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INTERNATIONAL CONFERENCE ON EVOLVING CITIES & TOWNS

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Preface

The [International Conference on Evolving Cities and Towns](#) (ICEC 2023) took place as a hybrid event at the [Centenary Building](#) (B100) situated in the Highfield Campus at the University of Southampton, UK from 12-14 September 2023. It brought together leading academics, policymakers, and industry specialists to debate the role of cities in addressing climate change mitigation impacts and accelerating our transition to net-zero carbon. Over the course of three days, there were [58 oral presentations and 4 panels with 16 panellists](#) covering research and case-studies from across 15 countries. The presentations were organised into three themes, one for each day: **inspiring innovation**, **frameworks for flourishing**, and **collaboration & co-creation**. These three themes cut across the conference topics shown in Fig. 1 to provide a rich, multi-disciplinary forum within which to discuss and debate ways to develop multi-stakeholder partnerships and implement innovative solutions to propel cities towards low carbon pathways.



Fig. 1: ICEC themes

This document provides a record of the submitted abstracts for the International Conference on Evolving Cities and Towns including all oral presentations and posters presented at ICEC 2023.

About ECCD

The [Energy and Climate Change Division](#) (ECCD) is part of the Faculty of Engineering and Physical Sciences at the University of Southampton. It comprises the Sustainable Energy Research Group (SERG) and the Coastal and Climate Research Group, established since 1990. ECCD/SERG research profiles address the University's mission focusing on fundamental understanding applicable to renewable energy studies, energy efficiency and energy for development. ECCD/SERG research [supports the United Nations Sustainable Development Goals](#) (SDGs) with fundamental and applied research across six research themes. These encompass (i) [Renewable Energy](#), (ii) [Energy Access](#), (iii) [Cities & Infrastructure](#), (iv) [Buildings & Communities](#), (v) [Behaviour & Modelling](#) and (vi) [Climate & Emissions](#). Visit www.energy.soton.ac.uk for further information.

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SESSION 1: Co-Designing Urban Solutions

Carbon offsetting for localized impact – What is everyone else doing? A Southampton Air, Land & Sea Transport sector perspective, in pursuit of a greater good – locally

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This paper delivers the context and findings from a recently commissioned Sustainability & Green Futures funding project, enabled with a multi-disciplinary research team from FoSS & FEPS (Southampton Business School & Future Towns Innovation Hub).

The project addresses a research question posited by Southampton Airport, to better understand the processes and ambitions around carbon off-setting across the city transport sector. Recognising the potential for increased carbon production with economic development outcomes of the Solent Freeport zones and airport runway extension, are positioned against the increasing environmental, economic and social challenges of the city. A need to better understand the extent off-setting practices are addressed, and particularly their impact globally are enabled. Further action is required to better understand their motivation to seek solutions to address issues closer to home.

A qualitative data collection with semi-structured interviews across a participant group of Southampton city transport stakeholders, provides the insights and context. The benefits of the university as a Business South Champion are unpacked, enabling strong working relationships with key industry leaders in the region, enabling a collaborative approach to the research with Business South's Maritime & Transport Action Group. The findings enable greater understanding around sector practices and recommendations requiring further enquiry to enable a solutions based approach for societal impact locally.

As this project was enabled with industry partners seeking answers to these questions in the first instance, the session will conclude with insights from a wide stakeholder group on how working collaboratively with their local university, has helped inform real business perspectives on addressing environmental challenges.

Healthy Residential Buildings in the Lake Constance Region: Analysis for Harmonization and Further Development of Standards for the Planning and Assessment of Healthy Residential Buildings

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Emissions from building products can negatively affect the indoor air quality of residential buildings. In order to avoid this, various assessment systems, labels and planning tools for pollutant-free construction products have emerged. However, the requirements of the various planning tools and certification systems differ in terms of their contents. Definitions, test specifications, measurement criteria and limit values are often not congruent. Especially in border regions such as the Lake Constance region, where the borders of Germany, Austria and Switzerland lie, this can obstruct the emergence of a common internal market for low-pollutant building products. Harmonization of building product requirements and joint further development of the different planning tools and certification systems offers a great opportunity to promote pollutant-free building across regions. Within the framework of the research project "wohngesund", which was funded by the Interreg V Alpenrhein Bodensee Hochrhein program, the requirements of the standards for pollutant-free residential buildings

established in the Lake Constance region were investigated. Not only the different product requirements but also the development, the reference to product labels and the kind of quality assurance of the investigated building standards have been analysed. Methodical approaches were developed for the various aspects, on the basis of which the differences and commonalities of the standards were worked out. In order to lay a foundation for a joint development of the criteria catalogues, relevant topics were identified on the basis of an extensive literature review of the state of the art in science, legal requirements and current product developments. Building on the studies of the existing criteria catalogues, it was possible to identify the topics that are not to be found in the criteria catalogues. The following topics were found to be highly relevant: Synthetic nanomaterials; human and ecotoxic substances not covered by REACH; release of microplastics from the construction sector into the environment. Another result was the conception and implementation of a criteria development platform. The aim of this is to provide an exchange platform where newly developed criteria can be presented and discussed.

User Centred Ecological Interface Design for Early-Stage Development of MaaS

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The Human Factors team at The University of Southampton have been engaged on the Solent Future Transport Zone using the User Centred Ecological Interface Design (UCEID) method in the early-stage development of the Breeze Mobility as a Service (MaaS) app. This method aims to deliver a user friendly and inclusive interface through a multi-stage process. This presentation will explain each of these stages and share the design recommendations which were generated.

BENCHMARKING

To evaluate competitor technology, 12 apps available in the Solent FTZ, were selected. These had features which could be included in Breeze to allow users to plan, book, pay or navigate journeys using personal car, public transport, micromobility and active travel.

INCLUSIVE DESIGN

An adapted heuristics tool was developed by the team to evaluate the usability and inclusive design features of the apps identified during benchmarking and will be used to evaluate the Breeze app at each development iteration.

COGNITIVE WORK ANALYSIS

An Abstraction Hierarchy for MaaS was developed. This is a five level model of a system which includes functional purpose, values and priorities, purpose related functions, object related purposes and physical objects. The complex MaaS system model helped to identify information MaaS users need and system constraints that may influence user behaviour. The model was validated with Subject Matter Experts (SMEs) to verify all nodes and connections and also identify any new ones.

FOCUS GROUPS – ICONOGRAPHY

Due to MaaS being a new technology there is no consistent visual language and so multiple focus groups were conducted with member of the public to establish the optimum icons which were currently in use across three different MaaS apps and issues which caused confusion or misunderstanding.

FOCUS GROUPS – DESIGN WITH INTENT

Design with Intent is a user centred design tool which uses written and visual prompts to encourage the creation of novel design concepts. Several workshops were held with over 80 concepts generated which have been scored and prioritised by SMEs leading to the further development of six prototypes and storyboards.

Make Your Place – Co-design for Future Towns and Cities

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Make your Place (MYP) is a schools enterprise challenge focused on place based innovation and built upon the EntreComp Framework for Entrepreneurship (Bacigalupo, Kampylis, Punie & Van den Brande, 2016). It is a collaboration between the University of Southampton, Southampton City Council, and the Solent LEP, and it is funded by UKRI HEIF. The challenge works with pupils to encourage exploration of their local environment and the economy of their town or city, and through that lens they develop consumer profiles and generate ideas for products, services, and activities to improve their place by making it more engaging, connected, and sustainable. This paper discusses the impact of the programme on the pupils and shares the findings of the external evaluator and the delivery team, including the lessons learned and opportunities for its future development.

Promoting the Adoption of Eco-Friendly Cars. Hybrid and Electric Vehicles in Kuwait: Addressing Challenges and Implementing Strategies

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Kuwait, a small Arab country in the Middle East, is about one-third the size of Scotland and has a thriving economy largely based on its crude oil reserves, which account for nearly 6% of the world's reserves. With petroleum accounting for over half of Kuwait's GDP, 92% of export revenues, and 90% of government income, Kuwait has a thriving automobile market, making it the most profitable and largest in the Middle East and North Africa (MENA) region. The low cost of fuel, tax-free customs on imported automobiles, improved economic situation, and increased per capita income over the last 50 years have all contributed to Kuwait's high vehicle ownership rate.

To meet future energy demands while preserving the environment, Kuwait must diversify its energy resources and adopt sustainable and innovative renewable energy technologies. Encouraging consumers to embrace eco-friendly cars, such as hybrid cars and electric vehicles, is an important step towards this goal. However, there are several issues must be addressed to promote the adoption of Electric Vehicles and Hybrid cars in Kuwait, including the installation of EV charging stations in various locations, funding for house owners to install small-scale PV systems, testing of different EV battery cooling systems under extreme climate conditions, and setting safety measures and precautions for hazards such as electrical power, high flammable batteries, and explosions. Other necessary steps include developing the country's infrastructure for EVs and Hybrid Cars, spreading public awareness, training emergency personnel on how to handle EVs in emergency situations, facilitating the import of EVs, and providing a safety mechanism to protect personnel working on electric vehicles. In addition, a national program must be developed and implemented in Kuwait.

SESSION 2: Collaboration and Civic Engagement

The Solent Cluster: Working Together for a Lower Carbon Future

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The Government has set targets for the UK to reduce its carbon dioxide emissions to Net Zero by 2050. Hampshire and its marine gateway, the Solent, is one of the largest and most successful industrial areas in the UK, supporting around 90,000 businesses and a £50bn economy. With around 200,000 large vessel movements each year, the ports of Southampton and Portsmouth are major trade and commercial hubs connecting the UK with the global economy. Our region is also close to the UK's busiest airports and our planned technology and innovation hubs will develop and produce a new generation of sustainable fuels that will support the UK's aviation sector and extend our impact far beyond the Solent. Working together we can help this vital industry to reduce its carbon dioxide emissions and meet its ambitions for a lower carbon future.

The Solent Cluster partnership represents a once in a generation opportunity to effect real change in energy production and consumption. It brings together a wide group of partners focused on the decarbonisation of businesses and industry in the southern region and beyond.

Citizen's Assemblies in Cities

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Southampton City Council is working with the University of Southampton, University of Oxford, Involve and the Sortition Foundation to run the Southampton Citizens' Climate Assembly (SCCA) in 2023. The SCCA will bring together a diverse group of people to learn about and discuss issues around climate change and transport in Southampton, and reach conclusions about what they would like to see happen in the city. Citizens' assemblies, like the SCCA, have been used by governments and parliaments around the world to help shape their work. The SCCA is one of over twenty local citizens' climate assemblies and juries to take place in the UK to-date. This talk will introduce the research that led to the development of the SCCA, provide an overview of Citizens' Assemblies as a process and explain the design of the SCCA, including implementation, research and evaluation.

Different perceptions on building urban social resilience among Dubai authorities

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Based on interviews with city officials and first responders, this paper analyses perceptions of social resilience in Dubai, a city whose authorities have vowed to make resilient and sustainable. Social resilience is difficult to achieve in urban settings of the Middle East. This is due to unique contextual challenges which include citizens being accustomed to high

standards of living founded upon a fossil fuel economy, and limited awareness of the concept of resilience. However, the region also faces increased vulnerability, owing to the increased local impacts of climate change, and increasingly frequent climate-related extreme events such as droughts and heat waves.

Dubai's Authorities have recognised this and in their efforts to build a resilient and sustainable city have employed innovative tools and methods that go beyond typical urban resilience frameworks, with a focus on new technologies. Yet they face challenges in ensuring that all involved stakeholders, especially among authorities responsible for implementation, share common goals and visions. It is therefore important to understand how members of different Dubai authorities view the social aspect of resilience, which measures they prioritise and why. As this paper demonstrates, there are diverging views between city authorities and first responders, relating to resourcing, accessibility and efficiency, as well as a notable blind spot in the form of effective community engagement, with it being viewed as a likely positive consequence of other resilience building measures rather than an end in itself. This paper will explore these approaches to social resilience in Dubai and argue for increased community participation and involvement in building and maintaining urban resilience, which can be achieved primarily through better public communication and improved interoperability between different authorities.

Exploring how the recent advances towards Smart Cities and the role of e-Governance can help integrate informal settlements into growing urban environments in developing countries

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New major cities in developing countries like Brasilia city in Brazil, Gaborone city in Botswana and Islamabad city in Pakistan invariably have significant numbers of informal settlements. These are residential areas where inhabitants do not have legal rights to the land they occupy, and the neighbourhood often lack basic infrastructural services. This study will explore how the recent advances towards Smart Cities and the role of e-Governance within the process of integrating these informal settlements into growing urban environments. The research work is based on a qualitative evaluation of the roles of e-Governance of informal settlements in developing countries with reference to Abuja, the new capital city of Nigeria. A case of Abuja, Nigeria will adopt a multi method approach to understanding this issue.

Following a comprehensive review of smart cities, e-governance and informal settlements of developing economy cities, an initial conceptual framework for e-Governance of informal settlements in developing countries was formulated. The framework is then applied in a case study to support further data collection and to establish an exhaustive view of the role of e-Governance of the Abuja informal settlements. e-Governance frameworks will encourage policy coordination at all levels to include the voices and participation of the residents of informal settlements who are mostly poor. e-Governance has become one of the reform tools geared towards public service delivery, which is premised on the use of Information and Communication Technology in day-to-day activities of the government. e-Governance is an enabler of Smart City.

Many of the models and frameworks built to determine the role of e-governance processes are based on the implementation experiences in Developed countries. Although, there are important lessons to be learned, these frameworks have limited application in developing countries. It was previously difficult to investigate e-governance in developing countries due to poor technical infrastructural development. Recent advances in e-governance in developing countries have made it possible to conduct studies in those countries.

Findings from the research show that e-Governance initiatives can bring more transparency, accountability, and inclusiveness to urban governance. The proposed framework can help integrate the informal settlement communities into the growing urban environment.

SESSION 3: Liveability in the Urban Environment

Understanding Pride and Place: Creative Approaches to Community Engagement

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This paper draws on our AHRC-funded knowledge exchange project, Feeling Towns: Place and Identity in Local Governance. In this project we worked with local authorities and cultural and heritage organisations to understand how ‘pride in place’, one of the 12 missions of the Levelling Up agenda, could be understood and measured in relation to how communities feel about the places they live and enhance place attachment and community engagement. We developed a tool kit detailing how our creative approaches, including photo elicitation, emoji mapping and poetry collage, can provide new ways of understanding the needs of communities trying to respond to a range of economic and political challenges. Often this assume a tension between economic need and environmental sustainability that needs to be unpacked with communities. In this paper we will give one case study from this work, focusing on our work with Sandown on the Isle of Wight: a community trying to balance severe economic challenges with a new green future.

Framing and Characterising the Quality of Urban Life in Post-Industrial Cities

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The places we live, work, and move have a major impact on our well-being. UN Sustainable Development Goals clearly state that ‘...promoting well-being is essential to sustainable development’. Post-industrial cities (PIC) have a legacy of urban deprivation and inequalities, which have a negative impact on well-being of urban population. PIC can be described as the emerging set of urban forms and functions as a result of de-industrialisation and the economic restructuring in the 1960s. Most of the medium-large sized former industrial cities in Europe can be described as ‘post-industrial’. The sudden political and economic changes in people’s living environment fostered social and spatial challenges. Urban deprivation and widening inequalities are the major outcomes of these changes since the 1960s. Previous top-down approaches in urban-planning that rely on objective data and statistical records to tackle these challenges resulted in poorer quality of life (QoL) especially for the disadvantaged end of the spectrum.

There are many definitions of QoL, but there is no universally excepted definition of it. In this paper, QoL is defined as a level of life satisfaction that a person can receive from their wider living environments. Our living environment includes all political, economic, social and physical aspects within it, and developing a framework for understanding and measuring these aspects and how they influence people’s well-being can be an effective tool for decision making while extracting the characteristics of QoL relevant to PIC. The paper aims to develop a quality of urban life (QoUL) framework to examine people’s life satisfaction with their living environment based on identifying key characteristics. The collected data from such a framework can be valuable for policymakers, planners, and researchers to examine the reciprocal connections between the characteristics of quality of urban life and the residential neighbourhoods in PIC and the way in which they can be improved towards enhancing the urban well-being of their populations.

Impact of neighbourhood urban form and socio-economic characteristics on the place-based elderly's social wellbeing

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The global phenomenon of population ageing has significant implications for social policy, especially in the context of urbanisation and urban development. As cities evolve, grow, and new neighbourhoods emerge, the accessibility of services and opportunities for social interaction, particularly for the elderly, are being impacted. However, there is limited consistent research on the influence of perceived neighbourhood urban form and socioeconomic status (SES) on the social wellbeing of elderly residents. This study aims to fill this gap by examining the impact of SES and selected urban form factors (density and diversity) on the perceived elderly's social wellbeing (ESW). A key challenge is to consider the neighbourhoods from the perspective of the elderly themselves, enhancing our understanding of how SES and contextual features interact with patterns of social wellbeing.

This study utilises a mixed methods approach, combining qualitative and quantitative methods. It incorporates a synthesis of interdisciplinary literature and the findings of 41 semi-structured interviews conducted with elderly residents (aged 65 years or above) from six distinct neighbourhoods in Isfahan, Iran. Both the literature review and the qualitative research findings inform the subsequent phase, which involves survey design. The questionnaires were administered to elderly respondents in the six case study neighbourhoods in Isfahan, resulting in a distribution of 1200 questionnaires and 184 returns. The questionnaire aimed to gather information from elderly individuals to examine the effects of SES and urban form factors on ESW. The study employed multiple linear hierarchical regression, ANOVA, and T-Tests to analyse the practical implications of the ESW model.

The study findings highlight a notable positive association between the perceived social wellbeing (ESW) of elderly residents and higher density as well as land-use mix in their neighbourhoods. Additionally, the study identifies that length of residency and number of children positively impact overall ESW, while the factor of homeownership was not significant in ESW. These environmental factors influencing perceived social wellbeing offer valuable insights for aging associations and urban policymakers in Iran to design and develop age-friendly neighbourhoods.

Will bats benefit if streetlights are switched off at night?

S. Leggett¹

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Anthropogenic light pollution is a significant issue globally. Artificial light at night (ALAN) has increased in association with human activity and is well known to being a threat to biodiversity. Nocturnal wildlife is especially affected, for example bat species. I will argue that reducing light pollution would be a major benefit to bats. Local councils face skyrocketing costs as energy bills rise sharply and are looking to reduce energy consumption by turning down or switching off streetlights at night. Resistance to this move comes from a perception that by reducing lighting at night crime rates increase. I will contend

that by decreasing ALAN, councils will reduce their carbon footprint, slash their energy bills, and improve the ecosystem for crepuscular and nocturnal biodiversity to thrive in urban environments.

Lagos, A Livable Mega City, Time To Ponder

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Globally, urbanization is trending with its associated values and challenges. Cities are ecosystems meant to be the engine rooms of development with opportunities. They should be functional, secure, well-connected, livable and smooth running. Interestingly, going by the index of global best cities or livable cities centred on robust and sustainable neighbourhoods, accessibility and sustainable mobility, a diverse and resilient local economy, harmonious public spaces, security and affordability. Most African cities failed to make the first 120 cities. An empirical analysis of the liveability of Lagos mega city in relationship with other global liveable cities constantly raises the question of whether Lagos is a livable megacity or a mega slum. The indices of measurements are; land use, traffic and transportation, migration pattern, living conditions, physical and social infrastructure, security, law and order, green and greenery, ease of doing business, and availability of space for internment of the remains of the citizens. Currently, Lagos is the second largest mega city in Africa after Cairo and comfortably edging to a status of a meta city with a population of over 20 million people. Regrettably, Lagos is still having all the attributes of a mega slum. This report will be addressed in line with internationally accepted criteria of a livable city vis-a-vis the existing land use in Lagos as well as other accepted yardsticks for liveability. More importantly, Lagos will be assessed amongst others on the availability of physical and social infrastructure, green/greenery and provision of space for the interment of residents of Lagos. The existing level of services in selected livable cities will be compared with what is available in Lagos. All these will be related to the efforts made by municipal authorities in Lagos.

Local Action in Compressed Spaces: Local Leadership and environmental issues in occupied Palestinian spaces

S. Halawani¹

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Living in the Occupied Palestinian Territories (OPT) meant accommodation and resilience. Compressed urban expansion is a term I devised to describe the experience of living in an area that is confined both in space and time, hence compressed, yet expanding uncontrollably in this confinement due to natural growth and change in internal demographics. The opposites in the term describe a dichotomy in the state of aspiration and reality of Palestinian Lives. Life expands and grows naturally, yet it is compressed through controls imposed by Occupation, and the population's attempt to manage the compressions.

Congestion, suppression, and suffocation are by-products of the original compression, and living in the OPT leads to adopting this compression and accepting its confinements as a natural destiny repackaging it as resilience. This compression led to stresses that became more and more visible as the population grew. In time, the stresses translated into violent

expressions of discord on multiple levels. Infrastructure deterioration and the subsequent mental health impact are taking a toll on the population.

These areas created a milieu where three concepts interact: Virtual Sovereignty, Compressed Urban Expansion, and Coercive Environment. Each unique concept has manifested itself to have a detrimental impact on the population that lives in those areas. Solutions to the situation will be complex, but most importantly, the role of local leadership in these urban spaces has not been studied sufficiently, especially in regard to the impact of environmental degradation that is becoming more prevalent and noticeable.

The research will study elements of leadership on the local levels in Palestinian communities and how these understand and deal with environmental issues, if at all. It will attempt to establish empowering factors that enabled the local leadership to provide leadership and guidance to their communities on dealing with environmental issues, as well as identifying obstacles that prevented action. The presentation will highlight the aforementioned concepts and present the initial results of the research, seeking feedback to develop the research further.

Unearthing embedded exclusion – promoting equity through system design in electrification

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The last decade saw access to electricity take centre stage in efforts to grow economies and improve equity in social policy in Sub Saharan Africa, to enable development. However, evidence from countries that were early and zealous adopters such as Kenya show mixed overall economic and social outcomes and poor sub-national results. National institutions responsible for electrification face the problem of responding to these outcomes, while maintaining progress towards universal electricity access, and are likely to contribute to worsening societal outcomes. We consider that development of electrification infrastructure in Kenya builds on a backbone of pre-existing infrastructure such as the railway network, which is an economic, social, and political legacy, whose development objectives were restricted to a segment of society. Additionally, that current energy engineering practices such as least cost electrification planning provide a technical framework for processes to expand electricity access but are limited in their acknowledgment of and response to this legacy. We argue that these practices effectively present a continuity in policy, one which has embedded and sustained exclusion of parts of society, and propagated inequality of opportunities. This paper seeks to explore the motivation for historical policy choices in electrification infrastructure development and the extent to which they continue to inform current electrification practices in Kenya. Through this work, we provide a better understanding of inequalities in electrification, and render visible to public policy makers parts of society which would otherwise continue to be left behind in development. We offer initial recommendations for further work on how system design can be improved to promote equity in and through electrification, beyond the mainstream urban – rural classification.

SESSION 4: Cityscapes of Change, Net Zero Pathways for Urban Areas

Interpretable data-driven methods to automate energy model calibration – Southampton Highfield Campus case study

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The building sector is one of the most resource-intensive sectors and a major contributor to carbon emissions. Reliable building performance analytics are required to provide the evidence needed to support the design of energy efficiency interventions and the planning of decarbonisation strategies for existing building stock. Due to the magnitude of investments required to meet decarbonisation objectives, reliable energy performance data serve as the basis for decision-making in the planning of energy efficiency interventions and carbon reduction strategies. At the same time, minimising the time and costs required to obtain reliable estimates of building performance in terms of energy, operational expenditures, and environmental impact is an important area of research at present. Currently, data-driven methods whose workflow can be (at least partially) automated while retaining interpretability (i.e., the possibility to be easily understood in human terms), represent a significant area of research. In this study, we present advancements in data-driven methodologies used to plan the decarbonisation strategy for the Highfield campus of Southampton University. The proposed methodology and tools are scalable and can be readily implemented in other case studies involving decarbonisation and energy efficiency measures for the building stock.

Post-COVID patterns of staff commuting in a Higher Education Institution

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To respond to the climate emergency many academic institutions set out targets for their carbon emission. The University of Southampton, UK, is no different and has set a net zero for Scopes 1 and 2 by 2030 and Scope 3 by 2045. In order to estimate its overall emissions under Scope 3, the staff commuting emissions component will need to be considered. Further, a detailed analysis of commuting practices will also enable the University to identify approaches and drivers geared to reduce commuting emissions. This research reports on the results of the analysis of the University's Staff and Student Travel Surveys conducted in 2022. The total emissions resulting from staff commuting estimated from responses from the survey were estimated to be approximately 1,900 TCO₂e with car emissions accounting for almost 97%. Compared to pre- and post-COVID periods, on average, ~50% emissions reduction is seen across all travel mode categories implying a significant reduction in the frequency of commuting post-COVID. Small cars contributed the highest share of emissions where petrol cars contributed more than 70% of the emissions. The 47% of staff respondents to the survey lived between 0-4 miles with around 15% of these commutes from 10-19 miles from the University. These seem to be the highest contributor to overall emissions (30%) of any distance range due to their use of cars. The change in pre/post-COVID emissions from the 10-19 mile distance category is also among the lowest implying that despite the lower frequency of travel, the reduction in emissions post-COVID is not as substantial. The survey also collected qualitative responses and our analysis showed very little behaviour change post-COVID in shifting public transport, car sharing, micro-mobility, and active travel.

Surprisingly, the use of single-passenger cars for commuting has reduced which indicates the impact of the home working policy.

Improvement of building envelope performance through phase change materials (PCMs): Results of experimental activities

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The maritime transportation sector accounted for 2.6% of the global CO₂ emissions in 2015, with the International Maritime Organization (IMO) predicting further growth of emissions by up to 250% by 2050. Consequently, sustainable urban development of large port cities whose local economy significantly depends on shipping, such as Southampton UK, requires low emission solutions. The recently formed “Solent Cluster” proposed the replacement of fossil fuels with alternative carbon-neutral fuels, directly integrable into the existing shipping infrastructure, such as methanol (MeOH). MeOH can be sustainably synthesised from the catalytic conversion of green CO₂ and H₂ using fixed bed chemical reactors. For its bulk production, however, scaling-up fixed bed chemical reactors is crucial. Moreover, optimising the reactor design and operation to achieve efficient catalyst utilisation while maximising product yield is a key concept of sustainable development.

In our previous work, we developed a computational fluid dynamics (CFD) model of a lab-scale fixed bed reactor used for MeOH synthesis. Using available experimental data, we validated the CFD model, and the model accurately replicated experimental results. The produced model was then applied to a parametric study to understand the behaviour of the reactor during operation, guiding further experimental investigations and novel catalyst engineering. At this conference, we will advance our model further and apply it to reactor engineering by scaling-up the reactor from the mm-scale (16 mm reactor length) to industrial-scales (7 m reactor length). Through dedicated parametric studies, its design will be optimised. Here, optimisation will focus on identifying the reactor dimensions which minimise the pressure drop and the temperature hotspots whilst maximising product yield and reducing catalytic loading. The generated results are highly valuable to advance the fixed bed reactor technology, bringing along significant economic and environmental benefits.

Assessment of EV infrastructure needs in a local authority context

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The transport sector in the UK must be decarbonised to achieve net-zero carbon emissions by 2050. However, there are limitations, particularly for automobiles in cities with limited charging facilities. Overcoming these obstacles would surely boost the adoption of electric vehicles (EVs), with corresponding reductions in emissions and improved environmental conditions in cities, particularly air quality. Overall, drivers hesitate to invest in an EV if they cannot find a handy charging station in their neighbourhood. This study proposes an approach to aid in developing optimal EV charging infrastructure placement so that it is accessible to as many individuals as feasible inside a city.

The work focuses on Southampton City in the United Kingdom. The Analytical Hierarchy Process (AHP) is connected to site spatial evaluation utilising the Geographical Information System (GIS) as a part of the multi-criteria decision-making method. Critical parameters such as road type, road access, on-road parking availability, road slope, accessibility to fuel stations, proximity to lamp posts, current or planned charging points, car parks, and demographic distributions were evaluated. The procedure included two suitability filters: a restricted road and a suitability mask. The initial step was to eliminate all prohibited roads from further investigation, which reduced the number of road segments from over 7,000 to roughly 1500. When the second filter was applied, the overall result was less than 100 appropriate EV charging point locations. These sites were then confirmed by comparing real locations to those predicted by the algorithm using the Google Earth® imaging platform.

A probabilistic analysis of future pathways for hydrogen in the City of Southampton towards net zero emission target

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From a socio-technical perspective, the transition to a low-carbon energy system can be described as a “great reconfiguration” that entails the risk of impact shifts. In order to achieve a rapid and deep decarbonization, electrification must be accompanied by effective efficiency and flexibility measures. Hydrogen can be favoured in the decarbonisation process when electrification of end-uses is challenging or impractical, as well as for long-term storage in an energy infrastructure with a high proportion of renewable energy sources. Hydrogen can represent a solution for use in multi-energy systems with combined heat and power (CHP), especially in urban energy districts and other large building facilities, despite the current uncertainties regarding costs, environmental impact, and the inherent difficulties of increasing supply capacity rapidly. In particular, the evolution of CHP from natural gas to hydrogen fuelled technologies represents an opportunity to reduce emissions and to provide flexibility services in the UK electric system, characterised by an increasing quota of RES electricity and low carbon emission factors. In this paper, various CHP systems located in Southampton (United Kingdom) are analysed to identify potential variations in their future energy demand in the presence of efficiency measures, the impact of climate change, and the advancement of CHP and district energy technologies. The study suggests using scalable data-driven methods and probabilistic simulation to generate seasonal energy demand patterns that represent the prospective short-term and long-term evolution of the energy demand patterns for the various case studies.

SESSION 5: Complexity and Risk in Urban Infrastructure

From energy security to sustainability: risk and resilience in fuel supply chains

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The characteristic of resilience of a system is derived from understanding and mitigating risks impinging on the system. The supply chains for all fuels – fossil and renewable – carry risks of various types. As a sustainable energy economy requires shifting from fossil fuels to renewable sources, it is important to understand what risks are present, where they reside in the supply chain, and their level of importance. The transition must be accomplished whilst maintaining energy security for provision of electricity, heat, and transport. The need to assess risk is common in industry and commerce, most notably in the insurance business where it plays a central role. Many previous studies of energy security have concentrated on resource availability, price, or international relations, neglecting other risks.

We present an approach to energy security which bring together environmental, human/social, and economic elements into a single self-consistent and transparent framework yielding indicators and metrics. We analyse the whole of the supply chain in a six stage process from exploring for resource to use by the final consumer. We identified 19 renewable and non-renewable fuels relevant to the UK, both current and potential sources. We find that sources of risks can be categorised into seven groups, namely economic, environmental, innovation, manufacturing, political, skills, and technical. Furthermore, we identify 34 specific sources of risk which we assess to compare their relative importance for the different fuels. This is a fundamental re-examination of what energy security means, and how it can be safeguarded for any community, region or nation. Our method underlines the need for assessments and data relating to many issues which are commonly not considered as part of energy security.

Once the risks are quantified for each unique fuel supply chain it becomes possible to compare different scenarios and investigate different policy choices. We applied our method to scenarios from National Grid, the Climate Change Committee, and the '7see' whole economy energy model. In calculating the levels of risk as the energy system design changes, we show that the total risk varies considerably for scenarios with the same desired outcome.

Application of a framework for exploring complex urban energy systems to heating and cooling two cities

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Cities must urgently transform their heat systems to meet net-zero targets, and to reduce fuel poverty and improve air quality. Such radical transformation requires consideration of energy technologies and vectors, as well as users, institutions and networks. A complex-systems perspective on the long-term future could help in developing pathways to steer such transformation to a desirable outcome, meet the multiple welfare goals sustainably, and mitigate uncertainties that can threaten our planned futures.

We recently published work (Basu and Bale 2023) presenting a methodological framework to explore futures of complex urban energy systems, drawing on methods from the futures and foresight literature, and embedding ideas to encompass uncertainty and complexity. In this presentation we will discuss preliminary results from the application of this framework to two contrasting case study cities, Leeds (UK) and Pune (India). We will present findings on the first steps of the framework to develop visions of heating and cooling systems for the future of these cities, mapping the context and identifying short-term trends and key drivers of change. We will report on the participatory methods involved and the learning in terms of the state of play of heating and cooling in these two cities, and the challenges that may lie ahead.

We will use this work to critically examine the usefulness of our futures framework (an example of a 'framework for flourishing') as a way to enable transformation of heating and cooling in cities through participatory processes.

SESSION 6: Human-centric, Equitable Infrastructures

Beyond Infrastructure: Prioritizing Social Sustainability in Urban Transportation through Stakeholder Engagement and Indicator Development

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This abstract explores the concept of social sustainability in urban transport and its importance in enhancing the overall quality of life for people in the built environment. While there have been numerous studies on planning sustainable transport systems, there is a lack of theoretical and empirical research on social sustainability concepts in urban development, particularly in developing countries. This research aims to address this gap by emphasizing the need for continuous evaluation of outcomes on the social dimension of sustainability.

The complex interactions between various variables involved in urban transport sustainability make it challenging to develop widely accepted sustainability indicators. The overlapping and differing opinions of stakeholders further complicate finding common ground between them. Therefore, this research explores the potentials and limitations of different stakeholders' perceptions of urban transport sustainability to identify the appropriate and major stakeholder groups. This allows for the development of an indicator system that reaches a middle ground for all stakeholders, leading to greater applicability for different stakeholders.

The research uses the case study of Amman, Jordan to apply the analytic hierarchy process (AHP) using experts' opinions to compare and rank the relative importance of these indicators. The study highlights the importance of social sustainability and provides a means for its assessment, providing insight to decision-makers about potential areas of policy intervention. The research argues that socially sustainable urban transport is a key factor in enhancing the quality of life of people in the built environment. The development of sustainability indicators that take into account the perspectives of various stakeholders can help decision-makers evaluate the social dimension of sustainability and guide policy interventions. This research highlights the need for a paradigm shift and continuous monitoring to achieve sustainable urban transport systems that benefit society as a whole.

Gender equitable transport systems: An e-micromobility case study

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Gender equity refers to the fair treatment of women and men in relation to their respective needs, understanding that these needs may be different and therefore require support in different ways. This differs to gender equality which refers to the equal treatment of women and men. Gender equality is important in enabling men and women to be seen as equals, yet within this work the need for gender equity within the design and development of systems is argued for. The concept of 'gender data gap' refers to the lack of data available on women in comparison to their men counterparts, which has led to numerous systems not being designed to adequately cater for women. The transportation domain is a domain where this 'gender data gap' is particularly pertinent, with numerous transportation system lacking in

data on how women use and interact with them. There are a number of different factors that contribute to the gender data gap which need to be targeted.

A group of inter-disciplinary researchers at the University of Southampton have formed a working group named 'Close the gender data gap' to try to target some of these factors. This presentation will introduce a small project that came out of the working group which focuses on gender equity in the relatively new mode of electric micromobility (e-micromobility), including electric scooters and electric bicycles. Research was conducted to understand how this mode of transport is perceived by women and men and review how it may overcome some of the gender issues identified from more established transport modes (including road vehicles, public transport and air travel). User-centered methods were applied including, interviews focus groups and an online survey to capture a range of perspectives. These were combined with sociotechnical systems analysis to provide gender equitable recommendations for enhancing the design and integration of this mode of transportation. These recommendations are gender equitable and aim to increase the uptake of this mode of transport and encourage modal shift away from private vehicle use.

Towards Crowdsourcing Journey Experience Data

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Promoting physical activity is acknowledged as an effective strategy for preventing chronic diseases such as obesity, depression and cancer (Lee & Buchner, 2008). One strategy for establishing a regular physical activity routine and increasing physical activity levels is to incorporate active mobility such as walking and cycling into our daily journeys (Jones and Ogilvie, 2012). Beyond the health benefits, integrating active mobility modes into daily travel contributes to more sustainable mobility practices, actively mitigating climate change by reducing greenhouse gas emissions linked to motorized transportation.

This research focuses on helping to integrate active mobility into daily journeys to increase physical activity levels. To achieve this goal, comprehensive data on journey experiences is crucial as it offers valuable insights into the factors influencing individuals' activity levels and exercise patterns. By adopting a qualitative approach, this study aims to deepen our understanding of journey experiences, motivations, and behaviours, ultimately creating healthy spaces and promoting active mobility. A diary study employing a design-led methodology is conducted to capture everyday activities, opinions, and values related to journeys. The research consists of two phases: an initial phase utilizing physical diary kits containing journals, stickers, and maps, followed by a transition to a digital crowdsourcing platform for enhanced scalability and data collection accuracy.

The primary objective is to inform the design of data-driven and human-centric journey experience data collection tools within the context of smart cities. By establishing a design space for journey experience data collection, this research contributes valuable insights applicable to transport planning, urban design, and individual route planning. To address the challenge of effective data collection, we present initial findings from the diary study, exploring the meaning of journey experience and investigating potential methods for data collection. Furthermore, we examine the distinction between journeying through space and being in space, providing an initial description of factors that influence journey experience. These high-level insights contribute to the design space of journey experience data

collection. By leveraging data-driven planning tools and incorporating qualitative perspectives, this research supports the advancement of more sustainable and intelligent transport systems within the context of smart cities.

How do people view gender inequality in transport

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The academic and activism communities have long discussed transport's gender inequities and their impact on the barriers men and women face when considering how to travel, whether on public transport, via active travel, or using private motorised vehicles. The extent to which these inequities are understood, or even accepted, by the broader public, has received scant attention.

To address this gap, a series of asynchronous online focus groups (using online forums) were held. Participants, of which there were 146 (with a mix of ages and a slight over-representation of females), were separated into nine groups based on their residential location and whether they wanted to be part of a single gender group (men or women) or a mixed gender group. They were told that "Research indicates that men and women often have different experiences when using local transport systems" and that "men and women are affected differently by the various external factors that might influence (or constrain/force) a person's decision to use a particular mode". They were then asked "Do you agree with this? What are your experiences?".

An inductive thematic analysis of the 130 forum posts made by participants resulted in the identification of 15 broad themes. As might be expected, Safety was by far the most prominent theme and was considerably more prominent in the women's and mixed focus groups. Additionally, men spoke about their perception of women's experiences to a far greater extent than women spoke about their perception of men's experiences. These and other results have clear implications for policies related to education, but also for those concerning transport service provision, infrastructure, and the information that could be provided to contribute to a safer, more inclusive, more sustainable transportation system.

Net Zero Transformation : Exposing, Challenging, and Banishing the Legacy of a Not Zero Paradigm

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Since the industrial revolution we have been living in a Not Zero paradigm, built upon the convenient, but erroneous, Not Zero assumption that GHG, and other polluting emissions, are acceptable externalities for which the polluter need not pay. This casting of polluting emissions as insignificant externalities, has facilitated the provision of abundant, convenient, affordable, transportable, energy from the combustion of fossil fuels. Which in turn has powered long term economic growth and improvements to our quality of life.

Success has normalised the assumption, and established it as a central (typically unstated) tenet of economic and political thinking. As a consequence, our mindsets, lifestyles, cultural

norms, institutions, Infrastructure systems, food systems, tried and tested ways of working, expectations, our governance structures, policy frameworks, legal frameworks, regulatory models, decision making processes, and systems of performance measurement have all emerged, developed, evolved, thrived in the context of a Not Zero paradigm.

The Climate Emergency, and our inability to respond effectively, are inevitable legacies of the above. It is a Wicked Problem of Problems, comprised of at least 3 deeply interdependent wicked problems

A: Achieving Global Net Zero GHG Emissions

B: Achieving Net Zero Pollution for all other polluting emissions and waste streams

C: Enhancing systemic and societal resilience to global warming impacts

A-C are best resolved synergistically, through transformation of the shared paradigm/common mindsets, system goals and purpose, system rules, system structures and processes from which they emerge.

Therefore, a successful response to the Climate Emergency requires the Not Zero assumption and Not Zero paradigm that have shaped, and remain deeply ingrained in, all aspects of modern life to be exposed, challenged, and replaced by a new Net Zero paradigm. This will require, all of the following:

The adoption of a new Net Zero mindset;

Fit for Purpose System Goals, explicitly aligned with 1.

Fit for Purpose System Rules, System Structures and Processes explicitly aligned with 1. and 2.

My presentation will draw upon my C-DICE Fellowship research into Net Zero Success factors to elaborate upon the significance of, and demonstrate the validity of, the above narrative.

The challenges of everyday banking in the South Wales communities

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Consistent and universally available basic banking services were taken for granted in the UK for decades. Basic banking services can be summed up as the ability to execute a payment and receive, deposit, or withdraw money in one's own account. Each of these money flows, depending on the means of payment – cash, card or digital – has behind very different technology chains, companies, and vulnerabilities. The availability of these services in space varies a lot. The concept of “access to banking” if it is limited to the presence or absence of a point of service in space rather hides than clarifies the availability of each basic banking service.

The transition to digital banking led to closures of banking branches, post offices and ATMs from all over the UK. The author monitored the closures of these points of access between 2019 and April 2023 and identified South Wales as an area particularly affected by the closures. The spatial analysis aiming to identify the characteristics of the “banking deserts” was complemented by an ethnographic study in the area. The purpose of the study is to identify suitable solutions for local communities and inform policy for maintaining and improving access to banking.

Assessment of indoor thermal comfort in low-income households: The case of Al-Asmarat neighbourhood in Egypt

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In the light of the rapid urbanisation processes and the sprawl of slum settlements, many countries in the global South have implemented affordable housing programmes to provide accommodation for the low-income groups and relocated slum dwellers. The design of these housing units plays a crucial role in shaping the behaviour of the occupants and influencing their indoor thermal comfort performance. While energy models have undergone significant development in recent decades, their focus has predominantly centred on cases in the global North, with very limited literature on the energy performance of low-income housing and its impact on indoor thermal comfort. Therefore, the principal aim of this research is to investigate the energy performance of the low-income communities and assess the indoor thermal comfort within these households. This study focuses on the case of Egypt and the recently developed slum rehabilitation programme “Al-Asmarat” to accommodate slum dwellers from different areas in Greater Cairo. To achieve this aim, a baseline model was developed using the geometric data of the households, alongside assumed schedules for occupancy, lighting, and appliances. These assumptions were derived from an extensive review of similar cases in Cairo. The results showed that the total energy use was relatively low (approximately 28 kWh/m²/year). However, based on the comfortable temperature range set by ASHRAE 55 Standard, an average of only 18% comfort time is achieved throughout the year. Thus, occupants face significant challenges in achieving adequate indoor thermal comfort. This paper recommends further investigation into the dynamic nature of occupant behaviour, as well as the investigation of the comfort temperature ranges for low-income residents, in order to gain a more comprehensive understanding of energy usage patterns and indoor thermal comfort conditions in the context of low-income housing. Such insights will enable the refinement of energy and adaptive thermal comfort models to enhance the effectiveness of energy planning and retrofitting.

Simulation of the Urban Microclimate in a Hot Arid Region: A Case Study in Abu Dhabi

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It is predicted that by 2050, 7 out of 10 people will be living in cities. With this rapid urbanization, the Urban Heat Island (UHI) effect poses a major challenge, resulting in higher temperatures in densely built cities compared to rural surroundings. Several studies have associated extreme temperatures with increased rates of mortality, morbidity, and higher energy consumption for cooling. Numerical modeling, specifically Multiphysics simulations,

offers a pathway to study the urban microclimate. These simulations allow for testing innovative cooling interventions, such as green infrastructure and advanced materials, while also aiding in development of thermal hazard metrics. Studying the microclimate becomes vital for cities in hot and arid regions such as the Middle East, as these climate zones will experience further heat stress beyond the existing precarious conditions. In this study, we use a Multiphysics finite element simulation to model the microclimate of a compact university campus in Abu Dhabi, UAE. The simulation involves the calculation of wind flow and heat transfer through convection, conduction, and radiation. It utilizes 3D URANS (Unsteady Reynolds Averaged Navier Stokes) equations with realizable $k-\epsilon$ turbulence model and standard wall functions. In studies that utilize numerical methods to evaluate urban microclimates, various intricate physical processes are often simplified, necessitating validation through field measurements. A large proportion of existing studies lack this component. To ensure the accuracy of our simulation results, we implement a thorough validation strategy focusing on flow parameters and surface temperature. This involves gathering outdoor air characteristics from multiple weather stations and collecting surface temperatures using Infrared cameras and contact-based sensors over a span of several days. The initial results show that the model accurately estimates air temperatures (avg. $R^2 = 0.970$, avg. RMSE = 0.45°C) within the area of study and reliably predicts surface temperatures for several material groups (avg. $R^2 = 0.900$, avg. RMSE = 3.17°C). The results demonstrate that our modeling approach and validation methodology effectively fulfill the objective of obtaining a comprehensive understanding of the prevailing microclimate. These findings suggest that similar modeling parameters can be employed for conducting further studies in other cities within the same climate zone.

SESSION 7: Energy Systems in Transition to Net Zero

Assessing rooftops for PV deployment using AI in Saudi Arabia

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Awaiting abstract.

Acceptability of photovoltaic systems at the building level by household in Saudi Arabia

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Over the last few years, the use of renewable energy has been evaluated widely and has grown rapidly. The Kingdom of Saudi Arabia (KSA) has focused on increasing renewable utilisation such as solar and wind energy to decrease its reliance on fossil fuels. The overall aims of this study are to (i) assess the utilisation of solar photovoltaic (PV) in domestic settings (ii) examine the impact of such deployment on the electricity demand in housing and (iii) provide insights into how such deployment at scale can contribute to the renewable energy target in KSA. The domestic sector is targeted as it has a substantial electricity demand arising from air-conditioning which corresponds to around 50% of the country's electricity load. Furthermore, a high percentage of households 99.33%, are connected to the public electricity grid, where the adoption of PV in households is very small at approximately 2.02%. Here we report of initial studies based on the literature which overall shows a growing interest in renewable energy sources. Our initial analyses of the literature indicate that approximately 70% of households in Riyadh and Makkah expressed interest in reducing energy consumption, with ~50% of households in these areas showing interest in utilising solar PV systems in their homes. In the case of Jeddah city (the focus of this work), the residential building stock consists of apartments (72%), followed by villas (10%) and traditional houses (6%). The paper reports on the distribution of the floor areas of these buildings which was estimated based on the National Housing Strategy. This will create an understanding and database of appropriate areas for installing PV system of such buildings. The study also analysed KSA's building codes as well as the regulation framework for small-scale photovoltaics implemented covering the period from 2021-2023. These initial components of the research are providing solid basis to allow the designs of effective solutions to accelerate the adoption of PV in the domestic sector and as well as to quantify its contribution to KSA 2030 targets. The paper also reports on the development of appropriately focused surveys to provide further understanding on the need and acceptability of deploying PV systems in KSA's domestic sector. These initial findings will also contribute to a better understanding of the potential impact of PV systems on reducing electricity consumption, particularly in air-conditioning loads.

A combined monitoring and modelling approach to understand cooling loads for residential PV system sizing: Case study of a villa in Jeddah

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Saudi Arabia is situated in a very hot and arid region, and ranked as the third largest country for electrical cooling demand. Almost half of its currently generated electricity is used by the residential sector, where ~70% of this is used to support cooling loads. The Saudi government has an aspiration to be net-zero by 2060, which cannot be achieved without transitioning its current fossil fuel dominated energy supply to a sustainable pathway based on renewable energy. The Saudi 'energy sector transition plan 2030' included 40GW capacity of solar photovoltaic (PV) based on large scale solar farms but also has some emphasis on rooftop PV power generation.

This paper presents a combined approach of monitoring and modelling to understand electrical demand and cooling loads that supports residential rooftop PV system sizing. Understanding cooling loads at different times of the day and across various seasons is crucial to appropriately size the PV systems, and it also helps in making better investment decisions by the building owners. This is especially important considering the low residential electricity tariffs in Saudi Arabia. A year-round monitored electricity consumption data of a villa in Jeddah was analysed in relation to ambient temperature and cooling demand to provide the basis for optimum PV system sizing. Electrical demand of the study villa was further studied using TRNSYS modelling to understand the effect of different temperature set points (21°C – 26°C) on energy consumption. Monitored data show that daily electrical load of the villa varied between 76kWh in December and 187kWh in July with a yearly total of 66.4MWh. Modelling results indicate yearly energy consumption between 30.6MWh and 57.8MWh for 26°C and 21°C cooling temperature setpoints respectively, where in all cases higher demands occur in the summer months. Thus, understanding the cooling load variations at different times of the year, and with different temperature setpoints help to model the techno-economically optimum PV system that maximise the self-consumption. It is anticipated that shifting cooling loads to rooftop PV power generation will result in reducing the demand on electricity utilities.

Supply chain for PV farms, global and KSA relevance

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Awaiting abstract.

Testing methods of initiating interactions on energy between generations in the home

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Heating homes is responsible for 28% of the carbon emissions in the UK and thus has a significant potential for positive change that would help the country reach its strict carbon targets. How people use their homes and what influences their decisions could be key to reducing energy consumption. An increased level of occupant 'energy literacy' has been linked with more 'positive choices' in the home. Previous exploratory studies have shown children are a potential under-utilised influencer in the home that could be employed to disseminate knowledge and understanding to the main occupiers, thus improving their

energy behaviour. This research aims to test differing methods of initiating interactions about energy between children and their parents in the home, with end goal of helping occupants make better energy decisions and reduce their overall consumption in the home.

To address this research, two differing methods have been tested; a school based 'in person' intervention (n≈150) (method 1) and a home based 'online' intervention (n≈20) (method 2). Both methods discussed the basic principles of sustainability, greenhouse gas emissions, and energy in the home. The first through pre-prepared lessons delivered by teachers, the second through cartoon style videos on a website accessed at home. Both interventions then promoted inter-generational interaction in the home through a game played with parents/carers. these 'energy detective games' required children to record energy behaviours and physical aspects of their home either within a simple snakes and ladders style game (method 1) or on the specially created Kids4climate website (method 2).

A short time after the intervention, participant parents completed a survey describing any interactions that had since taken place, then if they had made any behaviour changes due to these interactions. Both studies saw adult occupants state multiple energy related interactions between child and parent had taken place, as well as improvements in their energy literacy. A critical comparison of the two methods is presented, reviewing the key ideas of interaction creation and knowledge transfer, as well as ease of engagement, scalability of deployment and success of learning.

Study of Battery Thermal Management System Using Composite Phase Change

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The Battery Thermal Management System (BTMS) is currently categorized into three principal categories, active system, passive system, and hybrid system. Amongst them, active cooling systems by air or liquid are the most widely used. However, air systems have its cooling limitations due to its low heat capacity and thermal conductivity. Liquid systems are costly in terms of energy consumption, investment and maintenance. Passive systems are a less expensive alternative. Passive systems can be classified into two principal groups: Heat pipes and Phase Change Material (PCM) composites. BTMS using PCM systems can present a problem of low thermal conductivity, regeneration or leaks in the liquid state. The regeneration problem can be solved by the addition of an optimized and intelligent active system that only triggers when needed to evacuate the heat stored in the PCM.

PCM low thermal conductivity can be improved by integrating a material with high thermal conductivity [1] such as fins [2], porous-graphite [3], expanded graphite [4,5], nanoparticles [6], and high porosity metal foam (MF) [7–11]. Among these solutions, MF have special properties that make them a very good candidate to improve the thermal conductivity of a PCM [12]. MF are porous media with large porosities and large contact areas per unit volume [13]. Recently, some efforts have been focused on the study of hybrid systems for the Li-ion batteries thermal management by adding an active system in order to solve the problems of passive BTMS using PCM composite. However, most research has studied numerically this problem. In this paper we proposed a new BTMS using PCM-MF composite. The goal is to keep cell temperature around optimal temperature of 25°C under a 1C charge/discharge rate. A new platform will be presented and described. The mold intended to house the cell and the MCP composite was manufactured by 3D metal printing. The heat dissipated

by the cell has been calculated from the experimental results and by used MATLAB code. The results will be presented and discussed.

SESSION 8: Innovation in Flexibility to Support Infrastructure

Investment opportunities for individual energy supply systems: a UK household case study

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The current evolution of the energy context and progress in sustainable energy technologies are enabling the development of new energy supply systems for the residential sector. Therefore, property owners are now given the choice to invest in a diversity of technologies for their home energy supply. The techno-economic assessment of these choices is however not straightforward and depends among others on the building type, its thermal insulation rate, the way the inhabitant consumes energy at home, but also on the climatic conditions or the energy and technology prices.

This study consequently aims to determine the robust and optimal design and management of an alternative energy supply system in a typical UK household equipped with a PV installation. This system implies technologies such as heat pumps, hydrogen boilers as well as battery and hot water storage systems, that will be sized considering uncertainty on several input parameters and according to the owner's intentions while investing in such assets.

This techno-economic optimisation problem is formulated as a multi-objective linear program over cost-competitiveness, CO₂ reductions and peak reduction, highlighting the possible trade-off between these considerations in the form of pareto fronts. This program is then applied to a diversity of scenarios to quantify the sensibility of the output results over stochastic input data such as the electricity, domestic hot water and space heating demands, the outside ambient temperature and the global solar irradiation. This dwelling diversity is generated using a thermal-electrical demand model that uses stochastic programming techniques to model uncertainty.

The contribution will conclude with a discussion on how the citizen can take part to the energy transition, while minimising its energy bill and contributing to the stability of the electricity grid. This especially makes sense in the current context of high energy prices and need for local balancing of decentralised renewable energy production.

The scope for off-gas grid community participation in demand side response

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England and Wales have an estimated 3.9 million off-gas grid homes, with 1.1 million homes relying on carbon-intensive fuels such as LPG, oil, and coal. However, urban building energy modelling and demand side response (DSR) have rarely been applied to off-gas grid communities. Additionally, community energy systems have become harder to finance, following withdrawal of subsidies and feed-in tariffs. This study investigates whether revenue from DSR could financially benefit an off-gas grid community energy system, helping to decarbonise domestic heating.

Existing literature has focused on island communities, which have different characteristics to mainland communities. Hence this study applies an urban building energy model to explore how DSR could financially benefit a community energy system, in a mainland-Wales off-gas grid community of 1000 dwellings. The community's housing stock has low fabric efficiency, and the most common heating systems are high-emissions oil and LPG boiler systems. The approach uses a geographical information system to process input data for a physics-based urban building energy model. Energy loads are then batch-simulated via EnergyPlus using UCL's SimStock QGIS plugin.

The community energy system involves decarbonising heating using electric heat pumps. However, widely heat pump deployment risks creating large peak grid loads, which align poorly with intermittent generation from wind and solar technologies. DSR could engage users to shift energy loads to help resolve mismatches between supply and demand. Socio-technical aspects considered in the work include how to avoid the problem of all households simultaneously shifting loads and choosing occupant characteristics reflecting different household compositions. Techno-economic assessment evaluates whether stacking value from DSR and other grid flexibility payments could enable the case study community energy system to become economically viable.

As well as being associated with high emissions, off-gas grid homes are also more likely to be in fuel poverty than gas-grid homes. The techno-economic assessment also attempts to account for the current energy price volatility, that could exacerbate fuel poverty. The outcome is understanding the viability of using DSR to incentivise a decarbonised energy system for the case study community.

Empowering Grid Resilience: An Incentivisation Framework for Micro-Scale Battery Energy Storage Systems

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The push for net-zero by 2050 in the UK will lead to an inevitable increase in electricity demand, driven mainly by the electrification of heat and transport. The current network infrastructure, however, has insufficient capacity to cope with the required expansion due to its thermal limits. Therefore, alternative methods to traditional network reinforcement are required to provide flexibility in the electricity network by managing power flows and increasing hosting capacity, especially in the distribution network.

One potential solution is the use of micro-scale battery storage systems (BSS) to absorb on-site generation (eg. from rooftop solar photovoltaics (PV)) to then be used when the properties electricity demand increases. This can reduce the required grid electricity import and therefore help prevent network constraints arising. However, these systems are currently expensive to purchase and install. Previous UK government incentivisation schemes (Feed-in-Tariff and Renewable Heat Incentive) were previously introduced to help consumers with the initial purchase and to reduce the rate of return of investment for low-carbon generators and heating, and proved successful as shown by their rapid deployment after they were introduced.

This paper provides a framework for an incentivisation scheme to promote the purchase and installation of a 13.5 kWh micro-BSS which will provide crucial protection to the electricity

network, using the Isle of Wight, UK as a case study. By comparing the cost of a micro-BSS with the cost of reinforcing the network and protecting the network via utility-scale BSS, an incentivisation rate of below 40% was found to provide savings compared to the other methods. This method builds on previous work conducted and can be applied to other areas within the UK and globally as we make the transition to net-zero.

Flex in the background: preliminary results from a UK field trial testing 3rd party control of domestic heat pumps

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To enable the UK to achieve its net zero targets, space heating and domestic hot water in the housing sector will need to be electrified. Air source heat pumps (ASHP) are the only realistic option to deploy at scale across the UK housing stock and this is reflected in UK government's Heat and Building Strategy. When deployed at scale, ASHPs have the potential to cause existing assets within low-voltage electricity network to exceed their operating capacity. Automated 3rd party control of ASHPs could provide a useful method of reducing load at peak times.

The Residential Heat As An Energy System Service (LATENT) project is testing third-party control of domestic ASHPs using both quantitative and qualitative methods to understand whether it is possible to remotely control home heating in a way this is acceptable to them such that this would provide automated demand response at scale to the electricity network.

This paper presents the preliminary results from the first phase of the field trial conducted January to March 2023. Through this initial phase, the interaction of the deferral mechanism with operation of the heat pumps and potential load reduction was examined through the effect on power demand. The impact of heat flex on the internal temperature of dwellings was also examined alongside analysis of the use of an override function by participants.

This first phase demonstrated that 3rd party control of ASHPs using a blind approach is effective and appears broadly acceptable. This offers significant advantages over current text messaging approaches that require active participation by householders.

Pumped storage power development in China under the carbon peaking and carbon neutrality goals: Goals, barriers, and prospects

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In the context of the carbon peaking and carbon neutrality goals in China, renewable energy (e.g., wind power and photovoltaic systems) will experience a rapid growth, which requires substantial energy storage systems to ensure the safe and stable operation of power systems. Among different energy storage technologies, pumped storage power (PSP) has attracted much attention due to its better environmental and economic sustainability in accepting new energy sources into the grid and for storage and peaking. Existing life-cycle

assessment (LCA) studies also confirmed the superior environmental performance of PSP technology over other energy storage technologies such as chemical fuel cells and compressed-air energy storage.

This paper presents a review of the PSP development course in China and discusses its potential growth in the coming several decades. It shows the PSP technology has gradually developed and matured. Up to the end of 2021, the aggregated installed capacity of PSP plants have reached 36.39 GW, ranking first in the world. However, its development is still a little backward, because the planning targets for the PSP development during the 12th and 13th Five-Year Plan were not finished successfully. This is mainly due to the barriers associated with the electricity price and construction approval during the PSP development. Currently, China has set higher requirements for the PSP development and released a series of related policies to help achieve its carbon peaking and carbon neutrality goals. In such context, it is believed that the PSP technology will experience a new round of rapid development in China.

Exploring post-COVID business travel 'new normal' in a higher education institution

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Awaiting abstract.

Power quality improvement in a cement production company- Case study Kenya

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¹*Kenya Power, Kenya*

Reliable and good quality power supply are the key elements that are desirable by all categories of power end users. This is mainly because, the modern electrical equipment are sensitive to voltage fluctuations and perturbations. For their continuous operations, that is, without stoppage, voltage dips and swells need to be well within the admissible levels. This study involves carrying out a power quality investigation at a cement manufacturing company. The manufacturing plant had consistently experienced tripping of the electrical machines which contributed to massive losses. The losses incurred were mainly due to idle labor time, raw materials damage and worst cases malfunctioning of the installed machines.

The study involved installation of two power quality analyzers (PQAs); at the point of common coupling and at transmission substation where transmission line (132 kV), supplying the power consumer, emanates. From the data gathered, after two months period of data collection, shows that the plant experienced 3,862 voltage dips, out of which only six (6) dips caused equipment stoppage. It was noted that most of the dips were originating from the manufacturing plant while starting heavy machines. Methods to mitigate the nuisance tripping of the machines proposed were; (i) installation of automatic voltage regulator and, (ii) installation of a ferrorescence transformer. Considering also the consumer's demand of 33.8 MVA, STATCOM capable of smoothening the voltage profile, was proposed for ameliorating the adverse effects of poor power quality. By continuous operation of the cement manufacturing plant, without machines' stoppage due to poor

quality of power supply, promotes fast growth of the modern cities infrastructure such as bridges, roads as well as rail networks.

SESSION 9: Retrofit for the (Overheating) Future

Design Tactics for Retrofitting Residential Sites for an Enhanced Suburban Lifestyle on the Gold Coast, Australia

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¹Griffith University, Australia

In his book, *Architecture and disjunction* (1994), Bernard Tschumi invited architects to avoid seeing architecture as the faithful product of dominant society. He criticised the traditional view defining the role of architects as projectors of the current image of the government and society into their buildings. Instead, he proposed that architectural space can act as “a peaceful instrument of social transformation, a means of instigating a new lifestyle”, and as a catalyst for change. Architecture's role as an agent of change and instrument of social transformation is paramount within the low-density context of Australian suburbia.

Recent literature and built projects have taught us that creating better suburbs is key to better cities. Projects of suburban retrofitting now abound across Australia. In the region, a telling example is the foundation of the Suburban Futures organisation based in Brisbane to promote practical solutions for a more active and inclusive suburban life. However, while the focus of most emerging initiatives is on activating streets and public spaces, this project shifts attention towards residential sites to explore their latent capacities in revitalising suburbia socially and spatially through architecture and design.

The city of Gold Coast in Australia is selected as the case study, where residential sites comprise around 80% of the suburban built environment dominated by detached housing typology surrounded by plenty of private outdoor spaces. The project argues and illustrates that if innovatively reimagined, these sites can herald better, healthier and more sustainable suburban life. The project seeks retrofitting solutions for single-storey detached houses to achieve its goals. It explores sustainable, innovative and cost-effective design strategies to unleash latent design potential embedded within the existing domestic sites and will investigate the extended socio-economic values of such interventions in activating suburban streets, thereby fostering a healthy, prosperous, and forward-looking suburban lifestyle.

A school passivhaus retrofit case-study

P. Lovegrove¹

¹Morgan Sindall, UK

Morgan Sindall has been appointed by the Department for Education to retrofit the former 2012 Olympics Media Centre in Portland into a new SEND school. In doing so the aim is to achieve the Passivhaus EnerPHit standard. This project is a ‘trailblazer’ as it is unusual to retrofit a building of this age to the EnerPHit standard. The fact that it was already insulated to a reasonably high level did not in itself provide a shortcut to achieving Passivhaus certification. We have worked closely with the Passivhaus certifier throughout the design stage to supply the other essential requirements. This has attracted particular interest from the Passivhaus Institute.

This project is also important for Morgan Sindall, both locally and nationally, in the context of their ‘Decarbonising Communities’ strategy. This transformational approach to collaborative carbon reduction aims to achieve the target of net zero carbon by

2030. Having worked as Design Manager on the project for the past 18 months, Paul will provide an overview of this project and identify lessons learnt for future schemes.

Retrofitting Abri

R. Claydon-Smith¹

¹*Abri Group, UK*

Abstract to be updated.

Hampshire County Council Retrofit Business Case Update

C. Nadarajah¹ and D. Olsen¹

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Abstract to be updated.

Experimental investigation on the thermal behavior of phase change material for heat storage in buildings

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The word energy consumption increased in the last decades and a continuous increase in the future is predicted. The building sector is one of the biggest energy-consuming field since it is responsible for 40% of the global final energy consumption. It accounts also for 33,33 % of greenhouse emissions. Thus, an efficient utilization of energy in buildings is strongly required. The integration of solid-liquid phase change materials «PCMs» in buildings is a promising solution which enables the enhancement of the energy efficiency. The first purpose of this study is to present the current status and trends in the use of PCMs in buildings. The second goal is to conduct an experimental analysis of the heat transfer mechanisms during the solid-liquid transition of a PCM for building applications.

A novel experimental device “FISOMP” was set up to visualize the melting interface and to record the temperature in the PCM “paraffin RT27” throughout the phase change. The results showed that the melting process is controlled by four heat transfer regimes: conduction, transition regime, strong natural convection and vanishing convection. Image analysis of the solid liquid interface photographs was used to determine the evolution of the melting fraction. It revealed that the kinetic of the heat storage is significantly reliant on the intensity of the natural convection. The temporal evolution of the heat stored in the paraffin RT27 during the melting process was assessed. It inferred that this PCM has a high storage capacity of 208,16 kJ/ kg at a low cost of 5,95 euros.

Cool cities for people and planet

C. Leighton¹

¹Regenerate Cities, UK

Today's most urgent environmental issue, urban heat including pollution, is solved by Nature-based, people-centred cool cities for people and planet. They bring peace, calm and economic prosperity. Addressing temperature consequences where they arise, as Earth becomes hotter, is imperative. Challenges in other parts of the world eg rainforest destruction, are important. However when pollinators die locally, food security is threatened in the immediate region. It needs solving here too! Similarly if local wet bulb temperature results in excess deaths, reducing heat where it occurs, is critical. Thankfully, effective strategies are often beneficial over a wider area.

A systemic, iterative approach leading to effective consequences for billions, is cooling cities via Nature. It deploys wisdom accumulated over millennia. Regenerating people/other species on which human life depends, reduces urban heat, pollution and other metropolitan challenges. Biomimicry is humbling and inherently wise. Life depends on it. Why is it missed for so long in so many spheres? Earlier in human history it was common practice, addressing matters modern (wo)man finds difficult. Backed by growing scientific expertise as well as other disciplines, communities/towns/cities around the world instigate actions over the last 70y that showcase how cool cities regenerate soil/planet, remaking urban life pleasant for people and rebuilding biodiversity. Eco economics works!

People rather than car-centred cities repeatedly demonstrate that although economics is not the focus, community prosperity benefits. Life depends on natural resources and ecosystem services. Earth's biodiversity provides fresh air, clean water, nutritious food etc. Eco economics, as recently recommended by authoritative UK government-commissioned, Cambridge professor authored, Dasgupta report, makes sense. Incorporating natural capital costs/benefits, which conventional economics omits, enables economics to be more realistic! When costs/benefits of Earth's most precious resources are included, the clarity/cost-effectiveness of Nature-based solutions is seen more profoundly. Via a software app available through working with me/a partner, the need to decipher details of the recommended report is circumvented. Practical, scientific, business, developmental and eco economic implications are available to you easily and cost effectively. Humanity's survival on planet Earth depends on biomimicry in people-centred communities/towns/cities. Implemented, people's lives are regenerated so we all flourish and thrive!

What people say – Adaptive thermal comfort behaviours in UK homes

S. Gauthier¹ P. Turner¹, T. Rushby¹, P. James¹, M. Manfren¹, A. S. Bahaj¹, T. Sweetnam², S. Kim²

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To better advise and protect residents from ever more extreme cold weather events (e.g. the 'Beast from the East') and increased energy cost, there is a need to map out current adaptive thermal comfort behaviour. In 2021, a large online survey was undertaken across the UK; out of ~27,000 energy customers 5,486 participated. The survey consisted of seven sections; consent, demographic, household, heating, thermal comfort, energy literacy and personality traits. In this paper, we reviewed the residents' reported adaptive thermal comfort behaviours; these ranged from turning on the heating or putting on additional/warmer

clothes to closing windows. Using correspondence analysis relationships between these reported behaviours and occupants and environmental features are uncovered.

Results show that participants identifying themselves as female are more likely to put on additional/warmer clothes, while participants identifying themselves as male are more likely to turn on the heating. Participants on lower income are more likely to wait for the scheduled heating or have a hot drink, while participants on higher income are more likely to turn the heating on. Finally, participants willing to accept reducing their household temperature at peak energy-use time are more likely to close windows and put on additional/warmer clothes. These insights reveal some interesting demographic and household features, also emphasizing the active role of the residents in shaping future residential environment and energy systems.

POSTERS

Building space occupancy optimisation with estate planning at the University of Southampton**H. Moodley¹** and S. Gauthier¹¹*University of Southampton, UK*

The rise of connectivity in our cities has given individuals the ability to conduct their work from almost anywhere, with the recent pandemic demonstrating the importance of such connectivity. This great progression towards dynamic working is resulting in greater social inclusion in the workplace, as individuals are no longer tied to be in the office full time, allowing employees to optimise their working time around their own lives. The University of Southampton has embraced flexible working and expects that flexible working will remain common place in the future. Therefore, flexibility for employees results in space, which was once occupied full time, no longer being required for the same use. The university has a large student population and with student fees at an all-time high, Estates Planning are aiming to optimise spaces within the university which are presently underoccupied, into spaces which can be utilised fully by all users at the University.

Hence, Estate Planning are aiming to modernise their data collection and processing of room occupancy, from labour intensive manual studies of room occupancy and anecdotal evidence, to a reliable automated solution. There presently exists solutions, from large technology corporations, which could be implemented to conduct this task. However, such solutions are extraordinary expensive to implement. Therefore, a collaboration within the University of Southampton between Estates Planning and the Sustainable Energy Research Group to develop a relatively low cost and reliable solution to quantitatively assess occupancy of university space is underdevelopment. The present solution consists of small, easily deployable, occupancy logger sensors. The data for if a space is occupied from such sensors is binary, hence, a web application has been developed which processes this binary data, from the loggers, into usable data of occupancy percentage per hour per day. Such usable data can then be placed into an open access database which will be used in decision making by Estate Planning and other space stakeholders on the future usage of space at the University of Southampton. The details on development, advantages and disadvantages, and future upscaling of this collaborated 'low-cost and easily deployable' occupancy logging solution will be presented.

Work from home emissions in a higher education institute**R. Jain¹**, B. Anderson¹ and A. Tewkesbury¹¹*University of Southampton, UK*

EAUC is set to implement a new framework for universities to standardise emission reporting by HE and FE institutes across the UK. The new framework provides two methodologies to calculate work-from-home emissions: Advanced level – Best-in-class calculation methodology, and Basic Level: Lower-accuracy calculation methodology.

The basic level Lower Accuracy calculation methodology is derived from the SSN guideline on completing public bodies climate change duties annual report – 2020/21 reporting period. The report proposes a default emission factor of 0.3 tCO₂e / FTE / Year to calculate homeworking emissions.

The advance level methodology is derived from the working-from-home emissions white paper produced by EcoAct. It divides energy usage into three categories: 1. Office equipment, 2. Heating energy, and 3. Cooling energy. Each category has a base case and an enhanced case. It also uses workings hours per day and total number of working days to estimate the annual emissions.



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