

Book of abstracts for the 2025 INTERNATIONAL CONFERENCE ON **EVOLVING CITIES & TOWNS**



Compiled by the
Energy and Climate Change Division (ECCD)
Faculty of Engineering and Physical Sciences,
University of Southampton

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Preface

The **International Conference on Evolving Cities** (ICEC2025) will take place as a hybrid event (with both online and in-person delegates) at the Centenary Building (B100) situated in the Highfield Campus at the University of Southampton, UK from 16-18 July 2025. ICEC2025 brings 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, the **conference programme** includes 10 keynote/invited contributors, 48 oral presentations and 11 poster presentations across 10 sessions as detailed within this book of abstracts. The themes of the conference are shown in Fig. 1 where participants are able to discuss and debate ways to develop multi-stakeholder partnerships and implement innovative solutions to propel cities towards low carbon pathways.



Figure 1: ICEC Themes

This document provides the current record of the submitted abstracts for the International Conference on Evolving Cities, including all oral and poster presentations to be presented at ICEC 2025.

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 research profile addresses the University's mission "to change the world for the better" focusing on fundamental understanding applicable to low carbon technologies including renewable energy, energy efficiency and energy for development. ECCD research **supports the United Nations Sustainable Development Goals** (SDGs) with fundamental and applied research across its six research themes, encompassing: (i) Renewable Energy, (ii) Energy Access, (iii) Cities & Infrastructure, (iv) Buildings & Communities, (v) Behaviour & Modelling and (vi) Climate & Emissions. Details can be found at www.energy.soton.ac.uk.

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SESSION 1: Sustainable Business Practices in Action

Collaborative Pathways for Decarbonisation: Addressing Gaps in Governance, Investment, and Carbon Control

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Sustainable infrastructure systems are critical to achieving net-zero goals, yet they face challenges like regulatory fragmentation, misaligned financial incentives, and carbon measurement complexities. Despite growing recognition of these challenges, gaps exist between sustainability objectives and investment practices. Collaboration between the investment and sustainability sectors is essential to address these barriers and achieve decarbonisation.

This study concerns the gaps, barriers, and interdependencies in carbon reduction management across sustainable infrastructure systems, focusing on how collaboration between the investment and sustainability sectors can promote decarbonisation efforts aligned with net-zero goals. This study, in particular, focusses on whether and how standardised carbon metrics and investment incentive structures can support sustainable infrastructure investment. Through a series of semi-structured expert interviews with stakeholders across academic institutions, policy organisations, engineering firms, investment entities, sustainability consultancies, and infrastructure developers, this study explores emission scope complexities, governance and regulatory constraints, and economic and market challenges.

This study also examines the interdependencies among barriers and enablers influencing collaboration and explores whether strategic integrated frameworks can further support decarbonisation efforts and evaluate the carbon performance of infrastructure systems. Using Interpretive Structural Modelling (ISM) and MICMAC Matrice d'Impacts Croisés Multiplication Appliquée à un Classement" (Cross-Impact Matrix Multiplication Applied to Classification) analysis, this research structures constraints and influences among identified gaps based on their driving power and dependence relationships, identifying key intervention points.

Findings reveal that difficult-to-control carbon emissions, mismatched short-term and long-term costs and benefits, misaligned financial incentives, and regulatory fragmentation exhibit strong driving power as primary obstacles shaping other challenges. The findings further suggest that supply chain coordination and policy alignment could play a critical role in mitigating these barriers. The results highlight leverage points, where coordinated actions could significantly enhance collaboration between the investment and sustainability sectors while accelerating decarbonisation efforts. This research helps to address challenges specific to carbon reduction management as well as establishing a foundation for integrating standardised practices into sustainable infrastructure investment strategies.

A Social Science Case Study of Sustainability Practices in Action

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In the context of the urgent net-zero challenge, this study explored the critical role of collaboration and co-creation among diverse stakeholders in developing and implementing sustainable business practices. Recognising the complexity of achieving sustainability, this strategy-as-practice study examined an online only university. It considered how innovative solutions and stakeholder engagement can effectively navigate organisational, governance, and regulatory landscapes to address pressing environmental challenges.

The dominant discourse in sustainability often conceptualizes it through a hierarchy of Environmental, Social, and Governance (ESG) themes, which is termed a 'weak sustainability' perspective in environmental philosophy literature. This perspective tends to overlook the role of agency in understanding sustainability strategies within business. To address this gap, the study aimed to understand sustainability strategy-in-action within an ambitious small-sized organisation, University College of Estate Management, Reading, UK.

Using a mixed-method approach, the study draws on data from 11 interviews, 146 survey responses, documents, and archival information. The analysis is framed by the strategy-as-practice perspective, focused on practitioners, practices, and praxis. The emergent findings highlighted key themes:

1. **Practitioner Agency and Tacit Knowledge:** Middle managers act as 'dynamos' driving change, leveraging their tacit knowledge and agency to implement sustainability strategies.
2. **Iterative Practices and Relationships:** The enactment of sustainability strategies involves iterative daily practices and the development of relationships between different groups over time.
3. **Scope 3 Carbon Emissions:** Identified as the largest unknown, scope 3 emissions represented a significant area for future praxis shifts and improvements in sustainability outcomes.
4. **Buildings as Active Variables:** The role of buildings in strategy-as-practice is highlighted as a novel contribution, showing how physical spaces can influence sustainability strategies.
5. **Adaptive Tendencies and Serendipity:** Flexibility in practitioners' approaches and the role of serendipity in the unpredictable nature of strategy implementation are crucial for achieving sustainable outcomes.

This study underscored the importance of collaboration and co-creation in addressing sustainability challenges. It demonstrated how innovative practices and stakeholder engagement can lead to meaningful and transformative changes in business sustainability strategies. Finally, we ask the question: how can city businesses provide flexible use of office space for others in the community beyond the working week?

Optimising Sustainability in Public Transport Procurement

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Public transport is inherently sustainable, but it faces increasing pressure to reduce costs. Integrating sustainability requirements into procurement processes without compromising financial viability is a significant challenge. The concept of sustainability, as defined by the UN Brundtland Commission, involves meeting current needs without jeopardising future generations' ability to meet theirs. However, this definition can vary by country, emphasising economic, environmental, social, and sometimes cultural factors.

The weight assigned to sustainability criteria in procurement decisions is crucial. This impact will be discussed, along with recommendations for the most effective approach. Four main methods for incorporating sustainability into public transport procurement will be explored, each with examples, advantages, and disadvantages.

Approaches to Sustainability in Procurement.

1. **Incorporating Sustainability as Requirements (Sweden)** - Sustainability criteria are directly integrated into contracts, raising standards but potentially creating barriers for smaller companies.
2. **Question and Answer Approach (MENA and France)** - This flexible method allows bidders to propose innovative solutions, fostering competition and creativity. It is the most common approach.
3. **Social Value Economic Matrix and Commitments (UK & Canada)** - This approach involves creating detailed sustainability indicators with associated socio-economic values. Bidders submit commitments as part of their bid, enabling informed decision-making about social value generated. However, usability can be a concern.
4. **Outcome-Based Procurement (London, Northern Ireland)** - Focuses on specific sustainability outcomes tied to contract value, promoting accountability and measurable results. This ensures a level playing field for bidders.

Understanding these approaches helps attendees integrate sustainability into government procurement effectively. This enhances the case for public transport and infrastructure, highlighting its inherent sustainability. By balancing sustainability with cost-efficiency, public transport can maintain its environmental benefits while ensuring financial viability.

Quantitative Analysis of Small and Medium-Sized Enterprises (SMEs) Willingness Toward Industry 4.0 Adoption in Peninsular Malaysia: Implications for Evolving Urban Economies

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The expansion of small and medium-sized enterprises (SMEs) has been a cornerstone of the Malaysian economy, particularly in the wake of the Covid-19 pandemic. This study examines the advantages and challenges of adopting Industrial Revolution (IR) 4.0, focusing on SMEs' readiness through the Willingness Index. Key factors such as technological readiness, government incentives, management attitudes, and research and development infrastructure are assessed. A survey of 1,000 SME owners and managers across four regions of Peninsular Malaysia provides insights into their preparedness for IR 4.0. Data analysis using Statistical Package for Social Sciences (SPSS) and SmartPLS reveals the index scores for each dimension, highlighting areas where improvements can enhance SMEs' contributions to national GDP. The study's findings are crucial for supporting Malaysia's goal of becoming a high-income nation by 2025, as outlined in the 12th Malaysia Plan, and accelerating its development in line with the Transformasi Nasional 2050 (TN50) vision. By embracing IR 4.0, SMEs can play a pivotal role in shaping the future of Malaysia's urban economies, contributing to both innovation and sustainable economic growth.

Implementing a Sustainability Strategy within a Russel Group University: A Case Study of the University of Southampton

A. S. Bahaj¹, L. Blunden¹, T. Chilcott¹, R. Jain¹, E. Ridett¹, A. Rodd¹ and P. Turner¹

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The University of Southampton's vision is that by 2030, sustainability will be embedded in everything the University does — shaping individual behaviours, daily work, and decision-making to fulfil our mission of changing the world for the better. The Sustainability Strategic Plan (SSP) is one of ten Strategic Plans designed to support and drive forward the University Strategy in delivering on our sustainability targets, as set out in six key Goals.

This talk will introduce the SSP and its implementation, sharing insights, challenges, and lessons learned that may be of value to other academic institutions and the wider industry.

SESSION 2: Coastal Cities & Towns

Encouraging Healthy, Low-Carbon City Travel Choices Through Infrastructure Interventions

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Transport systems are a major contributor to urban carbon emissions and public health challenges. In this keynote, Prof. William Powrie will explore how targeted infrastructure interventions can help shift travel behaviours towards healthier, low-carbon options. Drawing on research and real-world case studies, the talk will examine the role of engineering and planning in enabling sustainable mobility choices and shaping more liveable urban environments.

Defining a Port's Societal License to Operate: The case of Southampton Using the WeValue Methodology

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Ports are essential to modern lifestyles and provide essential services the economy needs to function. However, the port's relationship with the host city has often deteriorated, and the benefits ports produce are increasingly spread across large geographical areas, whereas the negative impacts are often highly localised, such as poor air quality, traffic congestion, community severance and visual blight. This has led in many cases to a deterioration in the traditionally strong link between ports and their local communities. If ports are to operate sustainably in the future, they need to operate in a way that fulfils their economic targets, whilst also being acceptable to local people as a positive part of their community. To address this challenge, many ports are actively seeking ways to improve community relations. Ports can improve the relationship with local communities by working towards what is termed the societal license to operate (SLO). The SLO is defined by Pages Sanchez (2016) as "fulfilling the expectations of stakeholders and local communities in dimensions that go beyond the creation of wealth". The SLO is therefore difficult to define, and should vary from place to place, with different locations having different shared values and priorities. These values are often difficult to access via commonly used methods such as questionnaires, as these methods may struggle to access tacit knowledge. This study addresses this challenge by using the WeValue InSitu methodology to identify the perceived infrastructure needs of Southampton, as identified by local groups based there. This methodology allows a crystallisation of shared group values, identifying a desirable state for Southampton, as well as lower thresholds. These results highlight areas that the port could focus on to develop community support and work towards the SLO, such as enabling more accessible port and leisure activities, improving access to the waterfront, allowing local participation in decision-making, protecting green areas and ensuring sufficient infrastructure to prevent pollution and flooding. The WeValue methodology therefore provides a suitable approach for ports to clearly define their local SLO priorities.

Capturing Vulnerability and Developing Resilience in Urban Neighbourhoods: A Framework

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As the climate crisis becomes more severe, climate hazards are fast surpassing the thresholds that our urban areas are designed for and able to handle, putting our communities, structures, and spaces at risk. Clearly there is a pressing need to adapt and innovate to ensure that cities are more resilient and able to contend with the climate crisis, and the growing social, political, and economic challenges that come with it. But in increasing resilience, how can we design for thresholds we do not currently have a measure for, and how can we ensure that the most vulnerable people and places are prioritised?

Ramboll and Impact on Urban Health recently launched Neighbourhood Futures, a framework that sets out a structured approach to delivering resilience and health equity in urban areas. The framework provides five distinct but complementary capacities that together, outline five categories of resilience actions and performance objectives. It was written for the neighbourhood scale to support local authorities, planners, and other professionals and

stakeholders in reconciling large-scale strategic objectives with local vulnerabilities, risks, needs, networks, and community experiences.

The five capacities in the framework are threshold capacity, coping capacity, recovery capacity, adaptive capacity, and transformative capacity. These five capacities, developed from past research into flood risks in coastal cities facilitate the navigation of increasingly extreme climate threats and manage their aftereffects. By unpacking resilience across the five capacities we can be very intentional in the way we shape solutions.

Applying all five capacities generates a comprehensive set of responses to local vulnerabilities. It can guide strategic planning and design interventions to conceive of multiple local responses that together; deliver continuous services, and provide shelter and safety from hazards; and enhance flexibility as the neighbourhood and its communities can better adjust to uncertain future conditions and unpredictable change.

To deliver resilience, we need to take a systemic approach. The framework enables the multidisciplinary collaboration required for systems thinking in diverse urban environments. Bringing different sectors and specialisms together, to harmonise their efforts and thereby increase their impact.

Healthy Low-Carbon Transport: Integrating Health and Wellbeing Co-Benefits into the UK's Low-Carbon Transport Journey

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Accelerated transport decarbonisation is essential for the UK to meet emissions requirements. Measures adopted must maximise physical and mental health co-benefits and reduce inequalities, but this has not been the case historically. For example, in 2001 a lower diesel vehicle tax to encourage replacing petrol cars with diesel led to poorer air quality and health outcomes.

The health benefits of some forms of low-carbon transport, including increased physical activity and cleaner air, are beyond doubt. However, mental health and wellbeing benefits are less clearly evidenced. Some forms of low-carbon travel are being promoted without full consideration of health implications. For example, the increased weight and faster acceleration and deceleration of electric cars could lead to increased particulate pollution (from tyre, road surface and brake wear) and a greater likelihood and more severe consequences of collisions.

Health impacts and inequalities also arise from societal and economic trends, such as the rise in home working and policy measures to reduce the need to travel. Attempts to promote health-beneficial forms of transport have had mixed success. Cycle networks and Low Traffic Neighbourhoods (LTNs) are just two examples of interventions that have solicited public resistance.

A major new initiative, the Healthy Low-carbon Transport Hub, aims for “full integration of health co-benefits and equity considerations into the delivery of the Paris Climate Agreement” for transport and the associated built environment – echoing the November 2023 Lancet Pathfinder Commission report “Pathways to a healthy net-zero future”. This five-year, multi-university hub is providing policymakers with evidence to modify transport decarbonisation to maximise health benefits.

This paper provides an overview of the key literature underpinning the Hub's work:

- Whole-system conceptual frameworks within which health and transport evidence can be reinterpreted.
- Assessment frameworks for the appraisal of low-carbon transport and mobility schemes and policies and post-implementation evaluation.
- Application and testing of conceptual and assessment frameworks in live interventions and policies.
- Governance structures and reforms that enable better management of tensions between potentially conflicting outcomes, organisations and scales.
- Stakeholder engagement, especially with younger, seldom-heard and disadvantaged communities.
- Theories and practices of change, meeting both transport decarbonisation and public health goals.

Synergy of Tidal Power and Flood Alleviation in UK Estuaries

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Many UK estuaries present both tidal power potential and significant risk of coastal flooding, which is being exacerbated by climate induced sea-level rise. This project investigates the potential synergy between tidal power generation (through turbine arrays or barrages) and flood prevention through surge barriers. By exploring the integration of renewable energy production with flood protection.

The research aims to undertake:

- Desk study to review overlap between literature and UK datasets covering tides and surges in estuaries, tidal power potential, flooding and sea-level rise.
- Case study future-scenario modelling of the River Itchen mixed-use scheme using field data on tidal elevations and with flood prevention under long term future climate change & sea-level scenarios.
- Techno-economic feasibility assessment of such multi-use schemes, enhanced with bathymetric data, tidal measurements and recent cost estimates.

Hydrographic and official data layers were combined to identify areas of high flood risk and population density as potential sites for tidal power installations around the UK. Bathymetric data from the S-100 trial was used to calculate the depth of the estuaries such that the cross-sectional area of a potential barrage may be derived.

Tidal elevation data from Southampton Port was used to model a tidal barrage operating in ebb flow generation. Initial results indicate a modest annual potential of 3.5 GWh, accounting for the entire electrical demand of Southampton 033B LSOA which has 1200 electrical meters.

Future development of the model will introduce additional complexities, including sluicing, holding and generating, and will account for variations in tidal range, river flow, storm surges etc. Machine learning techniques could be applied to optimise the predictive operation of tidal barrages.

The time stepping model was effective in modelling the Solent's complex tidal dynamics, including its double high-water phenomenon, with the developed methods robustly applicable for other estuaries with similar characteristics.

Unlocking Rooftop Solar Potential: A GPU-Accelerated Assessment of PV Suitability Across Hampshire and Sussex

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Accurate, high-resolution assessment of rooftop solar photovoltaic (PV) potential can help to accelerate energy transitions and inform local energy planning. This study presents a bottom-up, building-level approach to solar suitability modelling across the counties of Hampshire and Sussex in the United Kingdom. While many wide-scale PV potential studies rely on top-down methods using generalisations or assumptions, our approach leverages detailed rooftop shapefiles and high-resolution LiDAR data to simulate solar irradiance for every 1 m² of roof surface in these counties over the course of an entire year.

The model accounts for dynamic sun position, slope and aspect of rooftops, and shading from nearby structures, trees, and terrain, enabling precise estimates of the available irradiance on each rooftop. To address the scale and complexity of this data, which amounted to over 350 GB of LiDAR data, GPU-accelerated parallel processing was employed, dramatically reducing computational time and enabling the modelling of just under a million buildings at high resolution. The approach taken here makes it possible to compute the rooftop PV potential for a wider area, even at a national level.

The output identifies not only solar potential but also suitability based on factors such as usable area, orientation, and irradiance thresholds. The results are delivered through a publicly accessible web application, designed to support planners, local authorities, businesses, and communities in identifying viable rooftops for PV deployment and hotspot areas to target. The platform also includes spatial data on existing and planned ground-mounted solar farms, offering a comprehensive view of solar development potential across both urban and rural areas. We

considered roofs to have potential for PV when (i) annual solar radiation of ≥ 800 kWh/m², and (ii) Contiguous areas > 3 m². In both Hampshire and Sussex, the rooftop PV capacity potential is ~ 2 GW, of which 65% is domestic.

This paper's approach offers direct applications for Local Area Energy Planning (LAEP), climate action planning, and community energy initiatives - helping cities transition towards a more decentralised, resilient, and sustainable energy future.

SESSION 3: Strategic Planning and Energy Transitions

Coastal Cities and Sea Level Rise

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Coastal cities around the world are threatened by climate-induced sea-level rise, and these changes are often compounded by subsidence (land sinking) in susceptible cities such as those built on deltas. The resulting relative sea-level rise threatens increased flooding, erosion and salinisation unless appropriate mitigation/adaptation measures are taken. The pervasive and fundamental challenge this presents is not fully appreciated by city planners and a change in mind set is needed to properly address these issues in the long-term. This paper will consider these risks and how they might be assessed, and what information is needed to begin the process of adaptation.

Transformational Doughnut Infrastructure: Enabling Net Zero and Enhancing Resilience

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Reaching net zero by 2050 (#RacetoZero[1]) is essential in order to limit global warming to 1.5°C. However, Net Zero implies acceptance of; and an urgent need to prepare for, adapt to, and ensure resilience to; the disruptive impacts of 1.5°C of global warming. Therefore, we must simultaneously #RacetoZero and #RacetoResilience.

Both are Wicked Problems. Neither is purely technical. Both are unreceptive to purely technical fixes. Neither can be transitioned out of, or resolved incrementally. Both require transformation of the societal enabling systems, such as national infrastructure, from which they emerge.

Transformation requires rejection of an obsolete mindset, the adoption of a new mindset, and its integration into a set of fit for purpose:

1. System goals (other strategic, societal and economic objectives).
2. System rules (governance and regulatory structures).
3. System processes (operational, management and decision-making processes).
4. System structures (performance requirements of extant system components and design specifications of all future system components).

The urgent need for a climate emergency driven infrastructural transformation creates a unique opportunity to reimagine the purpose of National Infrastructure and establish an aspirational vision of the type, and quality, of outcomes we expect transformed national infrastructure systems to play a role in enabling. The Doughnut economy model provides the perfect framework for this reimagination. The 12 social foundations it identifies represent additional environmental, societal or economic outcomes national infrastructure must play a role in enabling. Whilst the 9 planetary boundaries it identifies indicate the type of challenges that we need national infrastructure to be resilient to, avoid exacerbating, and ideally help to mitigate.

Infrastructure transformation driven by a mindset based on the Doughnut Economy model can support completion of the #RacetoZero and #RacetoResilience, whilst simultaneously establishing a national infrastructure system capable of providing universal access to the suite of 12 essential societal foundations, without cumulatively exceeding any of 9 critical planetary boundaries.

My presentation will draw upon my current UKCRIC and recent C-DICE research to elaborate upon the significance of, and demonstrate the validity of, the above narrative.

How do Sustainability Ideologies Manifest in Local Planning Decisions?

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Sustainability underpins planning within the United Kingdom and is applied to all scales of development management decisions, ranging from small-scale householder planning applications to major urban regeneration schemes. Although sustainability has long been a guiding principle in spatial planning, no academic research exists on how sustainability manifests across development scales within planning decisions in England. This research applies Davidson's novel typology for categorising sustainability ideologies to 21 planning reports from three outer borough London local authorities to advance an understanding of how sustainability manifests across development scales and to contribute to the literature at the junction of sustainability and development management. The research finds that sustainability adopts different socio-political ideologies across development scales. In large schemes, planners adopt a neoliberal approach where technology and the substitutability of capital justify sustainable outcomes. While in smaller household and minor schemes, planners adopt radical (micro) and social democratic (macro) approaches that insist on limits to growth and follow traditional authority-applicant power relationships when justifying sustainable outcomes. The paper argues that sustainability in planning practice is not a fixed concept but a fluid and negotiated discourse. This has significant implications for policy coherence, democratic accountability, and the legitimacy of planning decisions. By illuminating the interpretive flexibility of sustainability within planning decisions, the research provides an inroad to better governance for the practice-led sector and offers recommendations to improve outcomes for private and public sector planners in England.

Sustainable Decision-Making for Offshore Wind End-of-Life Strategy Selection

H. Altooq¹, G. Wall¹, M. Barbati² and D. Jones¹

¹*University of Portsmouth, UK*

²*Ca' Foscari University of Venice, Italy*

As cities strive for sustainability and a lower carbon footprint, renewable energies are key to ensuring a secure and clean electricity supply which is an essential element of urban development. In 2023, 17% of total electricity generated in the UK came from offshore wind showing the important contribution it is making to evolving urban areas.

When offshore wind turbines reach the end of their certified operational lifetime, typically within 25 years of commissioning, operators must determine how to strategically manage the wind farm's end-of-life (EoL) phase. This decision involves choosing whether to decommission the assets or pursue alternative strategies to extend the project's lifespan.

This research develops a decision-making framework for selecting an optimal end-of-life strategy, ranking the end-of-life options (Lifetime Extension, Refurbishment, Repowering, Partial Decommissioning, or Full Decommissioning) based on project-specific parameters. The study evaluates and compares these strategies using multi-criteria decision-making (MCDM) methods, incorporating quantifiable sustainability criteria and sub-criteria spanning technical, environmental, economic, and social factors.

A mixed qualitative and quantitative approach is employed to address this ranking problem. Expert interviews validate the problem structure and selection criteria. This is followed by questionnaires designed to establish pairwise comparisons between criteria and responded to by experts, enabling weight assignment using the Analytic Hierarchy Process (AHP). The ranking problem is then solved using two ranking MCDM methods: PROMETHEE II (complete ranking method) and ELECTRE III (partial ranking method).

The decision-making framework was applied to the Rampion offshore wind farm in the UK. Results indicate that Refurbishment emerged as the most sustainable feasible strategy, and full decommissioning ranked the lowest. The findings produced a series of recommendations for offshore wind policymakers and operators to enhance the sustainability of EoL decision-making and execution processes. Encouraging more sustainable EoL strategies will help extend the certified lifetime of existing offshore wind assets while minimising unnecessary full decommissioning.

Pathways to Inform Policy in Achieving Reductions in Air Conditioning Loads Through Efficiency and Photovoltaic Power Supply in Middle-Income Households in**A. Alshehri¹, P. James¹ and A. S. Bahaj¹**¹*University of Southampton, UK*

This study investigates residential electricity consumption patterns in the Kingdom of Saudi Arabia (KSA). It focuses on air conditioning (AC) usage in domestic buildings and how this can be reduced through power generation from building-deployed photovoltaic (PV) systems coupled with the use of energy -efficient appliance. The context is addressing energy use in apartments and villas of predominantly middle-income owner-occupiers in KSA. A detailed analysis of self-reported households' surveys incorporating income, education level, building occupancy, appliance classifications (such as AC, its age and type), energy demand profiles. The online survey was taken by households in 2024 achieving 282 responses. This work assessed not only households' usage of air conditioning but also their perception of installing photovoltaic (PV) panels on the roofs of their buildings. Half-hourly electricity data is analysed alongside the self-reported household surveys to provide an energy demand option model. Previous studies indicate that ~70% of the electricity consumption related to the AC system. The results showed that (a) 76% of participants live in large villas and apartments (over 250 m²) with up to five bedrooms. These rooms typically have air conditioning running for 12-18 hours a day, and (b) these represent middle-income households who more inclined to invest in renewable energy solutions and hence as key potential adopters of PV systems deployment to reduce AC loads. The paper explored whether policy drivers (such as subsidies and streamlined approvals for PV in homes) should focus either on encouraging households to (i) upgrade their AC units to more modern and efficient units or (ii) uptake of PV systems to dent the AC loads. A comparative assessment of these two investment options is presented in the paper. The considerations offer valuable guidance for sustainable energy planning in a warm-climate urban settings like the city of Jeddah, encouraging efficient electricity use and demand-side management.

SESSION 4: Heat Deferral and Energy Flexibility

LATENT – Flex in the Background: Findings from a Three-Year UK Field Trial of Third Party Control of Domestic Heat Pumps During Real-World Flexibility Events

P. Turner¹, P. James¹, T. Rushby¹, E. Ridett¹, S. Gauthier¹, M. Manfren¹, A. S. Bahaj¹, and T. Sweetnam²

¹*University of Southampton, UK*

²*Good Energy, UK*

This research investigates the potential for leveraging energy flexibility through third-party control of domestic air source heat pumps (ASHPs) in the context of the UK's transition to low-carbon heating. As the UK decarbonises domestic heating, large-scale deployment of ASHPs presents challenges for electricity networks, particularly during peak demand periods. The study forms part of the EPSRC-funded project “LATENT: Residential Heat as an Energy System Service,” which tested the feasibility and acceptability of automated demand response using third-party control of ASHPs.

A three-year field trial was conducted across households in the South of England to evaluate the impact of heat deferral strategies on both power demand and household comfort. Their third year of the project culminated in a real-world flexibility events programme Good Energy's FlexiRewards. The findings of the study demonstrate that third-party control effectively reduced peak demand while maintaining acceptable indoor temperatures. Analysis of user behaviour and feedback suggests that the approach is broadly acceptable to participants, with limited use of override functions. The results highlight the potential for ASHP flexibility to contribute to grid stability and support scalable demand-side response strategies.

Unlocking Heat Pump Demand Flexibility for Electricity Grid Services: A Quantitative Optimisation Approach

O. Smith¹

¹*University of Manchester, UK*

The large-scale deployment of heat pumps (HPs) presents a valuable opportunity to enhance electricity grid flexibility while supporting the decarbonisation of residential heating in the UK. HPs can shift demand away from peak periods, provide balancing services, and reduce network congestion, thereby improving grid stability and minimising costly infrastructure upgrades. However, quantifying the magnitude and duration of HP demand flexibility—while ensuring household thermal comfort—remains a critical research challenge. This study develops a systematic framework to quantify HP demand flexibility and optimise its strategic allocation across multiple grid services, unlocking their full potential as a demand-side response resource.

A proof-of-concept thermodynamic flexibility model is developed to estimate the potential for load shifting in space heating and domestic hot water demand. The model employs a mixed integer linear programming (MILP) approach, simulating HP operations under varying external temperature conditions. It integrates real-world housing stock characteristics from Energy Performance Certificate (EPC) data, incorporating heat loss dynamics and thermal storage potential. Flexibility quantification is based on indoor temperature deviations from setpoints, optimising HP operation within a time-of-use tariff framework.

Empirical validation is conducted using high-resolution half-hourly consumption data from the UK Heat Pump Monitor project and national-scale datasets from the Department for Energy Security and Net Zero (DESNZ), which include anonymised domestic hot water demand profiles from 115,000 households. The model assesses flexibility under different thermal storage capacities, building insulation levels, and external climate conditions, enabling precise quantification at both local and national scales.

To ensure practical applicability, the framework incorporates distribution network constraints, preventing localised overloading and voltage deviations. This is critical for understanding the spatial and temporal distribution of HP flexibility, enabling its use in frequency response, peak demand reduction, and congestion management. Additionally, the study explores the trade-offs between demand flexibility and household thermal comfort, optimising HP operation without compromising user well-being.

By advancing methodologies for forecasting and optimising HP flexibility, this research provides essential insights for grid operators, flexibility aggregators, and policymakers. The findings contribute to the development of cost-

effective demand-side response strategies, supporting renewable integration, grid stability, and reducing the need for network reinforcement investments.

Experience of Residential Heat Pump Deployment across Demographics

A. Goulden¹

¹*the Environment Centre (tEC)*

The Environment Centre (tEC) is an independent charity working with Local Authorities and other funding partners to deliver specialist advice and support services relating to home energy and the environment.

They are currently delivering Southampton Healthy Homes on behalf of Southampton City Council, Hitting the Cold Spots on behalf of Hampshire County Council, and the phone advice line for Portsmouth City Council's Switched On Portsmouth service. These services offer in-depth, one-to-one help for vulnerable residents who may be finding it hard to keep up with energy bills or maintain a suitably warm home.

In April 2025 they launched My Home Made Better, an advice service for homeowners outside of these audiences, to inspire and motivate residents to feel more confident when making decisions about upgrading their home's energy efficiency.

They also have extensive experience delivering air quality projects in partnership with local authorities and other charities and organisations.

Chief Executive Adam Goulden will talk about the Environment Centres early experience in installing Air Source Heat Pumps and investigate some of the barriers to uptake and opportunities to drive up demand.

Interpretable Data-Driven Energy Modelling to Support Decarbonisation Strategies

M. Manfren¹

¹*Politecnico de Milano, Italy*

The Clean Development Mechanism (CDM) under the Kyoto Protocol and its current evolution after the Paris Agreement are fundamental to promoting decarbonisation on a global scale. This opens the problem of correctly quantifying the emissions reduction achievable in projects and valuing the externalities related to carbon emissions with a pricing and credit attribution mechanism able to stimulate investments. Currently national and independent programmes are present for the attribution of carbon credits. In this presentation, the independent Verra's Verified Carbon Standard (VCS) is analysed to highlight possible improvements enabled by advanced Measurement and Verification (M&V) and interpretable data-driven energy modelling, with the goal of increasing transparency, accuracy and trust across stakeholders. The University of Southampton's Highfield Campus data are used as an example of the application of these techniques that can be embedded in energy management practices and serve multiple purposes. By overlaying interpretable data-driven analytics onto existing carbon credit frameworks, CDM-type mechanisms can be revitalised, enhancing independent standards like VCS and aligning institutional decarbonisation strategies with available carbon emission benchmarks.

Risk of Socio-technical Performance Gap of Heat Pumps in Social Housing

M. Alam¹, L. Blunden¹ and A. S. Bahaj¹

¹*University of Southampton, UK*

Achieving the United Kingdom's net-zero emissions target by 2050 is critically dependent on the decarbonisation of residential heating. Heat pumps, powered by low-carbon electricity, have been identified as a central technology for delivering sustainable heating solutions and are expected to play a pivotal role in this transition. In support of this, the UK Government has adopted a market-led strategy to encourage the widespread deployment of heat pumps.

However, the performance of heat pumps installed under current retrofit programmes, particularly those led by local authorities within the social housing sector, may not deliver consistent outcomes across all user groups. This raises concerns about the emergence of a socio-technical performance gap, where actual system performance and user experiences diverge from expected outcomes due to social, behavioural, or technical factors.

This study draws on secondary data and operational monitoring of heat pumps deployed in social housing settings. Building on these insights, the research tests and proposes a standardised, open-source monitoring toolkit designed to identify and mitigate socio-technical performance gap risks. The aim is to enhance the reliability and equity of heat pump performance across diverse residential contexts.

SESSION 5: Energy Innovation for Building and Infrastructure**Study on Optical-Thermal Properties of Phase Change Material Transparent Envelopes and their Comprehensive Impact on Large-Scale Building Environment**M. Karkri¹, Z. Zhang^{1,3}, Y. Huang^{2,3}, Y. Wang^{2,3}, A. T. Mahamadou¹ and L. Ibos¹¹CERTES, Université Paris Est, France²State Key Laboratory of Green Building, Xi'an University of Architecture and Technology, China³School of Building Services Science and Engineering, Xi'an University of Architecture and Technology, China

Globally, the building sector accounts for approximately 34 % of final energy consumption and 37 % of greenhouse gas emissions. Moreover, the total global building floor area is expected to continue to rise until 2050. In light of the severe energy consumption and emission statistics, as well as the upward trend in building floor area, various sectors have set increasingly stringent energy conservation and emission reduction targets. Consequently, it is imperative to explore effective strategies for reducing energy consumption in buildings.

Among building systems, traditional glazing units are often associated with poor heat storage capacity, limited ability to effectively control solar radiation, and high heat transfer coefficient. These shortcomings contribute to approximately 20 % - 60 % of building energy consumption in various building due to heat loss through glazing units. Therefore, the development of advanced energy-efficient glazing units holds significant potential for reducing building energy consumption while improving the indoor optical-thermal environment. Phase change material (PCM) glazing units (PCMGUs) have obtained attention for their ability to enhance the thermal mass of glazing units and dynamically manage solar radiation.

An experimental study was conducted to investigate the dynamic variations in the transmittance, absorptance, and reflectance of PCMGUs during both solid-liquid and solid-solid phase change processes of PCMs, as well as to evaluate the impact of cooling rates on these processes.

The effects of layer thickness, thermal properties, and temperature of PCMs on the transmittance, absorptance, and reflectance of PCMGUs were analyzed.

Two reduced-scale models of large-scale buildings (Fig.1.) were constructed, with PCMGUs and double-layer glazing units (DGUs) installed at the roofs, respectively, and all other aspects being identical. The experimental platform was then used to conduct tests under winter conditions in Paris (temperate oceanic climate, Köppen climate classification Cfb). The impact of PCMGUs on the indoor thermal environment of large-scale buildings was assessed, with indoor air temperature and the modified Predicted Mean Vote (PMV*) as the indicators.

Finally, the energy-saving effect of the PCMGUs was evaluated from the perspectives of the inner surface heat flux of the glazing unit, the transmitted solar radiation through the glazing unit, and the total heat flux.

Advancing Thermochemical Energy Storage: Vermiculite-Calcium Chloride Composites for Enhanced Discharging Energy Efficiency and Airflow Optimization to support the transition to Clean EnergyZ. Chang¹, T. P. E. Randazzo¹, E. Mainardi¹ and Michele Bottarelli¹¹Università di Ferrara, Italy

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Energy-Saving Potential of TPV Glass Integrated into Existing and Heritage Buildings: a Case Study Comparing a Typical Climate Series and an Extreme Year

L. Ruiz-Juncos¹, A. Sanchez-Ostiz Gutiérrez¹ and A. Monge-Barrio¹

¹University of Navarra, Spain

Given the urgency of decarbonizing the construction sector and the challenge faced by the built heritage in urban environments and the pressing need to enhance thermal resilience, the integration of renewable energy systems such as photovoltaics can be particularly challenging due to specific restrictions aimed at preserving the aesthetic and architectural value of the heritage buildings. In this context, the integration of transparent photovoltaic glass (TPV) in architectural design can enhance the energy generation capacity of existing buildings. This approach offers a solution that minimizes alterations to the aesthetic appearance of façades and roof, making particularly suitable for heritage buildings. Additionally, it is justified by the necessity of glazing replacement to improve the energy performance of built heritage in use. This particular case study explores the potential of TPV glazing implementation in an existing and listed educational building located in an urban environment in a temperate climate (Cfb) with the goal of maximizing its electricity generation potential and level of self-sufficiency. The study compares the energy performance of the refurbished building using high performance-glazing and TPV technologies currently available on the market, in combination with passive strategies (solar protections and night cooling ventilation), given that the rooftop PV installations are prohibited by heritage conservation regulations of the region. The results evaluate annual energy performance by distinguishing between summer and winter condition, and compares a typical climate year with an extreme year characterized by heatwave events (2022). The analysis addresses the advantages and limitations of TPV implementation in the context of decarbonizing and thermal resilience of listed buildings.

Building Heat Transfer in a Changing Climate

B. Johnstone-Bray¹

¹ University of Sheffield, UK

Anthropogenic climate change due to greenhouse gas emissions caused global surface temperature in 2011-2020 to be 1.1 °C above pre-industrial levels. By 2100, this increase is predicted to be between 1.4 °C and 4.4 °C under low (SSP1-1.9) and high (SSP5-85) emission scenarios respectively. In response to this and the need to reduce energy usage and fuel poverty levels, buildings are being retrofitted for energy efficiency. UK retrofit guidance considers building thermal performance in the context of steady-state heat transfer through the building envelope. This simplification describes heat flow when external and internal environmental temperatures are constant in time, which greatly reduces computational complexity. However, the steady-state approach neglects the thermal inertia of the building envelope, i.e., its ability to store and delay transmission of thermal energy. This can result in significantly inaccurate calculations of indoor temperatures and the energy required for space conditioning. It is currently unknown how climate change affects the problematality of using steady-state analysis for walls of different thermal properties. This research investigates this problem through a novel analysis of the dynamic nature of the interaction between a building and its environment. Air temperatures obtained from historical data and SSP5-85 projections are used to calculate sol-air temperatures at 100 km² resolution for 1951-1980, 2011-2040 and 2071-

2100. The deviation from steady-state heat transfer is characterised through analysis of the temperature field inside the building wall when excited by the air and sol-air temperatures. The dynamic nature of the heat transfer is examined for different building envelopes and environments across the three time periods. This information indicates when, or if, it is problematic to use steady-state thermal analysis in retrofit decision-making for buildings of a given location, orientation and envelope construction.

Integrating Climate Change Adaptation into Building Design Codes: A Focus on Multi-Story Residential Buildings in Iran

N. A. Fereidani¹, E. Rodrigues¹, N. Rosa¹ and A. R. Gaspar¹

¹*University of Coimbra, Portugal*

Building energy consumption and CO₂ emissions in the Middle East exceed global averages, with Iran's residential sector consuming five times more energy than the world average. Decades of energy subsidies have discouraged energy-efficient design, leading to excessive reliance on mechanical cooling. As climate change intensifies and temperatures rise, cooling demand will escalate, particularly in poorly insulated buildings, further exacerbating energy inefficiency. Addressing this challenge requires immediate action to enhance thermal performance and reduce dependence on mechanical cooling through climate-responsive design strategies.

This study aims to develop climate-responsive design recommendations for multi-story residential buildings in Iran by evaluating the effectiveness of different envelope strategies under present and future climate conditions. A validated real-case apartment model was used to simulate energy demand across Iran's major climate zones, utilizing EnergyPlus for energy simulations. Future weather data was generated using the EC-Earth3 model through the Future Weather Generator tool, ensuring reliable climate projections for the 2050 and 2080 timeframes. A sensitivity analysis was conducted using the Morris method to identify the most influential thermal envelope parameters. The top-performing energy-efficient cases from the sensitivity analysis were then compared with existing building code requirements to propose targeted envelope design strategies.

The results reveal that Iran's current energy efficiency standards are insufficient to meet both present and future climate challenges, highlighting the need for stricter policies and revised climate zone classifications. To address this, the study presents an updated, structured framework of climate-responsive recommendations to improve resilience to future climate conditions while increasing energy efficiency. This framework provides clear guidance for architects, designers, and policymakers, supporting the development of energy-efficient, climate-adaptive buildings in Iran and other regions facing similar challenges.

Pumped hydro energy storage plants in China: Increasing demand and multidimensional impacts identification

M. pang¹ and L. Zhang¹

¹*Chongqing University, China*

In light of the soaring growth of pumped hydro energy storage (PHES) plants in China in recent years, there is an urgent need for a comprehensive understanding of their developmental trajectory and their identification of multidimensional impacts. This paper reviews the development of PHES in China and highlights its various impacts. Despite the relatively late start of PHES development in China, the country has recently ranked first worldwide with an aggregated installed capacity of 50.94 GW in operation in 2023. These plants are primarily distributed in North China, East China, and South China, contributing to the safe and stable operation of regional power grids. Furthermore, over 300 plants are under construction or in the planning stage across the whole country, aiming at supporting large-scale renewable energy development and facilitating sustainable energy transition. However, it is important to recognize that such extensive PHES development requires significant land resources, which can lead to disturbances in local ecosystems and affect nearby residents. Additionally, environmental emissions may arise from a life-cycle perspective. To promote the green and sustainable PHES development in China, this paper proposes several countermeasures, including enhancing the rational planning of new plants to optimize their distribution and prevent unregulated expansion, refining the engineering design of new plants to minimize disturbances to local ecosystems and reduce life-cycle environmental impacts, and exploring avenues for sharing the benefits of PHES development with a broad spectrum of local residents.

SESSION 6: Urban Resilience in a Warming World: Adaptation Tools for Health and Heat Risk

The ETHOS Research Project on “Co-Developed Environmental Solutions to Mitigate the Impact of Temperature Extremes on the Health of Vulnerable Populations”

J. Sheffield¹

¹University of Southampton, UK

ETHOS is an interdisciplinary, multi-institutional project funded by NERC over 2024-2028 led by the University of Southampton, which aims to transform understanding of temperature-health relationships in vulnerable UK populations, with a focus on city case studies in Southampton, Newcastle and London, to address critical gaps in current evidence. The projects aims to: (1) deepen understanding of heatwave and cold spell evolution, merging multi-scale data for more precise risk assessment; (2) elucidate complex temperature-health interactions in vulnerable groups, including those with multiple conditions, through clinical records and climatic chamber experiments; (3) produce the first national mapping of temperature-health risks, incorporating mobility and socio-economic factors; (4) project risk evolution under future climate and demographic scenarios, including mobility and health status changes; (5) develop data-driven approaches to identify environmental interventions and co-benefits for policy; (6) explore community viewpoints on impacts and co-produce interventions in diverse urban case studies; and (7) provide evidence and tools for targeted mitigation and adaptation policies, addressing health inequalities and climate change. This presentation will provide an overview of the project and its intended outputs and outcomes, and present initial results from the first year of the project, with a focus on historic temperature hazards in complex urban environments and analysed relationships with exposure and health outcomes, and discuss how stakeholder input can shape the impact of the research.

Vulnerable populations’ perspectives on interventions to reduce the health impacts of exposure to extreme temperatures: a qualitative systematic review protocol

S. Wilson¹, C. Tolley¹, L. Morrison², D. M. Walker², V. Abayomi¹, N. Hassan¹, R. Slight³, D. Filingeri², M. Vaz-Monteiro⁴, N. K. Esteves², J. Sheffield² and S. Slight¹

¹Newcastle University, UK

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Extreme temperature events, defined as heatwaves and cold spells that deviate from the norms of a region, are becoming more frequent worldwide. Exposure to these events, can exacerbate physical and neurological conditions and increase mortality rates. Exposure to extreme temperature is shaped by mobility and behavioural patterns with outdoor and indoor conditions. The risk exposure will negatively affect an individual’s health is associated with various physiological (e.g. aging and disease), economic and cultural factors. Various interventions, such as urban planning, cool roofs, and self-dousing, currently exist to reduce exposure to extreme temperatures. However, there are growing concerns these interventions are contributing towards health inequities as they often fail to address the needs of vulnerable populations, (e.g., young children, older adults, those with multiple long-term conditions) who are most at risk of adverse health effects from exposure. To support the development of equitable interventions, this systematic review aims to synthesise qualitative literature exploring the perspectives and experiences of vulnerable groups on interventions to mitigate health impacts of exposure to extreme temperatures.

The review will follow PRISMA guidelines to systematically search environmental and health databases (GreenFILE, PsycINFO, Embase, Medline). Search terms related to interventions, extreme temperatures, temperature related health impacts, and vulnerable populations will be used to identify English-language qualitative studies exploring vulnerable population groups’ experiences and perspectives of different interventions to mitigate the health impacts of exposure to extreme temperatures. Two reviewers will independently screen studies using a computer software, Rayyan, to minimise bias. The quality of the included studies will be assessed with the Critical Appraisal Skills Programme (CASP) Qualitative Review Checklist. A narrative synthesis will be conducted to analysis the findings.

The acceptability and feasibility of various interventions to mitigate the health impacts of exposure to extreme temperatures will be examined at three levels: micro (individual e.g., comparing different vulnerable population

groups), meso (organisational/community), and macro (societal). Key recommendations for equitable interventions will be developed.

The findings of this review will support health equity by informing the design and development of acceptable, inclusive interventions designed to reduce the health impacts of exposure to extreme temperatures.

Vulnerability and Risk Assessment Against Climate Change Attributable Extreme Heat and Flooding Events: A Case Study of Southampton

C. Watson¹

¹*University of Southampton, UK*

This study is motivated by flood risk with residents at risk of losing homes and climate extremes already affecting Southampton. The product of a secondment with Southampton City Council, this study aims to answer: What impacts may climate change have on Southampton and how can we 'future proof'? We advise on this question in a way the council can understand with recommendations the public understand.

A qualitative approach is used to evaluate at-risk areas. For flooding, the strategic flood risk assessment, geology, land elevation, sewer networks, canopy cover, green space, and 15 years of flooding reports are used. For heat, development type, canopy cover, and green space are used. This data is supported by quantitative analysis of the data provided by the Southampton Data Observatory, where using metrics contributing to high flood and heat vulnerability neighbourhoods are max-scale ranked.

The primary recommendation was strategic reinforcement of fluvial flood risk areas. Sediment and debris often clog gullies; hot-spots were schools, busy roads, bridges, and where land elevation changes gradient; proactive clearance of gullies is recommended. Outdated foul sewers that clear surface water and open waterways that become culverted have an inability to handle high water volumes. For the former retrofit was advised, for the latter 'terracing' of open waterways into surrounding green space reduces flow so culverts are not overwhelmed downstream. Greening urbanisation aids with urban heat island effect and makes greened land permeable. Some neighbourhoods have harder to solve risk factors, therefore lowering vulnerability is key.

An issue facing researcher policy influence is {\it 'explainability'}. Putting things in someone else's terms can largely make communication more effective. This is no different with climate research and policy and to ensure the public are on board, aid must be clearly communicated to avoid disillusionment. Aid to schooling, information translation, and social clubs, events, and volunteer networks, were recommended to combat information inaccessibility. Social clubs can also aid in social isolation and a high population with mobility issues by helping the wider community to be aware of and aid them.

Climate Change Weather Files: A Comparison of Future Weather Generators for Building Simulation

V. Corona-Henriques^{1&2}, A. Monge-Barrio¹, I. Idzikowski², O. Martin² and L. Ruiz-Juncos²

¹*UNAV, Spain*

²*AECOM, Spain*

Considering the increasing pace of GHG emissions and expected climate changes over the 21st century, the demand for reliable future climate projections continues to grow. This research highlights the importance of incorporating future weather projections into building simulations to ensure long-term occupant comfort and optimize building performance toward decarbonization by 2050.

This study reviews and assesses statistical weather generators (WGs) used to create future weather files for evaluating building performance. The analysis examines these WGs based on format, cost, Global Climate Models (GCMs), downscaling methods, resolution, emissions scenarios, output year, and ease of use.

From this review, three WGs were selected to apply in a case study: CCWorldWeatherGen (CCWWG), Meteonorm (M), and Future Weather Generator (FWG). These tools were chosen for their robust climate models and ability to simulate different emissions scenarios. The study focuses on two locations with distinct climates, Chicago (USA, 5A) and Madrid (Spain, 3B), under two emissions pathways— a high-emission pathway and middle-of-the-road scenario—projected for 2050 and 2080.

A comparative analysis of the generated weather data emphasizes key climate variables relevant to buildings, such as temperature, radiation, heating and cooling degree days, and comfort hours. These weather files are used as inputs for energy demand simulations to evaluate how future climate conditions will affect a small office building, which is modelled according to local building codes.

Results show an overall increase in total energy demand, with variations by scenario. In middle-of-the-road scenarios, demand rises by 5-11% in 2050 and up to 14% in 2080. Under high-emissions scenarios, the increase ranges from 6-14% in 2050 and up to 18% in 2080. In Madrid, heating demand declines by 14% in middle-of-the-road scenarios by 2050 and 42% in high-emissions scenarios by 2080. Meanwhile, cooling demand rises by at least 43% by 2050 and up to 117% by 2080. In Chicago, heating demand decreases by 9% by 2050 and 35% by 2080. However, cooling demand increases by 26% by 2050 and up to 131% by 2080.

These findings emphasize the need to integrate future weather scenarios into building design to enhance resilience, energy efficiency, and sustainability in a changing climate.

Clean Energy Building Components for Off-Grid Architecture

P. Cascone¹ and M. Laddaga¹

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In the last years, several conflicts have affected dramatically our planet, from the current Ukraine situation to the Gaza and Lebanon conflicts. The consequences of such conflicts are critical from both the humanitarian and environmental points of view. One of the most dramatic scenarios is the one of the Gaza Strip, which has seen five wars since 2007. But this most recent escalation, in the last 16 months, Israeli strikes have damaged almost 62 per cent of all houses in the territory, displacing 90 per cent of the territory's population and killing more than 50,000 people. As explained in recent UN reports, the strikes have generated a sort of ecocide, creating a huge amount of rubble and polluting both the land and the water sources. At the same time, all of Gaza's water and energy infrastructures are either damaged or destroyed, forcing most of the people to live in very extreme conditions with very limited access to electricity and water. Taking inspiration from the Open Gaza publication edited by Michael Sorkin we have started our work on post-conflict architecture in collaboration with the Architects for Gaza, an association of Palestinian and international architects and researchers. This with the aim to rethink in a paradigmatic way possible manufacturing strategies to reconstruct Gaza's basic infrastructures using the scarce materials available onsite, generating a sort of atlas of possibilities. Therefore, we have developed a series of building components that could produce energy from renewable sources for off-grid architectural solutions. The manufacturing protocols are based on the use of rubble from destroyed buildings with the aim of demonstrating construction techniques that local people can use to rebuild their homes and neighbourhoods. The first scale 1 to 1 prototype was designed and developed by a group of researchers from the University of Westminster and the Milan Polytechnic and realised in collaboration with the students of the UoW. The components were installed to the first scale 1 to 1 prototype for a demountable clinic providing temporary GP surgeries staffed with doctors from the Mobile International Surgical Teams (MiST), which has been operating in Gaza since 2010.

Assessing the Urban Morphology Impact on Land Surface Temperature Around Elementary Schools

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Urban morphology significantly influences localized thermal conditions, impacting heat exposure in sensitive environments such as elementary schools. This study examines the relationship between urban form and land surface temperature (LST) around 78 elementary schools in Clermont Auvergne Métropole, France, using the Local Climate Zone (LCZ) framework. By analysing a 250-meter buffer zone around each school, we compare morphological characteristics with satellite-derived LST data to classify schools according to their thermal risk. The results identify a pronounced urban heat island gradient, with peak temperatures in compact mid-rise and industrial zones and the coolest conditions in vegetated landscapes. Contrary to expectations, open mid-rise zones exhibited slightly higher temperatures than compact mid-rise areas, highlighting the complexity of urban heat dynamics. Statistical analyses confirmed significant correlations between thermal traits and observed temperatures, underscoring the influence of urban form on school microclimates. This approach offers a practical framework for assessing heat vulnerability in school environments, supporting climate-resilient urban planning.

SESSION 7: Inclusive Cities and Towns: Law, Design and Civic Participation

Urban Spatial Justice: The Case of Settler Colonial Aotearoa New Zealand

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We live in unjust societies with that injustice structurally embedded in the geography and design of our towns and cities. That is, “justice or injustice takes place somewhere”. Spatial justice can be defined as “the fair and equitable distribution in space of socially valued resources and opportunities to use them”. Examples include: i) equitable access to food, healthcare or employment opportunities ii) resources such as funding or political power being fairly distributed across communities, or iii) ensuring resilience to the impacts of climate change irrespective of where you live, particularly if you have had little choice about where that is.

There has been very little consideration of the way in which space and spatial arrangements in urban settings have exacerbated inequities in unique settler colonial contexts such as Aotearoa New Zealand. Change is needed as our societies, and cities, appear to be moving more and more towards spaces of contrast. For instance, today 10 percent of New Zealand’s population owns around 70 percent of New Zealand’s wealth. We are not the equalitarian, classless society that many New Zealanders think we are.

The desire for change has been stimulated by the post peak pandemic transitional space that we find ourselves in, motivated by the promulgation of polarising social and geo-political concerns, such as the rise of far-right ideologies. This sits alongside, or perhaps even in reaction to, progress made towards equity through large-scale campaigns internationally, such as the Black Lives Matter movement. Concurrently, ecological crises, such as climate change, have led to a flurry of thinking around how to fundamentally reshape our societies to respond to the ‘wicked’ problems we face in order to create better, ‘just’ and more caring places.

The above concerns have substantial and complex spatial consequences in urban settings. This presentation explores the built environment language of Aotearoa New Zealand. It considers how, in our settler colonial context, colonisation has fortified injustice, ‘baking in’ the unfair distribution of resources impacting exponentially on Māori, thus creating further tensions around how best to respond to ecological concerns amidst this socio-economic inequity.

Civic collaborative worldbuilding via role-playing games: recommendations from two case studies

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This paper showcases the findings of current research around the use of collaborative worldbuilding techniques, facilitated by tabletop role-playing games (TTRPGs), to discuss aspects of transformative mobility and resilient futures. TTRPGs are great instruments to facilitate the design of worlds, via collective imagination. Since these games are inherently collective and collaborative, players often generate solutions to challenges together, being able to also change the gameworld, where their characters belong.

This paper first starts by outlining the features of TTRPGs that facilitate collective imagination, by focusing particularly on systems thinking, transformative mobility and resilient futures. We then utilise two case studies of current projects that address collaborative worldbuilding: a hybrid RPG game about participatory budgeting (Empaville) and an adaptive version of Dungeons and Dragons (DnD) for sustainability.

This is followed by an analysis of 4 one-shot games of 4 hours long each (16h of gameplay) of the DnD gameplay and 4 Empaville sessions, of 90min each (6h of gameplay). In both case studies, we have recorded the gameplay audio and we have taken observational notes. Our initial findings show that (fictional) shared objects in both gameworlds grounded the worldbuilding process. We suggest these shared objects could be further translated into the real world and influence policy making.

This work is centred around the themes of collaboration and co-creation, with further suggestions for the development of innovative frameworks that tackle citizen participation and the city observatory. TTRPGs can be great opportunities to study social sustainability and adaptive city systems.

A Cause Without a Claimant: The Voice of the Environment in Infrastructure Planning Judicial Reviews

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In the transition of cities towards net-zero, the legal mechanisms that govern infrastructure development have become increasingly contentious spaces of equity. This paper interrogates the role of judicial review in the representation of environmental interests in the planning of major UK infrastructure projects. It explores how these proceedings cut across the wider social themes of justice, public voice and intergenerational equity.

Judicial review is a mechanism intended to assure public decisions, such as those granting development consent, are legally sound. However, when it comes to environmental claims, the process exposes certain structural inequities. The most domineering of these is how the environment lacks legal standing and is dependent on concerned individuals or groups to speak on its behalf. This paper critically examines how such representation impacts the outcomes, rights and responsibilities of the planning process. It uses high profile case studies like the A47 Highways improvement, the HS2 rail project and Den Brooks Windfarm to assess how citizen litigants act as intermediaries for ecological wellbeing in the face of legal and institutional barriers.

An unsettling paradox emerges. Environmental judicial reviews are an important guise through which citizens can challenge decisions on the basis of community concerns that might otherwise go overlooked because of national interest. At the same time, the use of judicial review can delay or derail projects with long-term social and environmental benefits, such as low-carbon transport infrastructure, raising difficult equity questions around whose interests are actually served and at what cost.

Through a discussion of how environmental values are filtered through human-centric legal systems, the paper calls for a more inclusive planning framework that better embeds ecological and public wellbeing into legal and urban governance. It proposes reforms to ensure that judicial review processes remain accessible, focused and equitable so as to preserve the citizen right to advocate for the environment while maintaining clarity and efficiency in critical infrastructure delivery. In doing so, it contributes to the wider dialogue on how cities can evolve equitably through governance systems that protect people and the planet alike.

Anchor Points for Interventions in Decision Making for Cities and Combined Authorities

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As cities and combined authorities gain increasing responsibility for climate action, embedding effective decision-making frameworks within existing governance structures is essential. The lack of statutory responsibility to make carbon reductions or interventions in the resilience and adaptation areas of work necessitates the identification and utilisation of so called 'anchor points' that can support and enhance delivery of these priorities.

This research reveals potential anchor points (or hooks) within the decision-making pathways at two major combined authorities for frameworks that enable climate action to be meaningfully integrated into policy and operational processes across UK city-regions. Drawing on qualitative research with the Greater Manchester Combined Authority (GMCA) and the Greater London Authority (GLA), we have co-developed tools that utilise co-benefits, particularly those related to health and equality to better understand the institutional mechanisms that may have potential to accelerate or hinder climate governance at the local level.

Findings highlight the difficulty of using these points as anchors for climate action as potential structural and political barriers include fragmented oversight of climate initiatives, difficulties squaring the misalignment of organisational and directorate level priorities, and limited technical expertise on carbon among officers.

This work hopes to provide a direction of travel for local government practitioners, policymakers, and researchers seeking to operationalise climate action through governance interventions. In a rapidly evolving political and financial landscape, embedding structured, scalable decision-making processes will be essential to increased resilience and emissions reduction in all cities.

Adaptive Design for Socially-Oriented Healthcare: Integrating essential MEP Systems into SIP Structures for Long-Term Temporary Applications

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This paper presents the development of a flexible, demountable, and fully equipped architectural system, conceived in response to insights from a previous study involving interviews with third-sector healthcare providers. The aim was to rethink meta-design strategies in a more adaptive and responsive way.

The research highlighted a growing demand for spatial solutions that address not only clinical needs but also the broader social dimensions of well-being, in line with the World Health Organization's framework of Social Determinants of Health (SDH). This broader perspective calls for a shift in architectural practice—one where the built environment contributes proactively to both individual and community health, extending beyond conventional medical settings.

The study identified several essential spatial requirements: flexibility, demountability, ease of transport and storage, rapid on-site assembly, and seamless integration with utility networks.

In response, the proposed system reconfigures traditional Structural Insulated Panels (SIPs) through a Design for Disassembly (DfD) approach, enhancing them with pre-integrated service cavities capable of accommodating mechanical, electrical, and plumbing (MEP) systems. These upgraded panels are supported by a flexible design strategy that allows for context-specific configurations, ensuring optimal adaptability across different scenarios.

This approach significantly reduces on-site labour and enables immediate functionality without requiring additional installations or interior finishes. The system's feasibility is validated through a design matrix and the implementation of three theoretical case studies in the Emilia-Romagna region of Italy, as detailed in the second part of the paper.

Owing to its modularity and ease of deployment, the system also demonstrates strong potential for post-emergency applications, offering a scalable, dignified, and efficient architectural solution for temporary healthcare and community-focused environments.

Coastal Connections: systems and synergy

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This study addresses a critical societal challenge: removing physical and social barriers that prevent equitable access to urban green and blue spaces, and active travel. Despite the recognised health and wellbeing benefits of natural environments and active travel, marginalised communities frequently encounter significant obstacles in accessing them. The Coastal Connections project, funded by Infrastructure for Port Cities and Coastal Towns employed a transdisciplinary approach to develop an innovative model for improving accessibility to these spaces.

The research design synthesised qualitative and quantitative methods using Southampton, UK as a case study site. After obtaining ethical approval, we engaged community organisations working with marginalised populations in co-producing the research design. We then conducted seven interviews and two focus groups with members of marginalised communities. This participatory approach ensured that community voices were integrated throughout the project. Concurrently, we developed multi-objective optimisation models for designing active travel networks that prioritised connectivity, safety, equity, and cost-effectiveness and enhancing access to green and blue spaces.

Our findings revealed that existing cycle routes are perceived as not user-friendly, characterised by poor connectivity between routes, and insufficient safety measures. These infrastructural deficiencies force users into high-traffic areas and routes and frequently failed to connect with blue or green spaces to encourage use. The qualitative data identified three primary barriers to utilisation: social (feeling excluded from certain spaces due to social, cultural, or economic factors), and safety concerns (especially in deprived urban areas). These insights directly informed our optimisation model, which uniquely balances cost and coverage considerations with parameters for route quietness and social equity.

The model demonstrates the additional investment required to prioritise safety and equity while maintaining connectivity. This approach offers planners a practical framework for evaluating trade-offs in active travel infrastructure development, potentially transforming how cities design networks that serve diverse populations equitably.

The research will inform subsequent grant applications for international collaborations and established the groundwork for larger-scale investigations through UKRI funding streams. This project exemplifies how integrating community perspectives with advanced systems modelling can generate practical solutions to complex urban accessibility challenges, ultimately promoting environmental justice and public health.

Application of climate policy & technology in cities on the pathway to net-zero: A case study of South Korea

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Global warming is causing the climate to change in unpredictable and unstable ways, significantly impacting our daily lives and ecosystems. In response to the climate crisis, many countries are striving to achieve net-zero emissions by 2040 or 2050. Urban net-zero initiatives are gaining attention in this context. Cities, which consume approximately 75% of global energy and emit around 60% of CO₂, play a crucial role in environmental and social sustainability.

South Korea, the world's 13th largest emitter of greenhouse gases, declared carbon neutrality as the 14th nation globally and legislated the goal of achieving net-zero emissions by 2050. Despite various policy efforts, significant emphasis is placed on achieving carbon neutrality in urban areas. This study aims to examine South Korea's sector-specific carbon-neutral policies and climate technology applications in urban areas, focusing on energy, buildings, transportation, and waste management. The goal is to discuss strategies for achieving net-zero emissions within cities.

SESSION 8: Data-Driven Sustainability in the Built Environment**AI-Driven Urban Well-Being: A Conceptual Framework for Human-Centred Smart Cities and Sustainable Liveability****A. Moulay¹**¹*Royal University for Women, Bahrain*

Artificial Intelligence (AI) is quickly evolving the field of urban planning, making cities develop into a more adaptive, efficient, and human-centric direction. AI technologies, embedded in mobility systems, public space design, energy optimization, and digital governance increase urban liveability through accessibility, sustainability, and agile governance. AI empowers cities to utilize predictive analytics, machine learning, and sensor-driven insights to optimize city responses to urban challenges, fortify infrastructure, and improve the quality of life. Nonetheless, despite its promise, the use of AI in urban planning does not have a structured framework that explicitly connects technology with well-being. Urban planning has traditionally adopted operationally-oriented practices that focus on infrastructure at the exclusion of more human-centric considerations, resulting in cities that are deficient regarding social inclusion, psychological well-being, and urban equity. In addition, AI adoption is often based on technological advancements, rather than a systematic approach towards sustainable and liveable cities. Therefore, it leaves a critical gap in how AI can contribute to making cities more resilient, inclusive and adaptive to environmental changes. This paper presents a conceptual framework for AI-driven urban well-being that analyses the role of AI in public space optimization, mobility solutions, green infrastructure, and community engagement to achieve equitable, accessible, and sustainable cities. Using a systematic literature review and case study analysis of interventions driven by AI in most liveable cities, this study assesses AI's impact on well-being indicators. The results highlight the potential of AI for increased safety, environmental sustainability and citizen participation. It informs how key challenges like algorithmic bias, data privacy, and governance transparency can be solved. In addition, the research examines the ways in which human-centred planning can be informed through responsive, participatory urban spaces that adapt to behavioural patterns through AI. This study argues for an interdisciplinary approach, integrating AI, human psychology, and urban ecosystems, to bridge the gap between AI-driven urban design and planning that focuses on human well-being. The suggested framework presents policy recommendations for building smart cities that are resilient, adaptive, ethical, and ensure that AI-driven urban planning aligns with sustainability goals, equitable access to services, and improved quality of life.

Leveraging Blockchain and IoT for Smarter Construction: Digital Transformation of Modular Construction for Sustainability**Y. Zhang¹, T. Tryfonas¹ and N. Carhart¹**¹*University of Bristol, UK*

Motivation and Aims Modular Construction (MC) is a key enabler of sustainable urban development due to its efficiency, waste reduction, and adaptability. However, challenges exist in ensuring transparency, lifecycle traceability of source materials and compliance with carbon reporting regulations. This study explores how the Internet of Things (IoT) and distributed ledger technology, particularly blockchain, can enhance MC by facilitating the implementation of Digital Product Passports (DPP) for lifecycle monitoring and carbon reporting. Blockchain technology ensures transparent and immutable records, facilitating compliance with evolving regulatory frameworks and sustainability goals. This study aims to provide strategic insights for industry stakeholders on the adoption of digital tools to optimise MC processes and achieve net-zero carbon emissions.

Methodology Adopting a qualitative approach, we conduct semi-structured interviews with industry and academia experts, including construction professionals and digital transformation specialists. Half dozen interviews to assess current challenges and opportunities in integrating blockchain and IoT in MC are conducted. We extract key insights via thematic analysis focusing on barriers to adoption, the potential role of DPP in lifecycle transparency, and the feasibility of blockchain-enabled carbon reporting mechanisms. Findings from the interviews will inform a conceptual framework for the digital transformation of MC.

Expected Outcomes The study identifies key barriers and enablers for blockchain and IoT adoption in MC, particularly regarding lifecycle transparency and sustainability compliance. We propose a strategic framework demonstrating how blockchain-assured DPP can facilitate real-time monitoring of materials, enhance deconstruction planning, and streamline carbon reporting in alignment with international standards. These findings will offer actionable recommendations for policymakers, industry practitioners, and researchers to drive the transition toward

smarter and greener construction. By bridging the gap between advanced digital tools and sustainable construction practices, this research supports the development of more resilient and circular cities.

Selecting scour monitoring devices for smart infrastructure

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Scour is a cause of the failure and often subsequent collapse of many bridge structures. Therefore, owners and operators of hydraulic structures such as bridges need to appraise the scour risk to these important infrastructure assets. To determine if scouring has affected a bridge, visual inspection data is still commonly used by bridge engineers. However, this approach has various limitations, e.g. operations cannot be undertaken safely by human divers during flood events and visual inspection may sometimes yield inaccurate data about scour extent due to e.g. refilling of scour holes over time. Early detection of the onset of scour can ensure time for intervention and for the planning of alternative transport routes and thus some of the network service losses during and immediately after extreme weather events can be avoided. To have access to reliable data on scour, it is important to specify and deploy monitoring equipment for detecting the rate and extent of scour. In this paper, an updated framework to assist engineers with the selection of the most suitable instrument or instruments for monitoring scour around riverine bridges is presented. The existence of different types of monitoring devices and approaches requires a framework for selecting the most proper device for a specific field site or sites, as each device has its benefits and challenges with regards to, for instance: purchasing costs; ease of installation; maintenance requirements; operational resilience against debris/ice and provision of accurate data. The proposed framework was developed after an extensive review of other scour monitoring device selection frameworks. Then a pilot study was conducted at the University of Bristol to refine the framework which has now been tested by undertaking a series of interviews with practitioners. The results of the preliminary testing of the new framework are presented in detail in this paper. The paper concludes with recommendations for how rating frameworks can be used as part of the efforts to transition to 'smarter infrastructure'.

Potential Energy Savings and Carbon Reduction of Tropical City using Digital Twin Technology: Case study of BERTAM City, Penang, Malaysia

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Malaysia's urban population has surged to 78.9% in 2024, contributing to 80% of the nation's carbon emissions, roughly 200 million tCO₂e annually. To address this, the government aims to reduce 33% of carbon emissions by 2030, and achieve carbon neutrality by 2050, aligning with its COP21 commitments. Digital twin technology, which creates virtual replicas of physical systems, offers a promising solution for achieving these targets. This study focuses on Bertam, a city in Pulau Pinang, as a case study to explore the potential of digital twin technology in urban sustainability. A baseline simulation of Bertam shows a total energy consumption of 928 GWh. By applying both active and passive strategies in the digital model such as renewable energy integration and improved buildings' insulation, the study aims to evaluate the city's potential energy savings and carbon reductions. The findings will provide insights into optimizing energy consumption and reducing carbon footprints in urban areas, helping Malaysia meet its long-term sustainability goals.

Enhancing multi-level building energy performance using Benchmarks, Interpretable Data-Driven Models, and Occupancy Insights in a Digital Twin Framework

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Net-zero targets aim to significantly reduce greenhouse gas (GHG) emissions by 2050 through energy efficiency measures to mitigate climate change. According to the International Energy Agency (IEA), urban buildings contribute significantly to global energy demand, with the European Union's buildings accounting for 40% of final energy consumption and 36% of energy-related GHG emissions. In the UK, non-domestic buildings contribute approximately 22% of building emissions and 4% of total GHG emissions, with educational buildings alone consuming 4% of total electricity and 9% of total natural gas. Despite their small proportion of total floor area,

educational buildings are at the forefront of net-zero initiatives driven by the Climate Commission for Higher Education Institutions.

The COVID-19 pandemic drastically altered building usage patterns, shifting university operations toward hybrid working environments. This period presents a unique natural experiment to analyse energy consumption relative to actual building utilisation. Additionally, the energy crisis stemming from the war in Ukraine has heightened the urgency to reduce reliance on natural gas and implement energy efficiency strategies.

Understanding energy consumption in complex building portfolios is crucial for informed energy efficiency measures and reducing the energy performance gap. Traditional energy data reporting, often limited to annual kWh/m² values, lacks actionable insights for energy managers and decision-makers. Interpretable data-driven models are emerging as powerful tools for energy performance analysis, integrating physics-based and causal constraints. These models demonstrate effectiveness in quantifying energy savings and optimising building operations but must address key challenges: reliability for decision-making, human interpretability, dynamic behaviour representation, and spatial-temporal consistency.

This study introduces a scalable multidimensional building performance framework integrating interpretable data-driven models within a digital twin approach. Applied to 47 buildings at the University of Southampton's Highfield Campus, representing 94% of campus floor area, the study assesses energy performance pre-, during, and post-COVID using monthly aggregated energy data from 2017-2023. The findings aim to enhance large-scale building management by linking energy use to performance metrics such as occupancy, ultimately bridging energy performance gaps.

SESSION 9:**Renewable Energy Progress in Kenya****I. Kiva¹***¹Ministry of Energy and Petroleum, Kenya*

Kenya has emerged as a regional leader in renewable energy deployment. In this keynote, Eng. Isaac Kiva will provide insights into Kenya's renewable energy journey, highlighting key policy frameworks, investment strategies, and innovations that have driven progress. The talk will also explore the challenges and opportunities in scaling sustainable energy access across the country and the region.

Effect Of E-Mobility in Developing Cities: Case Study Nairobi, Kenya**C. Ndung'u¹***¹Kenya Power, Kenya*

Energy demand is increasing progressively mostly in developing Cities, in the third world countries, where the main pushing factors are human population, due to rural -urban migration and E-mobility. The former is due to the availability of social amenities such as good road network, good health care facilities and reliable electricity access. This paper explore how Nairobi town, the Capital city of Kenya, is managing the emerging issues that are related to upsurge of human population and E-mobility. It is worth to mention that the latter has presented an interesting area of research due to increase of E-mobility of dual and four wheel vehicles. To ensure a seamless transition between fossil to electrical vehicles, a study needs to be carried out to establish the readiness of the city's network to accommodate the new emerging loads, that is, E-charging points. It has been established that most parts of the city's network capacity have ability to cater for the current E-vehicles traffic. However, there is need to carry out a comprehensive study to establish areas that require reinforcement because of numerous E-charging loads projected in a near future.

This study aims to establish both energy demand Vs E-charges increases in Nairobi, city. This is to ensure that as more electricity vehicles are introduced on Kenyan's roads, the energy supply remains sufficient, stable and reliable. The study therefore involves investigating the current loading of the network, status of existing infrastructures, areas network needs reinforcement and quality of power supplies. This will be realized by installing data loggers such as power quality analyzer as well as grid-key devices to capture quality of power supplies and network loading, respectively. The research will be carried out on low and medium voltage networks.

This investigation will enable the transmission and distribution company to identify areas of concern in the network that the power utility needs to upgrade to achieve a reliable, safe and sustainable quality power supplies.

An Evaluation of Sustainable Mobility Pattern in a Sub-urban University**O. K. Aluko¹, S. Ogunleye¹ and O. O. Aluko¹***¹Ekiti State University, Ado Ekiti, Nigeria*

This study examined the travel pattern of staff and students within Ekiti State University Ado Ekiti, Nigeria campus. The goal is to determine the current level of use of sustainable modes and identify measures to improve them in a sub-urban university campus. The use of Google forms questionnaire survey was adopted to collect data. A total of 654 individuals consisting of 243 staff and 411 undergraduate students participated in the survey. The questionnaire covered themes including: choice of transport modes, challenges with various modes, and suggestions on what is required to improve modes. The results showed that 67.1% indicated that walking was one of their major modes of movement within the University while the use of motorized modes was selected by 65.5% - with personal vehicles selected by 32.9%; commercial tricycle, 23.9% and commercial motorcycle, 9%. Only 0.4% selected cycling. For the students, 80.2% indicated that walking was their major mode of movement within the University while the use of motorized modes was selected by 50% with personal vehicles selected by 2.9%; commercial tricycle, 34.8% and commercial motorcycle, 12.3%. 2.9% selected cycling. Similarly, when asked why staff might not want to cycle, the most important reason was lack of cycling facilities (22.2%) while the least important reason was unfriendly weather (7.8%). For the students, when asked why students might not want to cycle, the most important reason was also lack of cycling facilities (30.4%) while the least important reasons were weather (5.1%) and 'I can afford a car' (4.6%). When asked what improvement staff wanted to enhance cycling, the most important suggestion was dedicated and well-maintained cycle lanes (53.5%). The students also had a similar response, suggesting dedicated

and well-maintained cycle lanes (49.3%) as the most important improvement required. These findings reveal that cycling poorly adopted as a transport mode and that much needs to be done to improve cycling as a mode within the University. The conclusions indicate that improvement in the adoption of cycling may be able to reduce the use of motorized mode which is shown to be high for both staff and students.

How to deliver the UK's EV Charging Infrastructure: Off-Grid

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Via the Zero Emissions Vehicles (ZEV) mandate, the UK has set targets for a reduction in the proportion of internal combustion engine (ICE) vehicles sold each year with only hybrid ICE vehicles allowed from 2030 and a complete ban by 2035. In order to facilitate the resulting electrification of road vehicles, the government has set a target of delivering a minimum of 300,000 public electric charge points by 2030. However, obtaining the required grid connection for these chargers can be expensive and time consuming, particularly for sites with high power, or large numbers of charge points.

The FEVER project (Future Electric Vehicle Energy networks supporting Renewables) is developing a different approach to electric vehicle (EV) charging infrastructure by developing a fully grid-independent charging station. The FEVER concept integrates on-site renewable energy generation with a novel Off-Vehicle Energy Store (OVES), enabling sustainable, resilient EV charging without putting additional strain on the grid and avoiding grid connection costs and queues.

At the heart of FEVER is the OVES system, a hybrid energy storage solution that combines different storage technologies to optimise availability, cost, and cycle lifetime of the system. This hybridisation allows the system to take advantage of varied benefits of different storage technologies.

FEVER also addresses the social and behavioural dimensions of energy transition. The project explores public acceptance, user interaction, and the role of digital tools in shaping energy behaviours. A control system is being developed to allow real-time control over charging sessions, including smart grid functionalities such as Vehicle-to-Grid (V2G) integration, peer-to-peer energy trading, and dynamic tariff management. This user-centric design will benefit the system technically, allowing users to make best use of the system, with the features they desire, but also in a way that fosters acceptance from the local community.

To date, FEVER has successfully deployed a small-scale research demonstrator at the University of Southampton, validating key components of the system architecture and user interface. Building on these insights, the project is now progressing toward larger-scale demonstrators (in the hundreds of kWh range), which will be delivered into real world applications.

Can Improved Safety of Autonomous Vehicles Contribute to Decarbonisation of Cities Using Lidar Sensors?

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Improved safety of autonomous vehicles (AVs) can contribute to the decarbonization of cities with the use of LiDAR sensors. By reducing traffic accidents, reducing traffic congestion, and promoting more efficient driving, AVs can lead to lower fuel consumption, reduced emissions, promote shared mobility and reduce parking needs, which are key factors in decarbonization efforts.

This paper will focus on how the improvement of safety of AV can help reduce traffic accident with the use of sensors suite combined in order to achieve the design of a safe AV focusing on LiDAR sensors.

In order to achieve to fewer accidents, LiDAR sensors can contribute to eliminating human error, which is a major cause of accidents, AVs can reduce the need for emergency vehicles and infrastructure repairs, which often involve the use of fossil fuels. By minimizing human error, AVs can reduce the number of accidents, which can result in traffic jams and higher fuel consumption.

This paper investigates the use of LiDAR sensors to advance road safety including the safety of AV by helping reduce blind spots.

LiDAR (Light Detection and Ranging) sensors have several applications. In this research the focus is on LiDAR application in connected autonomous vehicles CAV in order to improve their safety.

AV depend on their perception systems to gather information about their immediate surroundings. CAV need to detect their immediate environment including nearby vehicles, pedestrians, and other obstacles. LiDAR sensors complemented with cameras and other sensors using perception algorithms can improve safety by providing more accurate estimation of the surroundings and reducing the blind spots (Li and Ibanez-Guzman 2020).

LiDAR sensors on AV contribute to better locate objects and ultimately pedestrians. Among other requirements for vehicles to become autonomous, LiDAR sensors need to function as well as the human eye, in order to eliminate pedestrian/vehicle collisions.

LiDAR sensors fall into several ranges and types. Each type has its own advantages and disadvantages, and the cost can differ. While some have argued that LiDAR sensors are expensive, one cannot put a cost on human life. Considering this, for the AV industry to become more sustainable, there must be a cost-effective solution for installing LiDAR sensors onto vehicles.

The conclusions drawn from this research suggest that LiDAR sensors can contribute in reducing the blind spot, which can contribute in improving the safety of CAV. Therefore, while there are potential challenges, improved safety in autonomous vehicles has the potential to significantly contribute to the decarbonization of cities by reducing traffic congestion, optimizing driving patterns, and promoting more efficient transportation systems.

Assessment of EV infrastructure needs in a local authority context

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Building on previous research into electric vehicle (EV) charging demand and spatial planning, this talk presents a follow-up assessment of EV infrastructure requirements within a local authority setting. It explores how projections, policy developments, and local data have informed evolving strategies to meet charging demand equitably and efficiently. Key considerations include grid capacity, land use, user behaviour, and alignment with decarbonisation targets. The presentation reflects on lessons learned and ongoing challenges as local authorities scale up EV support.

SESSION 10: Data-Driven Solutions for Resilient Infrastructure and Sustainable Energy**Remote sensing for detecting and tracking damage on municipal infrastructure systems: A review of recent trends****P. J. Vardanega¹**, M. Kashani², J. Bennetts³ and A. Sextos¹¹*University of Bristol, UK*²*University of Southampton, UK*³*WSP UK Limited, UK*

Ensuring safety, serviceability and resilience of infrastructure components and systems are key considerations for asset owners and engineers. However, realisation of these performance objectives is often hindered by ageing infrastructure and exposure to both natural and anthropogenic hazards. Furthermore, much of a nation's infrastructure may be located in extreme or remote environments where access for inspection and maintenance is costly, dangerous or even impossible. Remote sensing is increasingly being used by civil engineers to inspect and monitor infrastructure assets and systems. Remote sensing systems can capture data across large geographical regions using e.g. satellite flyovers or surveys using camera and/or laser technology carried by drones. Remote sensing is also an important approach for inspections in post-disaster zones due to, for example, access limitations, safety concerns and the need for rapid data collection post-event to guide relief efforts. Monitoring infrastructure performance and tracking damage progress on fixed infrastructure assets can also be attempted using remote sensing systems. The increasing use of many types of SHM systems has in part been driven by the desire to supplant or at least enhance visual inspection regimes. This paper presents a concise review of recent literature on the use of remote sensing approaches in municipal engineering applications focussing on both assessment of individual infrastructure assets and distributed infrastructure systems. The synthesis of the results of the review aims to illustrate to what extent remote sensing approaches are actually replacing or supplementing visual inspection efforts across a range of scenarios e.g. pre- and post-disaster and during normal operation. The paper also discusses possible uses of artificial intelligence and machine learning to process the large quantities of data generated by some remote sensing systems. The paper concludes with recommendations for asset owners and operators considering increasing their use of remote sensing systems for infrastructure assessments.

A study on empirical prediction and monitoring of bridge pier scour depth: implications for asset owners and operators**G. Gavriel¹**, W. Yaqoobi¹, M. Pregolato², T. Tryfonas¹ and P. Vardanega¹¹*University of Bristol, UK*²*Delft University of Technology, Netherlands*

Bridges are infrastructure assets which connect communities and in cases of collapse or reduced service, these vital transport links on which citizens depend for livelihoods, supplies and mobility are severed. The UK's ageing infrastructure has been termed an 'asset time bomb'. There is also a concern that as climate changes, these ageing bridges are increasingly going to have to withstand more extreme flood events accompanied by faster flowing water in riverine environments. These environmental factors may result in the bridge stock being more susceptible to the effects of scouring. Scour is the removal of material (usually soil) from around an object (e.g. a bridge pier) due to the action of flowing water. Scour often occurs in fast flowing river systems and in coastal environments. Scour is a complex soil-water-structure interaction process. This complexity makes the estimation of the amount of scour challenging when using empirical and semi-empirical approaches which often use only a few parameters such as: pier width; pier length; average particle size of the riverbed material; approach flow depth and velocity; critical velocity; angle of attack; pier shape and spacing. Scour being a complex process is also challenging to measure reliably in the field with some methods being suitable in some circumstances but not in others. This paper reports results of a study which investigated the relative accuracy of eight scour prediction methods that use some (or all) of aforementioned parameters. The influence of the measurement device used to originally measure the scour depths in the field is also examined. Recommendations are made for asset owners and policymakers on the relative merits of the different measurement approaches, when deploying scour monitoring systems in the field via use of a recently developed scour rating framework.

Curtailment of PV generation related to intermittent air-conditioning loads: case of residential PV installation in Jeddah, Saudi Arabia

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Residential villas in Saudi Arabia have installed tens of kW of air conditioning capacity, used intensively for most of the year due to the hot climate. On the face of it, there should be a good match between the electrical demand for air conditioning and generation by rooftop PV during the day, reducing power flows on the distribution network. However, vapour compression air conditioning units are by nature cyclic and there are periods of time where the demand drops significantly. This matters for residential PV in Saudi Arabia because, for the foreseeable future, export to the grid is difficult to achieve due to bureaucratic barriers; and is not particularly desirable due to a very low export tariff (US 2 cents per kWh). In this work, we use high time resolution electrical demand data and solar radiation data to quantify the curtailment of PV generation due to intermittent drops in electrical demand from air conditioning. We propose some options for reducing this curtailment, including short term energy storage and scheduling of air conditioning loads.

POSTER EXHIBITION

Exploitation of Thermochemical Energy in HVAC Systems: The ECHO Prototype

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Considering the current energy policies aimed at the decarbonisation of industrial and residential sectors, the recourse to energy generation systems based on renewable sources has become essential. As is already well known in the current state of the art, renewable energy systems are intermittent and non-dispatchable. Consequently, energy storage systems are the key to bridging the technological gap associated with the discontinuity of energy supply from renewable sources.

Focusing specifically on thermal energy storage, thermochemical materials (TCMs) have garnered significant attention within the scientific community due to their high energy density and performance. The present study investigates the application of TCMs for thermal energy storage as a means of supporting conventional heat generation systems. This research is part of the European Horizon Europe project ECHO (Efficient Compact Modular Thermal Energy Storage System), which aims to develop an innovative thermal energy storage system for heating, cooling, and domestic hot water production. The ECHO project specifically targets the integration of TCMs within a closed loop HVAC system, with the objective of maximising the energy storage potential during the thermodynamic charging and discharging cycles of the material. The research aims to evaluate both the energy performance and the practical applicability of the TCM based prototype in industrial and residential contexts. Therefore, a real-scale prototype has been developed at the TekneHub laboratory of the University of Ferrara. This prototype will serve as a platform for future experimental testing. The poster presented at the ICEC 2025 conference shows the experimental prototype developed at the Italian university facility and its potential operation as a dryer and humidifier for the thermal exploitation of the TCM in a closed thermodynamic cycle.

Beyond the Average: Machine Learning for Dynamic Predictions of Household Energy Demand of Thermochemical Energy in HVAC Systems: The ECHO Prototype

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Operational energy use in the domestic sector accounts for the largest share of building-related carbon emissions in the UK, highlighting the importance of developing effective interventions to take urgent action in mitigating climate change. However, the reliability of Energy Performance Certificates (EPCs), which are the principal tool for communicating building energy efficiency to householders, has been increasingly contested. Recent evidence suggests systematic overestimation of household energy consumption in poorly rated dwellings, indicating the presence of a 'prebound' effect driven by behavioural and economic constraints. Current assessment methodologies such as the Standard Assessment Procedure (SAP) embed static and unrealistic assumptions about occupant behaviour that fail to reflect actual energy usage patterns. This research aims to apply machine learning techniques to high-resolution smart meter datasets from the Smart Energy Research Lab (SERL) to disaggregate the influence of building fabric and user behaviour on energy demand, attempting to quantify the prebound effect and evaluate its prevalence across different demographics. Deep learning and causal inference methods will be employed to generate predictive models capable of informing personalised energy recommendations. These insights will potentially support development of dynamic EPC user interfaces that incorporate behavioural inputs and enhance trust in energy efficiency guidance. The findings could also contribute to the design of more targeted and sustainable national retrofit strategies in support of net-zero policy objectives.

Stabilising local renewable power generation using a large consumer private wire connection: a real-life case study on the Isle of Wight, UK

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Driven mainly by the electrification of transport and heat, and the increasing penetration of low-carbon energy sources, the current electricity network in the UK is increasingly under threat of outages and faults due to its thermal

limits. As such it is important, that as we make the transition to net zero, to manage demand, generation and power flows through the network, with large demand centres such as businesses and utility-scale renewable generation sites playing a vital role in this. This research explores the opportunities to connect large businesses directly to a local utility-scale generation site using private wires so that their demand can be met without import from the grid. This reduced the power flow through the electricity grid network and therefore frees up capacity for extra generators and to supplement increasing electricity demand. By analysing actual monitoring data of a real-life private wire between a large factory and a 1.15 MWp anaerobic digestion (AD) plant, the reduced power flow through the grid was analysed and a network capacity of 561 kWp (1.87% of maximum capacity for the primary substation that distributes power to the area) was freed. Economic analysis was also completed using the Capex of the private wire and the reduced grid import by the consumer to calculate the potential savings for the consumer and incoming revenue to the generator. Economic analysis was completed for the grid electricity price when the power purchasing agreement (PPA) was agreed and a year later when grid electricity prices were high. The results show the need for PPA agreements to be flexible depending on the current grid electricity price so that it is always favourable to both parties. This research not only provides local authorities with a way of increasing their renewable generation capacity, but also provides businesses with a way of saving on electricity bills and reducing carbon emissions. The results from this research will be replicable for businesses and generation operators across the UK and other nations.

The Hottest Day at School: An Assessment of Storytelling Delivery Mode on a Pupil Heatwave Behaviour Change Intervention

P. A. B. James¹, M. Charter², A. Alshehri¹, V. Aragon¹, L. Blunden¹, S. Gauthier¹, K. M. González-Carreón¹, K. Kalsi¹, A. Montazami³, L. Myers¹, Z. Ni¹ and P. A. D. Turner¹

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Climate adaptation at the building and occupant level is increasingly vital in education settings, particularly with the growing impact of heatwaves. This poster presents results from a follow-up field trial examining how the delivery mode of a behaviour change intervention influences pupil responses in Key Stage 1 classrooms. A total of 474 pupils across four Hampshire schools participated, split into 5 control classrooms, 6 physical storytelling classrooms, and 7 animated video classrooms. The intervention builds on prior research exploring the role of narrative in promoting heat-resilient behaviour. Findings offer insight into the comparative effectiveness of delivery modes in shaping young children's awareness and responses to extreme heat, with implications for future educational and policy interventions.

Residential Heat as an Energy System Service: LATENT

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As part of the UK's shift to low-carbon heating, the LATENT project investigates the potential for domestic air source heat pumps (ASHPs) to provide demand-side flexibility through third-party control. Over the first two years of a field trial across households in the South of England, the project tested the feasibility of deferring heat demand to reduce electricity use during peak periods. This poster presents insights into system performance, indoor comfort outcomes, and participant experiences during these early stages. Findings show that automated control strategies can effectively shift load while maintaining acceptable comfort levels, with high user tolerance and minimal intervention. These results offer a foundation for the wider integration of ASHPs into future flexibility markets.

Research and Innovation in Solar Home Systems and DC Mini Grids

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The Energy for Development (e4D) programme continues research and innovation to support United Nations Sustainable development Goal 7 with emphasis on cleaner, sustainable and affordable electrification for all. This poster provides highlights on the e4D teams work on solar home systems (SHS) and DC mini grids (DCMG). SHS

has been a widely accepted and proven technology for off-grid electrification. However DCMG is still a niche area of research in off-grid context. The common objectives of e4D research in these two areas are:

- Technological innovation in user focused product and service
- Product quality, sustainability and efficiency
- Reducing levelized cost of electricity
- Enabling productive use of electricity

Tidal Turbine Performance Enhancement Through Winglets

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Winglets could provide enhanced performance for tidal turbines. They have been successfully used in non-rotating applications such as passenger aircraft to reduce drag, hence decreasing fuel consumption. Only limited use in rotating applications has been seen, most notable being employed in Enercon wind turbines. This poster provides findings on the testing of twenty 3D printed suction-side winglet designs for different parameters including cant angle, height and radius of curvature.

Photovoltaic Integration in Refugee Settlement Shelters: Energy for Development

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Forcibly displaced people, who end up as refugees are normally supplied with immediate shelter, water, food and medical support. These urgent actions are very important but are mostly based on the premise that many of the refugees will not stay in the allocated camps for long. Energy, especially electricity supply, which underpins many services is lacking in large numbers of camps. It is estimated that over 80% of the around hundred million people in refugee camps have no access to electricity and this project is looking at remediating this through the provision of locally generated power from solar photovoltaic (PV) systems installed on individual tents. The project aims to demonstrate new and appropriate designs of PV systems integrated within the infrastructure of a standard disaster relief/refuge tent.

Demand Side Renewables for Agriculture Base Load Energy - DeSiRABLE

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In Rwanda, milk production has the potential to contribute to food security, nutrition and employment. The government of Rwanda set up the “one cow per household programme”, known as “Grinka” in 2006, allocating more than 110,000 cattle since; but further support is needed to develop the milk industry.

National milk production is low in comparison to other East African countries and the dairy value chain faces many limitations. Quality issues generate distrust from consumers and the high level of informality in the market, results in a lack of regulation and incentives for business development.

The DeSiRABLE project seeks to explore and develop strategies for development through the deployment of stand-alone solar electricity driven technologies to power agricultural base loads, such as the chilling units at the Milk collection centres.

Sustainable Fashion- Using strategic pattern cutting and unwanted clothes in the children's clothing sector to reduce fashion waste and support circular practices.

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Clothing is more than a piece of fabric on our bodies, it is a testament to our identity and self-expression, and as a means for social and cultural inclusivity. Behind every thread and stitch – there is a story. "More than 3.15 billion articles of children clothing are thrown away every year." and "that of the 32 billion garments produced for the fashion industry each year, 64% will end up in landfill." This statistic has been at the route of the exploration into this sector of the industry. Drawing from interviews, research and importantly workshops with experimentations alongside. This study examines how clothing hand-me-downs serve as a medium of intergenerational connection, resistance to fast fashion, practical necessity and storytelling through fabric. The research also considers how gender, class, and family backgrounds shape the motivations, reality and meanings behind this practise.

Prediction of indoor ambient temperature from air-source heat pump flow temperature

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Heating in buildings represents a major share of energy demand and associated greenhouse gas emissions, making the transition to efficient, decarbonised heating technology crucial. Air-source heat pumps offer a promising solution; however, their successful integration depends on maintaining thermal comfort while enabling energy flexibility. This work builds upon the LATENT project, a field trial exploring third-party controlled flexibility in residential building clusters across Southern England. Drawing on its findings, this research combines machine learning with a building-physics approach to model the relationship between heat pump flow temperature and indoor ambient temperature. Using high-resolution time series data from 65 UK homes over a two-year period, preliminary analysis develops a regression model to predict the temporal profile of indoor temperature. Ongoing work seeks to identify building-specific parameters that can inform predictive control strategies to optimise both thermal comfort and energy efficiency.