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Editorial

Sustainable Development of Energy, Water and Environment Systems (SDEWES 2022)

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The findings of the most recent Intergovernmental Panel on Climate Change (IPCC) report highlighted significant gaps in the targeted global reductions in greenhouse gas (GHG) emissions [1]. Implementation of sustainable development is at the core of achieving these targets and mitigating the anthropogenic environmental impacts. At the same time, sustainable development, as defined by the UN 2030 Agenda [2] and its associated sustainable development goals (SDGs), requires a holistic, interdisciplinary approach, which is not without its challenges. Indeed, studies tracking global progress towards meeting the 2030 SDG targets [3] show similar gaps in the implementation of sustainable solutions, with several SDG targets described as 'off track'. There is therefore an urgent need to address the challenges of an interdisciplinary, unified and practical sustainable implementation approach.

In this context, since 2002, Sustainable Development of Energy, Water and Environment Systems (SDEWES) Conferences have provided a platform for interdisciplinary discussion and advancement of sustainable solutions. Engaging a broad range of topics such as food, water, energy and waste cycles, the SDEWES Conferences Special Issue (SI) series provides an outlook on the key contributions and scholarly work presented at the SDEWES Conferences each year. The 2021 SI showcased a series of seven selected papers, providing insights into the topics of biorefineries, sustainable use of organic materials for various applications and waste management in industrial processes (Contributions A1–5), energy-positive buildings (Contribution A6) and methods for evaluating economic aspects of energy markets (Contribution A7).

This SI provides further depth and broadening of the topics addressed, bringing together fifteen selected papers presented during the 2022 SDEWES Conference series at the 5th South East European, 3rd Latin American and 17th Conferences on SDEWES in Vlorë (Albania), São Paulo (Brazil) and Paphos (Cyprus). The selected papers tackle a broad range of topics from circular governance models to education in relation to sustainable practices, impacts of current legislative frameworks targeting energy efficiency, built environment energy performance, bio-based industrial applications, transport and sustainable energy services, production, supply and infrastructure maintenance strategies. This SI, therefore, provides an interdisciplinary and holistic perspective on sustainable development solutions, with several of these papers highlighting interrelations between various fields and aspects of sustainability.

Combining both top-down and bottom-up approaches, this SI opens with a proposal for a flexible circular governance model assessed through a territorial circularity index

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and based on the analysis of current approaches and challenges for implementing circular economy principles at the urban scale (Contribution B1). Based on the review of relevant literature surrounding assessment and implementation of circularity indices, Rangoni Gargano et al. (Contribution B1) highlight the key challenges (flexibility and coherent policies) and enablers (use of synergies and circular approaches to create financial incentives) of transitioning from the typical linear urban production and waste models to circular, sustainable urban models. The proposed governance model and circularity index provide a step-by-step practical approach for assessing barriers and enablers through four identified key areas: material flows, loops, sharing and competitiveness. The theoretical governance model was tested via questionnaires aimed at a range of stakeholders in Italy, South Tyrol and showed an excellent potential to capture the complexities of circular model implementation and inform territorial-level decision making to facilitate transitioning to circular models.

The relationship between governance, legislation and sustainable implementation is further explored through a series of five papers focusing on the built environment and, adding detail to the discussion prompted by Rangoni Gargano et al. (Contribution B1) around the significant impact and potential of urban areas to enable sustainable development.

The first of the five papers (Contribution B2) explores the impacts of European Energy Performance of Buildings Directive (EPBD), focusing on Lithuanian multi-apartment blocks in relation to the implementation and effects of local and European legislation aiming to reduce energy consumption and CO_2 emissions. Monstvilas et al. perform statistical analysis based on registered Energy Performance Certificates (EPC) to provide insight into the effectiveness of the directives, as well as their impact on building features and energy performance, looking at the historical evolution of these parameters alongside increasingly stringent legislative requirements. The results indicate that in Lithuania, such policies are successful in improving the energy performance of buildings. Several improvement areas (e.g., hot water production, lighting, and electric appliances) that could further increase energy savings are also identified. While the study focuses on the Lithuanian context, the building typologies discussed, as well as the process of the EU directive adoption at the national levels, are similar in a number of European countries. The results are thus relevant for a broader range of contexts and provide insight into the performance of the EU approach.

Next, Caruso et al. (Contribution B3) propose a new design for a concrete masonry unit with embedded insulation. The thermal performance of the proposed masonry module is assessed through theoretical u-value calculations (ISO simplified and detail methods) and in situ monitoring of actual performance. Although the module exceeds the performance of conventional construction systems and Maltese building regulation requirements, testing shows a significant gap between the theoretical and actual thermal performance of the module. This highlights the broader issue of differences between theory and practice, where built applications often under-perform due to a multitude of factors such as installation quality, and it identifies an area of improvement for legislation and afferent calculation methods that affect the energy performance of the built environment.

Delving deeper into the links between urban fabric thermal performance and its effect on occupants and energy consumption, Liaw et al. (Contribution B4) explore the relationship between thermal comfort, energy consumption and energy poverty in the context of Brazil's social housing initiatives which strived to provide shelter and cover housing shortages for low-income families. This paper presents a case study for a social housing block in Brazil, which, as a typical low-cost project, was built to lower energy performance standards, leading to a lack of thermal comfort in the building. As a result, residents rely on mechanical ventilation and other appliances to achieve some level of thermal comfort. The implicit impact is that some low-income families cannot afford either equipment or the resulting increase in energy bills, therefore becoming exposed to health risks due to the hot and humid local climate. At the same time, the use of additional mechanical cooling and ventilation solutions increases both energy consumption and GHG

emissions for these projects. Using a system dynamics model, the authors explore various passive ventilation solutions and other low-cost design changes (e.g., use of insulating materials), showing that increased insulation and passive ventilation solutions (increased window size and opening typology) can drastically increase thermal comfort. In a broader context, this paper highlights the efficiency and potential of low-cost design solutions and draws attention to social housing as a key urban typology that may aid in reducing overall urban energy consumption and GHG emissions and increase thermal comfort.

Similarly, Mangan (Contribution B5) draws attention to retrofitting as a necessary step in improving the performance of the built environment. While energy performance legislation setting minimum targets can have positive impacts on the overall building stock performance, given that most urban contexts are dominated by existing, often historical stock, retrofitting plays a key role in holistically achieving future energy performance targets. This paper proposes a combined parametric and multiple-criteria decision analysis workflow for retrofit, which aims to help increase implementation and feasibility of retrofit solutions by providing insight to key decision makers (designers and homeowners) towards a performance-based rather than building code minimum requirement approach. On the basis of a case study in Istanbul, Turkey, the author proposes a three-step workflow including identification of key design parameters and performance indicators, performance analysis and generation of various combinations and possible retrofit approaches and a multi-objective analysis for the selection of an optimal solution that takes into account benefits and trade-offs between primary energy consumption savings, life-cycle cost savings and payback periods.

The last built environment paper provides further detail on how improved energy efficiency can be achieved using Combined Heat and Power (CHP) and Combined Cooling, Heating, and Power (CCHP) systems for the hospitality sector in Malta. Magro and Borg (Contribution B6) look at a range of Maltese hotel typologies, aiming to determine the technical and economic feasibility for improving energy efficiency by the use of CHP and CCHP, providing a holistic perspective which takes into account both the technical and energy demand features of the different hotel typologies in relation to the implementation of CHP and CHPP but also the impact of the broader legislative and market trends (e.g., feed in tariffs, available grants and other incentives). Based on the results of a series of simulations, the authors highlight that the feasibility of both co- and trigeneration solutions is highly dependent on financial factors, with CHP providing feasible solutions, especially for four-star hotels, and CCHP not feasible in the current legislative and market context despite its high potential and technical performance. The authors discuss implications and conclusions for hot and cold climates and how they may differ, highlighting the correlations between feasibility and policy, incentives and market approach (e.g., feed-in tariffs). Although this paper focuses on the Maltese context, it provides a clear example of the impact of policy and market approach in the adoption, feasibility and development of sustainable energy generation technologies.

While the built environment is highly representative in terms of establishing primary demands, the larger scale service provision including production, supply and waste cycling infrastructures play a key role in achieving sustainable future development. The following six papers, therefore, focus on industrial production processes, services and infrastructure.

Linking with the discussion around built environment and domestic energy consumption in the previous section, Aranda et al. (Contribution B7) explore the possible application of energy service provision and performance contracts in a domestic context. This paper proposes several innovative methods of applying pay for performance (P4P) approaches for domestic customers to improve benefits for both service providers and users. The authors highlight low-cost home smart system retrofits as a means of achieving the required levels of monitoring and data collection, as well as the implementation of artificial intelligence algorithms to optimize service provision, management of peak demands through flexible schemes and end user behaviors. While such approaches have been used in the past for commercial applications, variability of usage and challenges for data collection and instal-

lation of monitoring infrastructure have represented barriers for the emergence of similar initiatives in the domestic sector. The authors suggest that the application of P4P schemes in this context can improve overall energy performance while creating a new market sector and thus an incentive for energy service providers.

Aside from improvements in service provision through monitoring and optimization of energy consumption and resource allocation, the exploration and improvement of technologies harnessing waste and using alternative sources for energy production could provide key alternatives to fossil fuels. Based on the case of the German—Jordanian Water-Hydrogen-Dialogue project, Adisorn et al. (Contribution B8) explore relations between water, waste water, energy and hydrogen production sectors to identify opportunities for hydrogen production in water-scarce contexts like Jordan. Although hydrogen has a variety of applications (e.g., mobile fuel cells, excess energy storage, steel manufacturing), its production process is energy intensive, with 'green hydrogen' production depending on water availability. Using a combination of desk research and expert workshops, this paper provides a systematic analysis of water–hydrogen relationships, highlighting key water feedstocks deriving from water and waste water treatment processes and their potential use and reuse in the production of hydrogen. The findings are transferred to the specific context of Jordan, aiming to inform policy and decision making by highlighting key risks and opportunities. However, in a broader context, the research is relevant for both resource use management in water-scarce contexts and process optimization in general.

The following two papers focus on the optimization of lignin processing for bio-based refineries which have numerous applications including alternative (biofuel) energy production and other industrial uses. Adamcyk et al. (Contribution B9) explore optimization through high-temperature lignin separation during ethanol organosolv pre-treatment in biorefineries. The study demonstrates improved lignin production and overall yields. A series of experiments were used to analyze separation of extract and residual biomass at different temperatures after pre-treatment. Results showed that the higher lignin concentrations at high temperatures led to a 46% improvement in the yield of solid lignin without impacting lignin purity. Optimizing lignin production through this method, thus, has a high potential to improve efficiency and promote the economic viability of lignocellulose biorefineries.

Providing insight into potential applications and optimization of industrial lignin processes, for chemical and cosmetic industries, Tomasich et al. (Contribution B10) explore the use of colloidal lignin particles (CLPs) as a sustainable alternative to fossil-based and synthetic ingredients. Several experiments were conducted to determine production and characterization of CLPs from different bulk lignins and assess the potential of CLPs as emulsifiers in Pickering emulsions. The production process was successful in obtaining CLPs from a variety of bulk feedstocks as well as in stabilizing Pickering emulsions by use of CLPs, highlighting an opportunity to advance the transition from fossil fuel-based to bio-based economy, an essential step towards future sustainable development.

Given that sustainable economies and their associated industrial processes, supply strategies and services are still in an emergent stage, improvement and optimization of existing infrastructure and especially the mitigation of the risks and lingering effects of the fossil fuel economy are key to achieving sustainable futures. The following two papers provide poignant examples for how such approaches can be managed, focusing on the case of in-line inspection robots for gas and oil pipelines. A key implication of developing more efficient in-line inspection protocols is the early warning and prevention of potential environmental hazards due to pipeline malfunctions.

The first paper presents a comprehensive literature review and analysis of existing in-line inspection (ILI) tools and technologies for steel oil and gas pipelines. Parlak et al. (Contribution B11) review the key types of ILI tools providing a comparison of their associated sensor types, capabilities and limitations. ILI tools are classified according to pipeline structure and context, capability and application areas and assessed through comparison of advantages and disadvantages of various combinations of sensors. Findings

suggest that although other tools are still more prevalent in today's market, due to their numerous advantages, electromagnetic acoustic transducer technologies are likely to dominate the smart ILI tool market in the future. Additionally, the authors discuss the positive environmental impact of ILI tools, noting significant reductions in hazardous incidents correlated with the gradual introduction of ILI tools.

The second paper (Contribution B12) presents a new approach towards wirelessly controlled ILI robots which can aid in early warning and prevention of ecological damages due to malfunctions along transmission and distribution lines for oil and gas. The authors add to existing research which used the transmission pipe as a conduit to transmit a low-frequency signal over 100 m [4], proposing and testing an improved system which can be used for complex transmission and distribution networks with various bends and specialized transitions. Based on laboratory and real-world tests, this study demonstrates significant advantages of the proposed system including the possibility of long-range video transmission and communication, improved communication by use of low-attenuation-frequency windows and feasibility of early diagnosis that can reduce incidents with detrimental environmental impact.

The final three papers included in the SI offer an additional human-centric dimension to the previous discussions around optimizations, policy and practical implementation of sustainable solutions, focusing on the impact of cultural factors and education on the adoption and successful implementation of sustainable solutions.

Linking with the previous infrastructure- and industry-focused papers, Iancu et al. (Contribution B13) discuss the impact of cultural factors on the adoption of low-emission passenger cars in EU countries. Through a mix of literature review and data collection, the authors first analyze distribution of high-, medium- and low-emission passenger vehicles across EU countries, followed by a characterization of each country based on six cultural dimensions according to Hofstede [5]. Using multiple regression analysis, the various degrees of low-emission vehicle adoption are correlated with the intensity of the six cultural dimensions, providing insight into the relationship between cultural traits and adoption of more sustainable transportation options. Based on this analysis, specific marketing strategies and considerations for decision and policy makers are discussed for each identified correlation, adding to the available tools that may help to encourage adoption of sustainable solutions.

Complementing cultural factors, Rosi et al. (Contribution B14) focus on the possible impacts of education systems on the adoption and implementation of sustainable solutions, exploring the relationships between logistics industry education, growth and sustainability in the context of the Middle East (ME). This study developed a novel conceptual framework to help analyze data and identify keywords relating to the integration of sustainability integration logistics and supply chain management-related study programs. Correlation analysis was conducted to identify links between sustainability integration and sustainability and logistics performance index. The results of the study indicate varied conditions across the 15 ME countries analyzed, with some areas focused on efficiency more than sustainability and an overall lack of integration for topics such as circular economy and corporate social responsibility. Although no correlation was established between sustainability curriculum integration and country-wide sustainability indices, given the high impact of education curriculums through their influence on graduates and future work force, the conceptual framework and analysis method presented provide a systematic and practical example for identifying curriculum areas in need of improvement.

This SI concludes with a paper by Abina et al. (Contribution B15) presenting interface design and testing results for a computer-based interface (decision support system) for monitoring sustainability-related competencies in higher education institutions. A result-oriented engagement system for performance optimization (RESPO), which collects data on required competencies and available educational programs, is adapted from a business-oriented application for higher education institution contexts. Using practical trials in higher education institutions, the interface successfully underwent initial testing

and validation with further testing and development underway. A key finding was the identification of the need to integrate key competencies in relation to educational programs, employer needs and international and national strategies. Overall, the presented RESPO system shows an excellent potential as a tool that uses learning analytics and competency monitoring to inform decision making in higher education, as well as to improve competency levels and adoption of sustainable approaches.

This SI of *Sustainability* overviews selected papers submitted to the SDEWES Conference series in 2022. These papers address various facets and scales of sustainable development, providing insight into linkages between different sectors, disciplines and policies which are vital to ensuring sustainable futures. Practical examples of new methods and approaches for future development of circular and bio-based economies, energy-efficient buildings, optimizations of services, supply chains, infrastructure, cultural and educational aspects are included alongside strategies for retrofitting, improved management and mitigation of potentially hazardous effects of existing infrastructures. This SI and selected papers respond to the urgent need for interdisciplinary knowledge development, understanding of interlinkages and adoption strategies required to address the growing climate crisis and accelerate the implementation of sustainable alternatives.

Future SDEWES conferences will continue to provide a platform for interdisciplinary discussion and dissemination of new research methods and findings on sustainability. Readers are referred to the International Centre for Sustainable Development of Energy, Water, and Environment Systems (SDEWES) for information on the upcoming events [6].

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