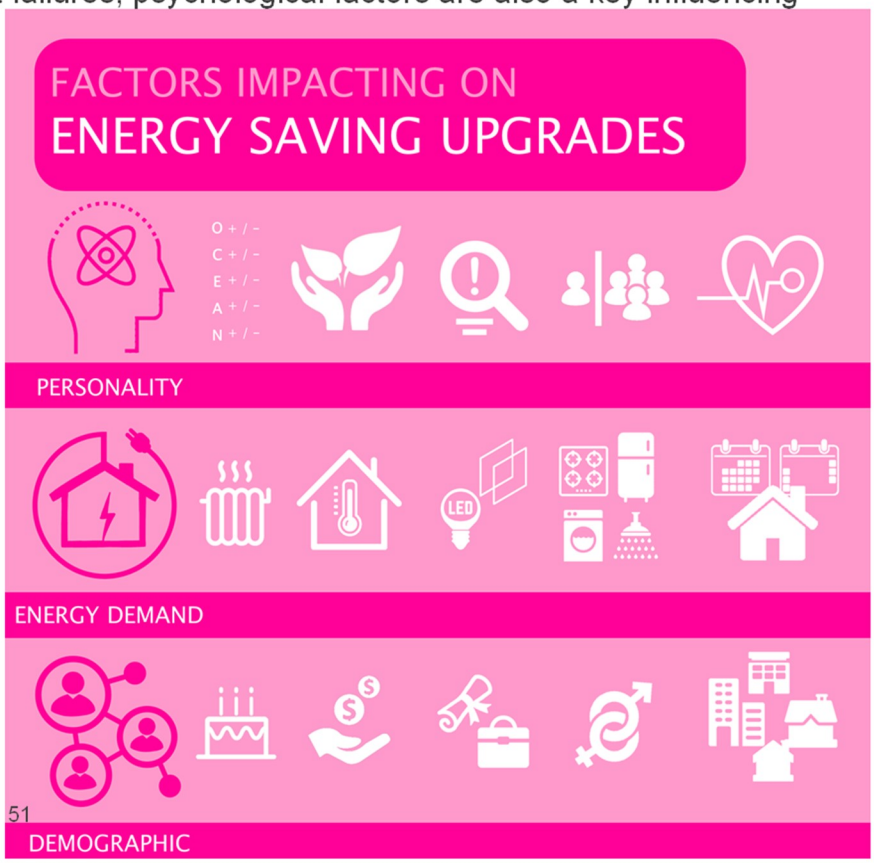
Future provision of energy services

ECCD research aims to develop and enhance approaches to providing energy products and services to residential customers, further understanding how to increase uptake.

Working in partnership with Igloo Energy, research is undertaken to establish the influencing factors affecting the uptake of energy-efficient household upgrades (including smart thermostats and hybrid heat pumps) economic market failures, psychological factors are also a key influencing factor in particular energy literacy and personality traits (Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism).

Research with online focus groups are being undertaken in order to determine whether personalised messaging based on an individual's traits will enhance understanding and uptake of energy saving propositions (*Fig.51-54*).

In addition ECCD are working on the LATENT project, continuing the partnership with Igloo Energy ti understand household thermal preference and acceptance of automated 3rd party control of residential heating systems for grid support.



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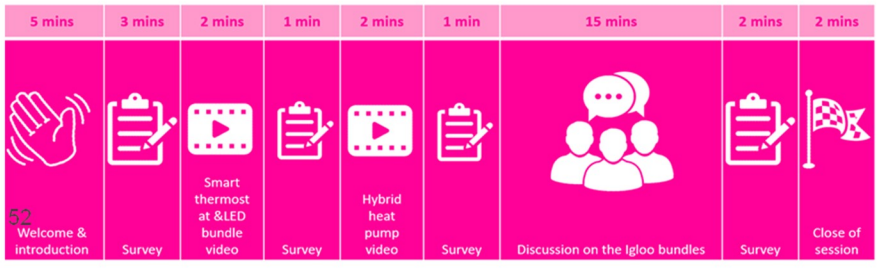

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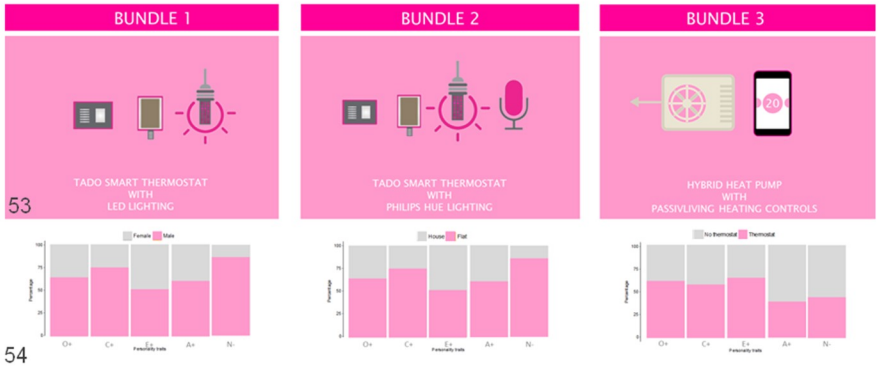

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Sensing to support independent living

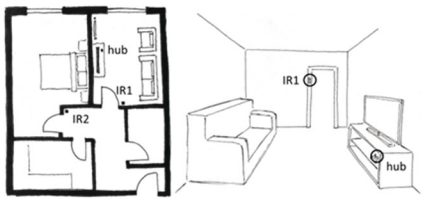
Research incorporating background environmental sensing has been conducted to help detect changes in health conditions. Findings have shown that continuous evaluation of the occupancy behaviour, or thermal conditions can provide insight to informal care networks and provide evidence for additional support.

The CareTeam project in partnership with industrial partners Nquiringminds, Southampton and and Portsmouth city councils incorporates background environmental sensing to unobtrusively monitor and predict behaviour of those receiving care to help provide reassurance and detect changes in condition. Aiming to help adults who currently *receive* care to remain independent, comfortable and active in their own homes for longer.

55

As part of the adult digital health support platform developed under CareTeam, the research proposes the introduction of soft warnings, based on the continuous evaluation of the occupancy behaviour, care conditions and the home environment.

Results have shown that the care needs of a person are key determinants of occupancy behaviour. The work is also integrating a probabilistic approach to the occupancy profiles and evaluating the merits of different machine learning approaches.



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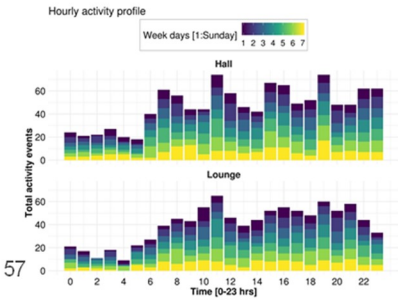

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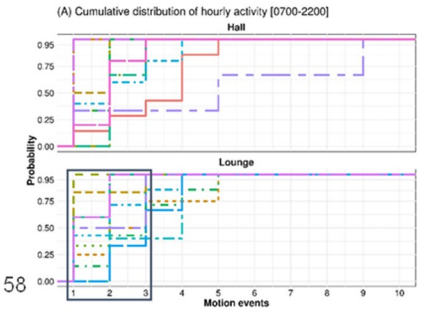

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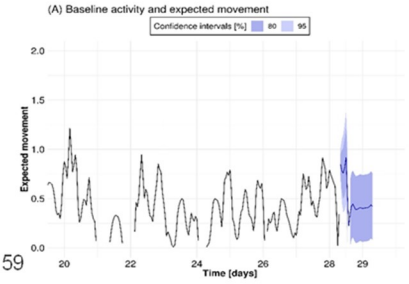

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Climate and Emissions

Supporting cities to achieve net zero.
Research into coastal engineering and management

Regional and city emission studies

In 2008 the UK was the first major economy to pass a Climate Change Act committing the Government to 80% reduction in emissions from 1990 levels by 2050, which was augmented in 2019 to net zero emissions by the same date. ECCD research looks to develop engineering solutions to regional and city-level emissions considering the practicality and costs of various methods and approaches.

Research encompasses analysis of a number of city and district councils and organisations, including businesses and schools, developing evidence and providing advice on sustainable future pathways. The work includes the development of a robust sustainability performance tool to help assist cities measure their progress in achieving sustainability targets while educating organisations in identifying and targeting sustainable strategies (*Fig.65-66*). ECCD has developed a number of tools and observatories including climate change world weather file generator allowing one to generate climate change weather files for use in building performance simulation programs and the energy consumption and carbon dioxide emissions observatory for the Solent region.

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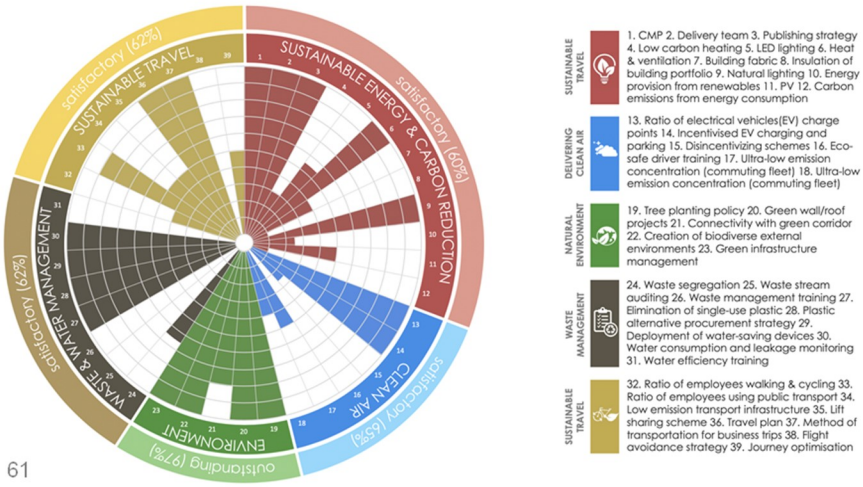

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Coasts and climate change studies

Research in coast and climate change studies is undertaken across four key areas; climate change impact, coastal engineering, coastal management and coastal vulnerability.

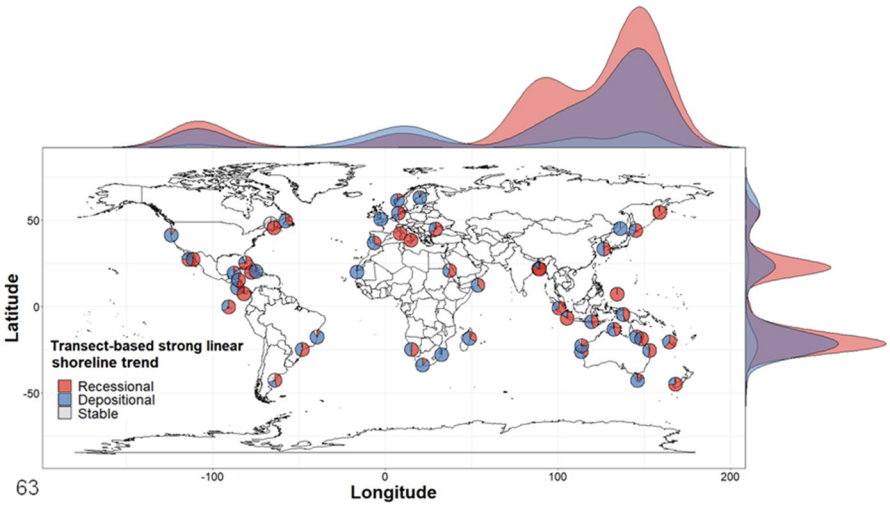
Climate change impact work studies impacts at global and continental scales, undertaking risk and impact assessments. Our research encompasses a diverse whole system approach to understand the societal challenges in instigating change with outcomes supporting plans to reduce the number of people exposed to coastal flooding.


62

Work in coastal engineering estimates flood risk and standards of protection at global and local scales. Undertaking analysis to predict the consequences of flooding and identifying regions likely to be impacted by extreme water levels as a result of sea-level rise.

Coastal management research provides analysis on how coasts are managed today, and the implications of the competing interests that may exert, today and in the future. Identifying the need for a more collective approach in coastal management involving stakeholders at different levels of government, and the community in decision making.

Coastal vulnerability is assessed through analysis of coastal ones that are vunerable to change such as through rising sea-levels or wider coastal change. The research includes analysis of natural heritage sites to determine how and why they are vulnerable and how vulnerability manifests itself, providing evidence on how reduce vulnerability.



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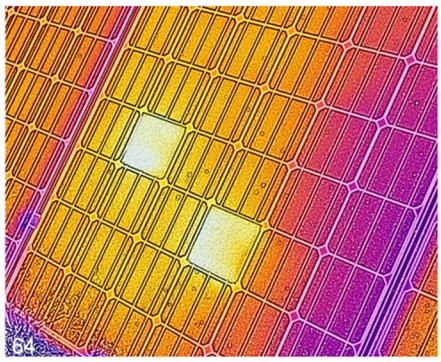
Further Fundamental Research

Further fundamental research to augment the 6 research themes of the Energy and Climate Change Division

Artificial intelligence in renewable energy systems

Photovoltaic (PV) solar energy production is the fastest growing form of renewable energy, with forecasts of generation doubling by 2024. This growth is led by a decrease in capital cost, causing the relative cost of PV maintenance to increase, from ~50% of the total cost of UK's large-scale PV farms in 2019, to ~67.5% in 2030. Because of this, research is being undertaken into optimising solar PV maintenance using automated fault detection using AI. In this work, infrared thermography (*Fig.76*) is used to capture an image of the temperature of a solar PV module. State-of-the-art deep-learning-based image-classification algorithms are then used to detect if there is a fault and the type of the fault providing warning to farm operator.



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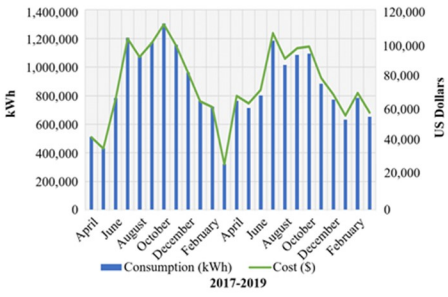
Impact of solar PV penetration on city grids in the Kingdom of Saudi Arabia

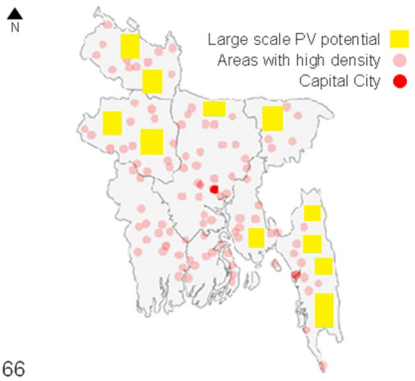
Saudi Arabia has announced plans to build 20GW of photovoltaic (PV) electricity generating capacity by 2024 and 40GW by 2030. Solar PV total installations by 2020 will reach 2.5 GW. KSA 300 MW PV project expected to operate by November 2019, holds one of the records for low tariff for PV of US Cents 2.3417/kWh. This research studies the impact of PV penetration on the grid of the University of Jeddah Campus (*Fig.77*), knowledge generated will support analysis on a medium size city in KSA to displace fossil fuel power supply currently been used. The relationship between the consumption, economics, social and environmental aspects as well as grid impact will be assessed through different scenarios in both cases.



65

Transitioning Bangladesh to renewable power

This research addresses what are the policies required to guide Bangladesh through its sustainable energy infrastructure transformation to support its aspiration of becoming a developed country by 2041. A regression-based simulation model will be developed to exhibit the effects of influencing factors on the transition pathways. Based on the model outcomes, the research will suggest what renewable share in the energy mix should be progressively elevated in accordance with the future escalation in financial affordability and technical advancement of the overall efficiency of suitable renewable systems for the country. This work also aims to help policymakers and energy managers to understand better the dynamic interrelationships between different transition factors and plan the wide-scale implementation of renewable energy systems according to the available resource and fiscal potential of the region.



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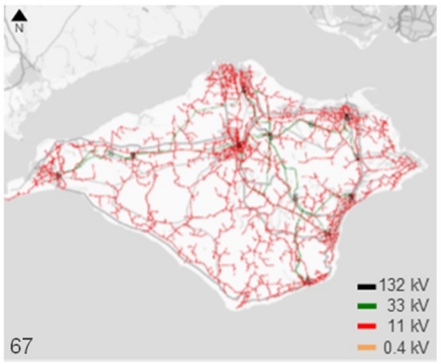
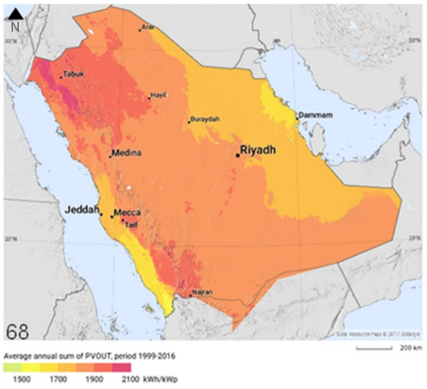
Realising the Isle of Wight's aspiration for renewable energy power generation and local consumption

In the UK, the Isle of Wight (IoW) wish to become self-sufficient in electricity from renewable sources, which is likely to be achieved through the deployment of utility-scale solar PV farms augmented with roof-top solar PV systems. However, the required expansion is constrained due to an insufficient network capacity, which has resulted in the curtailment of current generators during times of peak generation. The research undertaken explores the potential options to develop the IoW's renewable power generation by looking at opportunities for local consumption demands, energy storage systems, demand response strategies and smart grid solutions (*Fig.79*). The resulting methods and concepts will be tested on real-world conditions and will not only support the IoW Council's aspirations, but also have national and global applications as we make the transition to a low-carbon future.



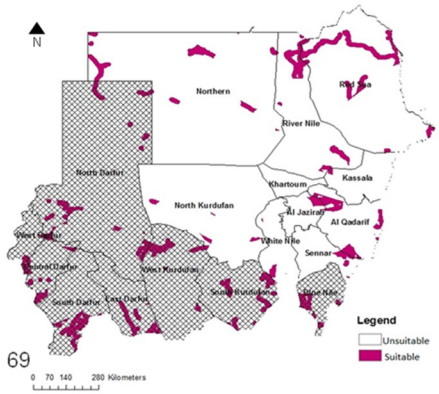
Supply chain readiness for renewable energy expansion in the Kingdom of Saudi Arabia

Saudi Arabia is aiming to intensify the adoption and the advocacy of their renewable energy sector, to localise 30% in the short term and 60% in the long term of its value chain. To achieve this, a local content market should be large enough to supply the planned 27GW capacity contained with 35+ renewable energy farms by 2024 with additional capacity of 59GW by 2030. Although Saudi Arabia has excellent natural wind and solar resources (*Fig.80*), the current skills are not adequate for planned future expansion in renewable energy. The research aims to identify means to reduce this skills shortage and proposes practical recommendations as to how to achieve this through robust research on KSA's supply chains and how this can be adapted and augmented to support the above targets.



Site suitability analysis for renewable off-grid systems using GIS-MADM in Sudan

This research aims to investigate the potential for implementing clean off-grid energy systems for rural electrification in Sudan. Analysis using the GIS (Geographic Information System) -MADM (Multiple Attribute Decision Making) method will identify sites suitability for renewable off-grid electricity systems. The methodology includes four main strands of work: (a) assessment of renewable energy availability in Sudan, (b) identifying suitable weighting criteria for site selection, (c) location of appropriate sites that fulfil the criteria via MADM-GIS, and (d) performing experts' NGT (Nominal Group Technique) via AHP (analytic hierarchy process) - SAW (simple additive weighting) to select the most suitable sites in rural Sudan (*Fig.81*).

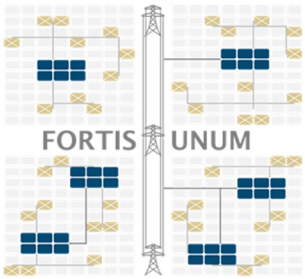


Recent Projects

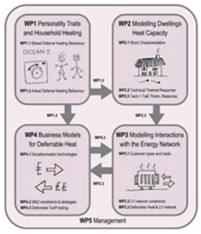
DeSiRABLE

Green City Performance Tracker

Decarbonisation of Winchester District



Fortis Unum

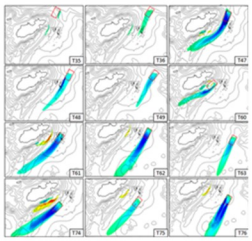


LATENT

DC Mini-Grids

Distributed Powerhouses

UoS Sustainability Strategy



Marine Energy

THERMOSS

SAVE

Low Carbon Cities

Energy for Development

Solar Shaded Car Park

SENSE

CareTeam

Liveable Cities

Energy Access & Energy Efficiency

International Centre for Infrastructure Futures

PhD & MSC Research

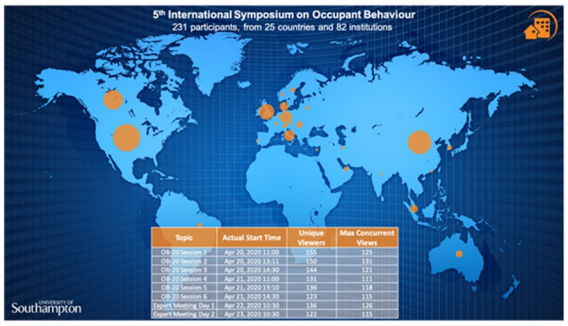
Outreach

For current events see www.energy.soton.ac.uk

5th International Symposium on Occupant Behaviour

April 2020

In light of the COVID-19 pandemic, the 4-day International Energy Agency's (IEA) Energy in Buildings and Communities (EBC) Programme Symposium and Task Group meetings addressing Occupant-Centric Building Design and Operation (Annex 79) was organised and held virtually by ECCD. This was the first time the event was held online resulting in a record attendance of over 230 delegates from 25 countries and 82 institutions



International Conference on Energy and Cities (ICEC)

July 2019

More than 90 delegates from 21 countries and 40 organisations attended the International Conference on Energy and Cities 2019 (ICEC2019) from 10 to 12 July 2019 in Southampton, UK. Hosted by the Energy and Climate Change Division the occasion was the second in the series of academic fora promoted by the International Academic Alliance for Low Carbon Cities, Neighbourhoods and Buildings (IAA-LCCNB).

Keynote speakers

5th African Mini-Grid Summit

June 2019

Prof AbuBakar Bahaj, head of the Energy and Climate Change Division at the university of Southampton, chaired the 5th African Mini-grid summit held in Nairobi, Kenya . The Summit was part of the World Bank engagement on energy access, bringing together academic, government and stakeholders.

Key Cities Meeting - City and the Environment

Feb 2019

The Southampton City Council joined forces with the University of Southampton and hosted a Key Cities Meeting addressing challenges on air quality, energy efficiency, transport, and infrastructure development. In a united effort to highlight the green agenda the meeting urged local authorities to adopt a "healthy and prosperous" vision towards air quality and energy efficiency in towns and cities across the UK.

Recent Publications

Lixiao Zhang, Mingyue Pang, Abubakr S Bahaj, Yongchuan Yang, Changbo Wang (2021) Small hydropower development in China : Growing challenges and transition strategy, Renewable and Sustainable Energy Reviews 137(December 2019), p. 110653, Elsevier Ltd, https://www.sciencedirect.com/science/article/abs/pii/S1364032120309370?via%3Dihub

AbuBakr S. Bahaj, Luke Blunden, Leonidas Bourikas, Milena Büchs, Patrick James, Yue Wu (2020) Energy, Wellbeing and Cities, Designing Future Cities for Wellbeing, Christopher T. Boyko, Rachel Cooper, Nick Dunn (ed.), p. 71-90, New York: Routledge, https://www.taylorfrancis.com/books/designing-future-cities-wellbeing-christopher-boyko-rachel-cooper-nick-dunn/e/10.4324/9780429470684

Sisi Yu, Yanfeng Liu, Dengjia Wang, Abu Bakr S. Bahaj, Yue Wu, Jiaping Liu (2020) Review of thermal and environmental performance of prefabricated buildings: Implications to emission reductions in China, Renewable and Sustainable Energy Reviews(13), p. 110472, Elsevier Ltd, https://www.sciencedirect.com/science/article/abs/pii/S1364032120307589?via%3Dihub

Tatiana Alvares-Sanches, Patrick E. Osborne, P. A.B. James, Abu Bakr S. Bahaj (2020) Tracking a city's center of gravity over 500 years of growth from a time series of georectified historical maps, Cartography and Geographic Information Science 47(6), p. 524-536, Taylor & Francis, https://www.tandfonline.com/doi/full/10.1080/15230406.2020.1774420

A S Bahaj, M Alam, L S Blunden, P A B James, I Kiva (2020) Pathways to Universal Electricity Access for Rural Communities in Africa, {IOP} Conference Series: Earth and Environmental Science 588, p. 22047, {IOP} Publishing, https://iopscience.iop.org/article/10.1088/1755-1315/588/2/022047

J Stephen, L Bourikas, D Teli, A S Bahaj, R Congreve (2020) Internal thermal environment and futureproofing of a newly built, naturally ventilated {UK} school, {IOP} Conference Series: Earth and Environmental Science 588, p. 32071, {IOP} Publishing, https://iopscience.iop.org/article/10.1088/1755-1315/588/3/032071

P Turner, L Bourikas, A S Bahaj, S Gauthier, P James, H Dalton, N Allott, J Lines (2020) Implementation of digital technology for connected resilient communities, enhancing access to public services, {IOP} Conference Series: Earth and Environmental Science 588, p. 32018, {IOP} Publishing, https://iopscience.iop.org/article/10.1088/1755-1315/588/3/032018

Sam Paine, Patrick James, Abu Bakr Bahaj, Andrew Waggott (2020) Heating and controls use resulting from shared-cost charges in communal network social housing, Building Services Engineering Research and Technology 41(3), p. 315-331, https://journals.sagepub.com/doi/10.1177/0143624420911170

D S Coles, L S Blunden, A S Bahaj (2020) The energy yield potential of a large tidal stream turbine array in the Alderney Race, Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 378(2178), p. 20190502, Royal Society, https://royalsocietypublishing.org/doi/10.1098/rsta.2019.0502

Luke S Blunden, Stephen G Haynes, AbuBakr S Bahaj (2020) Tidal current power effects on nearby sandbanks: a case study in the Race of Alderney, Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 378(2178), p. 20190503, Royal Society, https://royalsocietypublishing.org/doi/10.1098/rsta.2019.0503

L. Bourikas, D. Teli, R. Amin, P. A.B. James, A. S. Bahaj (2020) Facilitating responsive interaction between occupants and building systems through dynamic post-occupancy evaluation, IOP Conference Series: Earth and Environmental Science 410(1), https://iopscience.iop.org/article/10.1088/1755-1315/410/1/012021

Abubakr S Bahaj (2020) (Re-) Introducing the IMEJ : A home for the dissemination of research and development in marine renewable energy 3(1), p. 36688

AbuBakr S. Bahaj, Mostafa Mahdy, Abdulsalam S. Alghamdi, David J. Richards (2020) New approach to determine the Importance Index for developing offshore wind energy potential sites: Supported by UK and Arabian Peninsula case studies, Renewable Energy 152, p. 441-457, Pergamon, https://www.sciencedirect.com/science/article/pii/S0960148119319421

Ben Anderson, Tom Rushby, Abubakr Bahaj, Patrick James (2020) Ensuring statistics have power: Guidance for designing, reporting and acting on electricity demand reduction and behaviour change programs, Energy Research & Social Science 59(June 2019), p. 101260, Elsevier, https://www.sciencedirect.com/science/article/pii/S2214629619303780?via%3Dihub

Alois Klink, Abubakr Bahaj, Patrick James (2019) aloisklink/flirextractor v1.0.0: An efficient GPLv3 Python package for extracting temperature data from FLIR IRT images, University of Southampton, url, doi:10.5258/SOTON/D1133 https://eprints.soton.ac.uk/435549/

Ben Anderson (2019) NZ GREEN Grid Household Electricity Demand Data: EECA Data Analysis (Part C) Upscaling Advice Report v1.0, https://ourarchive.otago.ac.nz/handle/10523/9820

Ben Anderson (2019) NZ GREEN Grid Household Electricity Demand Data EECA Data Processing (Part A) Report v1.0, https://ourarchive.otago.ac.nz/handle/10523/9822

Carsten Dortans, Ben Anderson, Michael Jack (2019) NZ GREEN Grid Household Electricity Demand Data: EECA Data Analysis (Part B) Report v2.1, https://ourarchive.otago.ac.nz/handle/10523/9821

Kiti Suomalainen, David Eyers, Rebecca Ford, Janet Stephenson, Ben Anderson, Michael Jack (2019) Detailed comparison of energy-related time-use diaries and monitored residential electricity demand, Energy and Buildings 183, p. 418-427, https://www.sciencedirect.com/science/article/abs/pii/S037877881831661X?via%3Dihub

Michael Harper, Ben Anderson, Patrick James, AbuBakr Bahaj (2019) Assessing socially acceptable locations for onshore wind energy using a GIS-MCDA approach, International Journal of Low-Carbon Technologies, doi:10.1093/ijlct/ctz006 https://academic.oup.com/ijlct/article/14/2/160/5370116

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