Energy for Sustainability

Research Day

2020

Book of Abstracts

1290 UNIVERSIDADE D COIMBRA

Research Day

2020

October 14 | Wednesday

PROGRAM

15h00 | Opening

Presence of Manuel C. Gameiro da Silva, EfS Initiative Coordinator, and Cláudia Cavadas, Vice-Rector for Research and Director of the Institute of Interdisciplinary Research (III-UC), and the intervention of Fernando Seabra Santos, Former Rector of the University of Coimbra.

15h15 | Lecture | UNLIKELY RESEARCH QUESTIONS ON ENERGY

by Professor António Gomes Martins, Co-founder of the EfS Initiative.

16h00 | Current research @EfS

- ISR| **BUILDING-INTEGRATED MICROGRID FOR THE MANAGEMENT OF DISTRIBUTED ENERGY RESOURCES IN LARGE BUILDINGS** by Alexandre Correia
- CeBER| **PROPOSAL OF A CIRCULAR INDEX FOR THE TOURISM SECTOR** by Susana Garrido
- INESCC| **AZORES REGIONAL ENERGY EFFICIENCY ACTION PLAN** by Luís Neves
- INESCC| **ENERGY AND BEHAVIOUR: BUILDING BRIDGES AMONG DISCIPLINES FOR A MORE SUSTAINABLE LOW-CARBON FUTURE** by Marta Lopes
- itecons| **INNOVATIVE VIP PRODUCTS FOR APPLICATION IN THE BUILDING SECTOR** by Catarina Serra
- CITTA| **TRANSPORT RELATED AIR POLLUTION IN URBAN AREAS** by Oxana Tchepel
- CITTA| **SUSTAINABLE MOBILITY IN A NEW ERA** by Anabela Ribeiro
- ADAI| **ECO-EFFICIENCY IN EARLY DESIGN DECISIONS: A MULTIMETHODOLOGY APPROACH** by Carla Rodrigues

18h00 | Closing

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BUILDING-INTEGRATED MICROGRID FOR THE MANAGEMENT OF DISTRIBUTED ENERGY RESOURCES IN LARGE BUILDINGS

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Keywords: Distributed Energy Resources, Microgrid, Battery Storage, Building-to-Vehicle-to-Building, Demand Response, Photovoltaic Generation.

Abstract *The large-scale integration of renewable generation in large public and commercial buildings requires new management tools due to the potential mismatch between the local renewable generation and demand. Nowadays, there are several effective options for energy flexibility in buildings, including energy storage and demand response options. Therefore, to optimize the use of such flexibility resources a centralized management is required. In this work,* a microgrid was designed to ensure the management of flexibility resources in large buildings based on the availability of renewable generation and electricity tariffs. Such microgrid integrates photovoltaic generation, lithium-ion battery storage, bi-directional charging of electric vehicles, and controllers for the space conditioning systems. Such microgrid was implemented in the Department of Electrical and Computer Engineering – University of Coimbra, for supporting sustainable energy systems operation, ensuring the optimized integration of renewable generation in large buildings. The microgrid implements demand response actions controlling the charging of electric vehicles (using a Building-to-Vehicle system) and the operation of space conditioning systems, as well as energy storage using lithium-ion batteries and the energy available in electric vehicles (using a Vehicle-to-Building system). To enable it, the management and performance of the batteries and the Building-to-Vehicle-to-Building system have been assessed and a novel smart thermostat was developed. Additionally, a monitoring and management system was developed to integrate all the relevant data from the microgrid resources, and to ensure its control, facilitating the implementation and assessment of different management strategies. Therefore, the microgrid also enables the assessment of new smart grid solutions, acting as a testbed for the research developed on flexibility options for future power systems.

PROPOSAL OF A CIRCULAR INDEX FOR THE TOURISM SECTOR

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Keywords: Circular Economy, Tourism, Data Envelopment Analysis, Portugal, Spain.

Abstract

In the last years, the circular economy (CE) paradigm is being widely explored by researchers and institutions as a possible path to increase the sustainability of our economic system. Reuse, repair and recycling are becoming crucial activities in many sectors. There are some important reasons calling for an urgent assessment of tourism circularity, such as: the fragile ecological settings and cultural sensitiveness of attraction sites call for consistent monitoring and evaluation of tourism impacts; the dynamic, unstable and unpredictable natures of this industry urge to conduct a consistent assessment and monitoring of a progress towards tourism' circularity. Being so, this work aims to propose a circularity index to the tourism sector. The selection of indicators to build the Circularity Tourism Index (CTI) was based on the eight blocks suggested by the European Union in its Circular Economy Action Plan developed in 2015. These blocks are: i) material resource efficiency; ii) product life-cycle extension; iii) biological products; iv) energy efficiency and renewable energy, v) the performance economy; vi) the sharing economy vii) the platform economy and finally, viii) the industrial symbiosis. From these eight blocks the last one (industrial symbiosis) is not used since it is related to the industrial sector being not suitable to a service sector as is the case of the tourism. Methodologically a survey was used to collect data from Portuguese and Spanish hotels and the DEA (Data Envelopment Analysis) to compute the index. The usefulness of this Index from a managerial perspective is the possibility of supporting the decision-making process giving insights on the initial level of circularity, the circular practices implemented and which should be implemented in the future in direction of a more circular sector and also to perform benchmarking analysis.

AZORES REGIONAL ENERGY EFFICIENCY ACTION PLAN

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Keywords: Energy, Energy Efficiency, Sustainability, Azores

Abstract *Promoting Energy Efficiency is one of the main pillars of the Azorean energy policy, aiming to increase regional competitiveness, energy access, sustainability and security of supply by reducing energy costs, energy related Green House Gases emissions and energy imports.*

The Regional Energy Efficiency Action Plan (REEAP) defines a set of priority actions to promote Energy Efficiency complying with National and Regional objectives. The REEAP presents a characterization of the energy consumption in Azores and outlines a set of intervention areas with corresponding planned actions, considering their impact and cost-effectiveness, defining guidelines for their implementation, assuming a perspective of continuous improvement in the long term. The plan identifies the main consumption sectors and their representativeness in both economic and consumption terms, namely the industry, the commercial and services sector, the public administration, the residential sector, the transportation sector and the agriculture and fisheries sector, defining appropriate actions for each of them.

The energy savings potential is analyzed through two different perspectives, the final energy consumption and the primary energy consumption. The biggest potential for reducing final energy consumption lies on the transportation, the residential and the commercial and services sectors. The highest savings are obtained through interventions on mobility, HVAC systems, water heating systems and industrial heat generation.

A significant share of primary energy savings will be obtained from the electrification of current fossil fuel-based end-uses, combined with the expected increased contribution of renewable sources to electricity generation, and other forms of renewable energy integration. As a combined result of both the final energy savings and the increased contribution of renewables, even if only the ones directly tied to the actions planned in the REEAP, a significant reduction of the fossil fuel consumption and consequent emission of GHG is expected. By 2030, the REEAP forecasts savings of at least 61 kTOE of primary energy, 15% of the regional consumption in 2010, and 45 kTOE of final energy consumption or 14% of the final energy consumption in 2010 with a forecast of direct economic benefits corresponding to approximately 10 times the cost of the interventions. Therefore, Energy Efficiency assumes a major role in the quest for decarbonization, following the European strategy towards 2050.

Acknowledgement

This presentation is based on the work of a team of INESC Coimbra researchers under a contract with the Regional Government of Azores through DRE, the Azores Regional Directorate for Energy.

ENERGY AND BEHAVIOUR: BUILDING BRIDGES AMONG DISCIPLINES FOR A MORE SUSTAINABLE LOW-CARBON FUTURE

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Keywords: Energy, Energy behaviours, Sustainability, Interdisciplinary research, Coimbra

Abstract *The transition to a low-carbon energy system implies profound and large-scale transformations, including decarbonising energy supply by increasing renewable generation and reducing demand by fostering energy efficiency and behavioural changes [1]. Energy and behaviour encompass the role of people, organisations and technology in energy use, being closely interconnected with 'efficiency' (efficient use), 'conservation' (avoiding waste), 'sufficiency' (consuming within limits) as well as equity and fairness issues. Energy behaviours are influenced at the individual and societal levels through approaches that are complementary and competing, and several disciplinary fields address it differently. Experience has demonstrated that when aiming to reduce energy demand and greenhouse gas emissions, the most promising actions are those having higher impacts when considering the technical potential (the amount of reduction) and the behavioural plasticity (the capability of delivering effective behaviour change). Hence, finding effective paths towards decarbonisation requires innovative interdisciplinary work at all scales, bringing together engineering, economics, environmental, social and political sciences. Interdisciplinary work for a more sustainable low-carbon future offers the opportunity to design more participative and effective development strategies on the global scale. This work presents INESC Coimbra recent contributions in energy and behaviour interdisciplinary research, which has been developed in real-world settings using modelling tools to gain insights about problems and derive effective solutions, in a close cooperation with different stakeholders as policymakers, the industry and public entities.*

References

1. Lopes, M., C.H. Antunes, and K.B. Janda, *Chapter 1 - Energy and behaviour: Challenges of a low-carbon future*, in *Energy and Behaviour*, M. Lopes, C.H. Antunes, and K.B. Janda, Editors. 2020, Academic Press. p. 1-15.

Acknowledgement

We would like to express our appreciation to all researchers who participated over time in this research path opened by the seminal work of Prof. António Gomes Martins. This work has been developed in the framework of the Energy for Sustainability Initiative of the University of Coimbra and supported by INESC Coimbra and the FCT - Portuguese Foundation for Science and Technology within several projects, including the ongoing project MAnAGER - Models and algorithms for automated stand-alone and aggregated energy management systems to enhancing demand response in the SME and residential sectors (POCI-01-0145-FEDER-028040).

INNOVATIVE VIP PRODUCTS FOR APPLICATION IN THE BUILDING SECTOR

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Keywords: Vacuum insulation panels, super insulation materials.

Abstract *Worldwide there is growing demand for insulation products with superior thermal performance. In order to comply with the increasingly stricter building energy performance requirements and achieve the nearly zero energy targets set by European Policies, the industry together with researchers have been investigating novel super insulating materials. Vacuum technology has been used for several years in many applications, however Vacuum Insulation Panels (VIP) have not yet greatly penetrated the construction market due their high cost, difficult application and uncertainty regarding long term performance. The INNOVIP project focused on developing innovative solutions for walls, roofs and floors with improved performance and novel features which will lead to a breakthrough in energy efficiency of the opaque building envelope – both in new built and existing constructions. The success of the development process was demonstrated through an extensive experimental characterization campaign and two real onsite applications.*

TRANSPORT RELATED AIR POLLUTION IN URBAN AREAS

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Keywords: vehicle emissions, road transport, air pollution, modelling

Abstract *This presentation will be focused on two recently finalised research projects related with air pollution in urban areas.*

The TRAPHIC project ("Traffic related air pollution impacts on historic city centres: an integrated approach") addresses the need for policy-oriented integrated research on cities and transport, and more specifically on the impacts of traffic related air pollution on people and buildings in historical city centres. The prime goal of TRAPHIC was to develop a consistent approach to assess the effects of traffic related air pollution on human health and on the built environment using integrated modelling at city level. To achieve this goal, the project combined transport-emission-dispersion-exposure-impact assessment models within an integrated modelling framework, in order to provide a more comprehensive measure of air pollution on population health and building deterioration.

The ISY-AIR project ("An integrated system for urban scale air quality assessment and forecast") is addressing a multidisciplinary research in the field of atmospheric pollution in a complex urban environment and focused on atmospheric aerosols, including their sources, concentration and size distribution. The main goal of the ISY-AIR project was to advance in understanding of atmospheric aerosols and exploring of new products and services available at regional scale in order to improve the characterization of the urban aerosol and its most relevant anthropogenic and natural sources, through the combined use of modelling techniques and aerosol measurements.

A brief overview of these two projects and main outcomes will be presented.

SUSTAINABLE MOBILITY IN A NEW ERA

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Keywords: Sustainability, Mobility, Future Mobility

Abstract *We have lived for more than six months in an unthinkable situation in the beginning of 2020. The daily activities and, in general, the lives of all of us have changed in an unusual way. Although new technologies have solved many of the problems raised by those who work, for example, at universities, the truth is that the way we move around in cities, our personal urban mobility and the alternatives normally placed at our disposal face complex limitations. In addition, the vast majority of people still need to move to their jobs every day, using, for example, public transport. One of the most observed reactions was the most incisive use of active modes, walking and cycling, especially for short distances, as it is thus possible to maintain independence and personal distance when traveling. Likewise, a greater awareness of our personal health has been an influential factor in this process. Another reaction was to avoid public transport whenever possible, especially for trips longer than half an hour and in vehicles with greater ventilation difficulties. For those who had possibilities, there was a return to the individual motorized vehicle for many who had already chosen to leave the car at home and ride more on public transport. If the intention was to reduce emissions in this way, it is natural that we start to see a setback, which has even been held back by the fact that the number of trips is lower. The vehicle sharing sector, collective or individual, is also, of course, quite affected by the increased difficulties of vehicle hygiene. Another major impact was the reduction in air travel due to confinement limitations within each country and the economic impact that this phenomenon is having on the aviation sector. In a global way, we can say that the impacts on the transport sector are enormous, both in economic terms, in environmental terms, in social terms, and also in the challenges posed to those who manage a country, a city or a company transport. As a researcher in the context of sustainable mobility, I believe that the opportunities and challenges facing us are of great dimension and breadth in the face of these difficulties and I believe that the lines of research I was already developing now have new opportunities to produce useful results for this new future: How can cities adapt in terms of policies and urban design to promote active modes? How can we captivate young people, especially university students, for more sustainable behavior in terms of mobility? How can companies and municipalities responsible for collective and individual vehicle sharing systems, public and private, optimize their transport systems and vehicles? How can one continue to discourage the use of the individual motorized vehicle, the car, without interfering with the right of access to daily activities? How can we adapt the concept of vehicles that had been designed for the future: autonomous, shared and electric, to serve the needs of a new future and, necessarily, a new society? How can we use the characterization data of our trips accessible from our mobile phones, as instruments for planning the city and mobility of the future? How can we guarantee the concept of inclusive mobility contained in the other dimensions of sustainability in mobility?*

ECO-EFFICIENCY IN EARLY DESIGN DECISIONS: A MULTIMETHODOLOGY APPROACH

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Keywords: Building retrofits; Data envelopment analysis (DEA); Decision-support tool; Life-cycle assessment (LCA); net present value; Regression analysis.

Abstract Eco-efficiency is a key concept encompassing economic and environmental aspects to promote a more efficient use of resources and lower emissions. An eco-efficiency perspective in the design of products and services is thus essential in the pursuit of sustainability. This article proposes a novel decision-support methodological approach to assess the environmental impacts and costs in early design stages, aimed at providing informed recommendations to designers, manufacturers and decision makers. This multimethodology approach integrates a streamlined life-cycle environmental and cost assessment with a data envelopment analysis (DEA) model that derives eco-efficiency ratios and compares alternative designs, without the need to subjectively weigh the different environmental and cost life-cycle metrics. A linear regression model is then used to indicate the most influential decision variables. This approach was applied to a retrofit process of a historic residential building located in Southern Europe. The metrics used to assess the design parameters are: climate change, acidification, eutrophication, non-renewable primary energy, and net present value. A sensitivity analysis on the decarbonization of the electricity mix was also performed. The multimethodology offers valuable guidance to allow decision-makers to progressively specify the decision variables in an iterative way, using robust methods allowing for the statistical validation of results. The case study revealed robust empirical results for building retrofits in Southern European climates, indicating that the variables that most impact eco-efficiency (in both short and long-term) are roof insulation thickness and material followed by exterior wall insulation material. After three variables specification, the average eco-efficiency always increased, with higher gains obtained for the scenarios with the current electricity mix (22-25% increase) and more modest gains obtained for the electricity decarbonization scenarios (8-15% increase).