Supporting the 2030 Agenda for Sustainable Development: Special issue dedicated to the Conference on Sustainable Development of Energy, Water and Environment Systems 2019

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Abstract
This paper is an editorial for the virtual special issue (VSI) of Renewable and Sustainable Energy Reviews (RSER) dedicated to the 14th Conference on Sustainable Development of Energy, Water and Environment Systems (SDEWES 2019) held from 1 October 2019 to 6 October 2019 in Dubrovnik. The VSI published both high quality review papers and original research articles presented at SDEWES 2019 that were of relevance to RSER. A total of 38 articles from the SDEWES 2019 were invited by the guest editors for this VSI. After a scrutinizing peer review process, 28 articles were accepted and published. These articles fall into three broad categories, dealing with smart energy communities, bioenergy and solutions for sectors that are difficult to decarbonize, and produce knowledge relevant to a number of Sustainable Development Goals (SDGs). This editorial discusses the contributions of the articles relevant for expanding the knowledge on the use of demand side flexibility, advancing the three visions of the bioeconomy, moving forward on the difficult challenges for a sustainable energy system and developing effective tools and guidelines for policy makers. Also, the editorial identifies synergies and trade-offs with a number of SDGs, confirming that the generated knowledge is a valuable support to the 2030 Agenda for Sustainable Development.

Keywords: Bioeconomy, Decarbonization, Smart Communities, Sustainable Development Goals, 2030 Agenda, Synergies, Trade-offs.

1. Introduction

This virtual special issue (VSI) of Renewable and Sustainable Energy Reviews (RSER) is dedicated to the 14th Conference on Sustainable Development of Energy, Water and Environment Systems (SDEWES 2019), held from 1-6 October 2019 in Dubrovnik, Croatia. Over 600 papers were presented at SDEWES 2019, in a wide range of topics relevant to the sustainable development of energy, water and environment systems. This VSI of RSER contains the accepted works from the SDEWES 2019 conference that were relevant for, and met the publishing criteria of RSER. As such, they build on past research presented at the SDEWES conferences, part of which have been published in four special issues of RSER dedicated to the 2015 [1], 2016 [2], 2017 [3] and 2018 [4] SDEWES Conferences. Considering their contribution for achieving sustainability, the papers in this editorial are discussed in light of the 2030 Agenda for Sustainable Development.

The 2030 Agenda defines humanity's roadmap for developing a more sustainable relationship with the biosphere, while ensuring reduced inequality, sustained economic development and improved living conditions [5]. Signed by 193 countries [6], it serves as a guideline for decision makers, industry and academia, informing them on the importance and priority of the goals at hand [7,8], while accounting for the synergies and trade-offs with different SDGs [9–12]. In the past, SDEWES has contributed to the 2030 Agenda debate by offering relevant research on the sustainability of energy, water and environment systems. Of greatest relevance for this VSI is the conference's exhibited tradition in research on energy sector coupling [13,14,23,24,15–22], demand side measures [20,25–31], bioenergy [32–38] and alternative fuels [39,40,49–52,41–48].

The SDEWES 2019 contributions add to these topics, as they fall in three broad categories, dealing with (i) smart communities and buildings, (ii) solutions for the bioeconomy and (iii) solutions for those sectors that are most difficult to decarbonize (beyond the low-hanging fruits). In this editorial, their synergies and trade-offs with certain SDGs are discussed, based on a macroscopic evaluation, as shown in Figure 1.

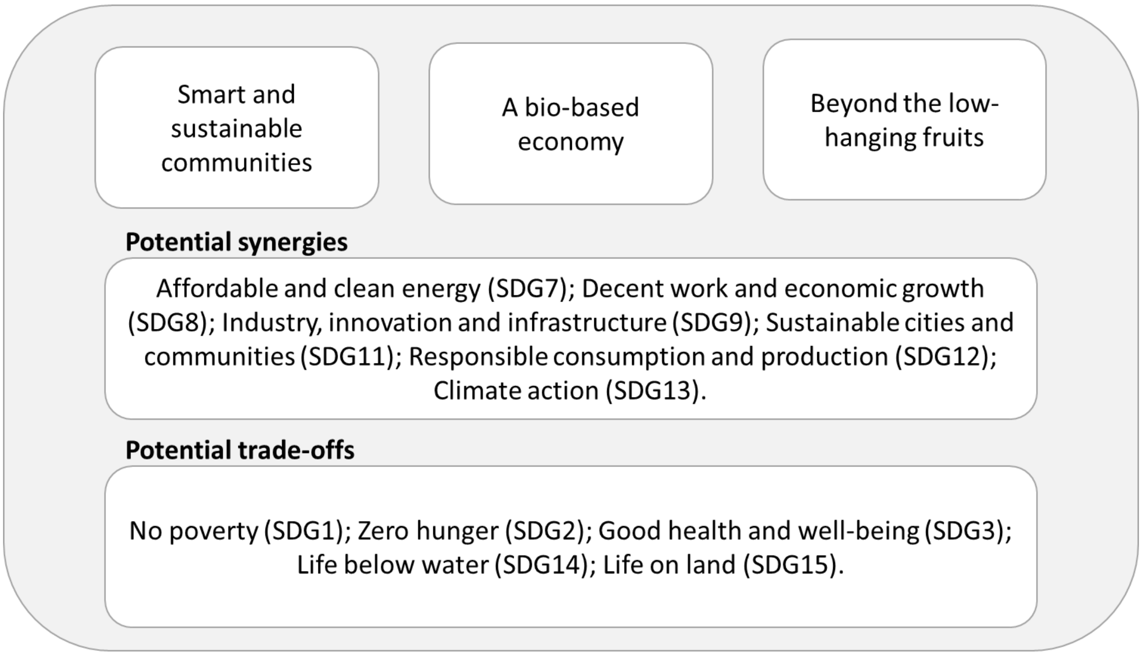

Figure 1. An illustration of the potential synergies and trade-offs between the topics covered in this VSI and different SDGs

2. Smart and sustainable communities

The development of smart and sustainable communities (SDG11), should go hand-in-hand with ensuring affordable housing and services, inclusive and sustainable urbanization, protection of natural and cultural heritage and reducing the adverse impact of urban areas on the environment [53]. The building sector offers significant room for efficiency improvements and untapped area for renewable energy integration. Hence, it can greatly contribute in reducing carbon dioxide emissions. The reason behind this is that the technologies required for reducing energy demand and integrating distributed renewables are well known and have reached market maturity. Hence, spearheading the process at this point, among other things, requires equipping policy makers and engineers with the adequate tools. SDEWES research has addressed some of the challenges related to the assessment of energy efficiency measures and their potential

[54–58], the integration of renewable energy sources in buildings [34,59–62], as well as the utilization of the flexibility which buildings can provide to the energy system [26,63–68].

Part of the papers in this special issue focus on bridging science and application, by developing new tools and techniques that can be used by decision makers and engineers. For instance, Zabala et al. develop a reliable model which can be used alongside a model predictive controller for a district cooling system [69]. It was tested and simulated using Modelica and Python and the results show savings of up to 50% when the model predictive controller is compared to a standard cascade controller. Energy savings are also the focus of Hunt et al. [70]. They evaluate the ability of EN16573:2017 to isolate and quantify the energy efficiency and renewable generation contributions of multifunctional balanced ventilation systems. Their paper assesses systems that integrate air-source heat pumps and ventilation, considering two similar configurations. Moreover, Gatt et al. [71] discuss the cost-optimal method defined in the Energy Performance of Buildings Directive (EPBD). They point out that it is difficult to visualize the effects of the diversity in input parameters on the cost-optimal level benchmarks and to verify the choice of reference buildings, as given in the EPBD. To enhance the EPBD cost-optimal method, they introduce 'Probabilistic Bayesian calibrated reference buildings'. Another tool that could be useful to stakeholders is the PrioritEE toolbox, presented by Salvia et al [72]. The toolbox is intended to be used by local administrations so that they can improve energy efficiency and renewable energy deployment in municipal buildings. In the context of historic urban areas, Egusquiza et al. have assessed the efficiency improvements and the refurbishment solutions for two living labs [73]. More specifically, they analyse eco-rehabilitation strategies of two buildings in Spain and France, taking into account the involvement of multiple stakeholders. As per the 2030 Agenda, improving efficiency has a positive feedback for ensuring decent work and economic growth (SDG8), especially through the actions in the building sector which bring many new domestic jobs.

A specific case study elaborated by Thellufsen et al. [74] illustrates how the municipality of Aalborg can transition to 100% renewable energy. Despite the fact that the paper focuses on a case study, the methodology it introduces can be used by other municipalities for similar analyses. Depending on the local conditions, municipalities will be inclined to use the locally available energy sources. Macenić et al. [75] have constructed a novel geothermal gradient map based on well preserved records of 150 oil and gas exploration wells in the Croatian part of the Pannonian Basin. Other municipalities, such as Samso, Denmark [76] may utilize offshore wind or other renewable energy sources. Advance in offshore wind generation have been evident and research on the topic is moving forward. Pustina et al. [77] introduce a fully coupled aero/hydro/servo-mechanic model for response and control of floating offshore wind turbines in waves that is suitable for preliminary designs. The model was tested on NREL wind turbine [77].

Modern energy services and reduced air pollution contribute to better health and the general well-being of citizens (SDG3). In this special issue, Pigliautile et al. [78] address this point by inviting questions on the role of urban planners in ensuring outdoor thermal comfort and reducing local emissions. In line with this idea is the work of Ozgen et al. [79] which analyses nitrous oxide emissions from domestic heating, thus, broadening previous research that had focused on local emissions of particulate matter [60,80,81].

The second portion of papers of the special issue focus on the wider role of buildings in the energy system and how sustainable cities and communities (SDG11) can enhance its flexibility so as to accommodate greater shares of renewable energy generation (SDG7). To achieve this, however, innovation and enhancement of the energy infrastructure needs to take place, based on both past experiences and new and emerging technologies (SDG9). Gjorgievski et al. review 34 large scale power-to-heat demand response projects, implemented on four continents over a wide time horizon [82]. They find that power-to-heat demand response has been implemented most successfully to deal with capacity limitations on a large scale, by load cycling or load shedding. More recent projects offer reasonable evidence that power-to-heat can also be used for real-time balancing and frequency response, although at a smaller scale and with uncertainty on the effects of the market. Flexibility measures will be required in fossil fuel-based systems [83] and islanded systems which aim to integrate large shares of renewable energy. Groppi et al. review the demand side and storage alternatives which enhance the energy flexibility of islands [84]. Developing on previous research [28–30], this paper investigates flexibility mechanisms which focused on (i) reducing excess electricity generation and (ii) improving the system's hosting capacity for variable renewables. The value of the demand side and energy sector coupling is also demonstrated by Dorotić et al. [87] which analyse the impact of power-to-heat for enhancing wind integration under market conditions. The paper essentially uses a district heating optimization model to explore how different heating supply technologies operate under market conditions. It concludes that heat pump capacities linearly follow the wind penetration in the system. At lower voltage levels, end-consumers can also play a similar role, by following price signals to reschedule deferrable loads. Schellenberg et al. investigate the prediction accuracy, run-time, and reliability of several metaheuristic optimisation problems used to optimally perform demand side management given different price signals [88]. Their findings could be useful for guiding future research, as it informs that Genetic Algorithms (GA) and Particle Swarm Optimization (PSO) outperformed Simulated Annealing and Direct (Pattern) Search for the given purpose. Furthermore, the paper points out that GA with binary variables was 5-15 times more effective when compared to a case when continuous variables were used.

Moving towards the realization of the Sustainable Development Goals related to energy and climate change will require stimulating participation of end-consumers and keeping the less financially able on board. With this in mind, subsidies need to be designed to aid lower-income households, as noted by Lekavičius et al. [89]. Although their paper observes the support system for renewable energy in the Lithuanian households, the results transcend these boundaries and are more generally applicable. The paper employs a microsimulation model to find that financial support, despite being efficient in terms of energy, is most beneficial for households with higher income and can therefore increase inequality. This could lead to an increase of energy poverty [90] or adverse effects on energy prices [91]. Policy decisions related to measures on the demand side should therefore weigh in on the opportunities for meeting national energy targets and opportunities for job creation, but should also consider the potential trade-offs related to poverty (SDG1) and ensuring health and wellbeing of citizens (SDG3).

3. A biobased economy

Having the basic building blocks for materials, chemicals and energy from renewable biological resources is the basis of the bioeconomy [92]. The SDEWES works on biobased solutions cover the bio-technology vision, the bio-resource vision and the bio-ecology vision of the bioeconomy acknowledged by Bugge et al. [93]. Taking steps to implement these visions should ensure a sustainable energy system (SDG7) based on a responsible management of the local resources (SDG12), while not hindering life below water (SDG14) or on land (SDG15).

Three innovative distillation schemes for large-scale sugarcane-ethanol biorefineries have been presented by Milão et al. in this special issue [94]. Their work adds to the knowledge related to the bio-technology vision and builds on previous works dealing with improved sustainability of biorefineries presented at SDEWES [95,96]. The comparison is aimed at exploring a less energy-intense process which has a higher thermodynamic efficiencies and steam savings. The findings of [94] show that approach based on the innovative Petlyuk column for bioethanol distillation outperformed the other two approaches, achieving the highest thermodynamic efficiency of 11.1%, while the other two approaches achieved efficiencies of 7.65% and 7.03%, respectively.

Biomass has been considered as a substitute fuel for coal in power plants. The technical differences of coal and biomass, however, require changes with regards to the boiler design. On that note, Zabrodiec et al. [97] have analysed the results from an experimental study conducted on a series of 40 kW_{th} aerodynamically stabilized pulverized biomass flames compared with coal flames. Within the 2030 Agenda framework, one should note the potential trade-offs related to the use of non-waste biomass instead of coal for electricity generation. For example, large-scale biomass cultivation for energy purposes may counter the efforts for reducing hunger (SDG2) by taking up land that can be used for agriculture. In the case of monocultures and extensive fertilizer use, it can also result in soil degradation (SDG15) and reduce the ability of the soil to effectively act as a sink for carbon dioxide (SDG13).

On that note, the bio-ecology vision highlights sustainability through bioderversity, avoiding monocultures and soil degradation, as it can significantly affect the fluxes of carbon dioxide [98]. This vision requires a sustainable management of the bioenergy resources. As stated by Knápek et al [99], 'the potential of biomass from agriculture land cannot be seen as a constant value over time'. For this reason, their paper attempts a dynamic evaluation of the available biomass which can be obtained from agriculture. Its most notable finding is that allocating 20% of the arable land to be used for energy crops would increase the national biomass potential by 35%. On a time horizon of 2040, this would result in 35 PJ and 42 PJ, given that the analysis is performed with and without a learning curve effects consideration, respectively.

The bio-resource vision of the bioeconomy covers raw material processing and value streams. Contributing to a better understanding of this topic is the work presented of Seljak et al., presented in this issue [100]. It provides a valuable link between the past efforts of utilizing bio-based resources for power generation and the recent circular vision of the future, which will require a realistic exploitation of these resources. The circular vision is captured by the Sustainable Development Goal on responsible consumption and production (SDG12), which specifically targets the sustainable management and efficient use of natural resources. Seljak et al. note that the two concepts can merge by swapping the existing bioenergy feedstock with a waste stream. Doing so, could also improve the economic viability of biocrude production, since there are negative costs associated with the use of waste biomass [100]. The findings of Poblete et al. [101] confirm this notion after evaluating the biogas chain from waste-to-bioenergy, using models for dynamic simulation of biogas processing, bioenergy generation, and carbon capture. Their findings show that bioenergy storage with negative carbon emissions is feasible for small-scale biogas-fired combined-cycle plants.

4. Beyond the low-hanging fruits

Decarbonizing some sectors, such as buildings and electricity generation, will be fairly easier to achieve than decarbonizing others, such as transport, heating and heavy industries. This is because the challenges related to the maturity and the availability of the technologies at hand are greater for the latter sectors. Renewables, energy efficiency and electrification are projected to reduce the global emissions by 94% in 2050 [102]. However, the substitution of fossil fuels with alternative fuels poses significant challenges for those sectors which cannot be electrified and point to the urgent need for research and development in the area (SDG9).

For this special issue, Stanćic et at. [103] provide a comprehensive review of the alternative fuels and their applications for energy generation and transport. They cover hydrogen, ammonia, biodiesel, methanol, ethanol, dimethyl ether, biomass and non-recyclable waste. The review goes over the production pathways of these alternative fuels and discusses the advantages and drawbacks, aiming to find their most suitable roles. Some of these alternative fuels are discussed in further detail by other authors. For instance, Carminati et al. discuss natural gas reforming as a promising technology that transforms fossil natural gas to hydrogen [104]. They present a low-emission gas-to-wire facility integrating natural autothermal reforming to hydrogen combined-cycle (ATR-GTW). Ammonia production, on the other hand, is covered in [105]. Although it is most widely used as a fertilizer, the ammonia market is expanding since there is increasing interest in its application as a carbon-free energy carrier. Chisalita et al. [105] evaluate the European ammonia production considering various hydrogen supply chains. They conduct a cradle-to-gate environmental assessment of hydrogen production routes with ammonia synthesis based on the ReCIPe impact assessment method. The results illustrate that the Global Warming Potential is mostly reduced when natural gas-based ammonia synthesis integrated with chemical looping hydrogen production is used. At the same time, this approach has potential trade-offs with six out of the nine investigated impact indicators (excluding Global Warming Potential), as they are increased between 30% and 60%. Achieving efficient heat transfer and energy conversion is increasingly important. Heat flux equipment, as can be found in nuclear reactors, heat exchangers, spacecraft avionics and electronic devices largely depends on efficient pool boiling heat transfer. Li et al. offer a comprehensive review of passive and active surface modification on pool boiling enhancement [106]. The review offers a timely overview on the topic and points to the challenges found in recent studies.

The learning curves of the new technologies being deployed to tackle climate change are influenced by many factors. How learning effects are obtained and used, and how they should be used is the focus of Thomassen et al. [107]. In this paper, the authors reviews the use of learning effects on technology sectors ranging from solar, wind, hydro, bioenergy and biorefineries, chemical, carbon capture, fuel cell and batteries and others. Based on this review, they offer five recommendations which could provide a better understanding of the costs and impacts of the new technologies and what it takes to compare them with conventional technologies on a fairer ground.

The challenges for achieving the Sustainable Development Goals are not only related to fuels and energy generation. They also require sustainable management of waste and avoiding other ‘greenwashing’. Solar PV panels, for example, have an estimated lifetime of 25 years. As the annual capacity additions of solar PV are expected to double by 2050 [102], questions should be raised whether dedicated capacities for solar PV recycling are being developed at a sufficient rate [108]. If this is not the case, continuing forward without resolving the issue could adversely affect the goals for responsible consumption and production (SDG12) and could have negative consequences due to water (SDG14) and land (SDG15) pollution.

In this special issue, Salim et al. [109] argue that failing to build effective end-of-life management systems for residential PV and battery systems will result in the disposal of valuable and hazardous materials in landfills, or that they will be stockpiled or illegally dumped. They come to this conclusion from a system dynamics perspective and identify three subsystems which were validated through two stakeholder workshops. These subsystems, mutually interlinked with each other, focus on (i) the waste flows, (ii) the regulatory aspects and (iii) industry strategies and government incentives, respectively. The paper highlights that governments will play a key role in introducing and monitoring regulations. A similar approach was also applied by Schlör et al. [110]. As presented in this issue, they approximate the food-energy-water nexus by using a system thinking approach and investigate if and how nexus research incorporates a systems thinking perspective, as stipulated by Donella Meadows. The test that they developed was used to analyse nexus papers from the 2017 SDEWES Conference in Dubrovnik.

Any SDG assessment, regardless of the entity which conducts it, should be framed so that 'cherry-picking' and 'greenwashing' are discouraged. Johnsson et al. [111] have provided an overview of existing SDG assessment tools and have proposed a framework which allows the assessment of SDGs to be conducted robustly. The framework has been applied on a case study of the construction sector and SDG13. It leads to the conclusion that (i) the introduction of biofuels for transportation in the construction sector, (ii) the electrification of transport and industrial processes, (iii) the substitution as part of the transition away from fossil fuels and (iv) the use of carbon capture and storage in the production of cement and steel have issues that are difficult to overcome. In the concluding remarks of the paper, the authors go on to propose that the SDG assessment of any business should be well in line with the Paris Agreement and should clearly address the entire value chain from a carbon emission point of view. If conducted objectively and timely, it should enable businesses to navigate through the sustainability challenges of the future and avoid making panic-driven decisions that could result in sub-optimal solutions.

5. Conclusion

The SDEWES conferences continue to be an important gathering for researchers that are interested in cross-cutting and holistic sustainable solutions. The diversity of covered topics exposed the 2019 SDEWES Conference participants to a vast pool of ideas and concepts from researchers with wide-ranging expertise. The merging of these different fields should allow for the key synergies and trade-offs to be identified and inform the ways of moving forward with the optimal solutions. This VSI equally addresses the sectors which can be made more sustainable using the readily available technologies and measures and the sectors which require additional fundamental research and industry developments. It notes that pursuing sustainability will require going beyond large deployments of wind and solar energy, and more towards thinking of ways to further reduce energy demand, find suitable alternatives for fossil fuels, harvest the biosphere sustainably and deal with the challenges that arise after the life-cycle of the shorter-lived renewable energy infrastructure. These are not minor challenges and are ones that require to be closely studied if humanity is to succeed in achieving the goals of the 2030 Agenda for Sustainable Development.

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