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ABSTRACT

The Journal of Sustainable Development of Energy, Water and Environment Systems (JSDEWES) is an international journal dedicated to the improvement and dissemination of knowledge on methods, policies and technologies for increasing the sustainability of development by de-coupling growth from natural resources and replacing them with knowledge based economy, taking into account its economic, environmental and social pillars, as well as methods for assessing and measuring sustainability of development, regarding energy, transport, water, environment and food production systems and their many combinations. In total 48 manuscripts were published in Volume XI, all of them reviewed by at least two reviewers. The Journal of Sustainable Development of Energy, Water and Environment Systems would like to thank reviewers for their contribution to the quality of the published manuscripts.

KEYWORDS

Editorial, Renewable Energy Solutions, Heating Sector, Water-Energy Nexus, Bioenergy and Waste, Smart and Sustainable Future.

INTRODUCTION

This editorial discusses the contributions of the papers belonging to Volume XI of the The Journal of Sustainable Development of Energy, Water and Environment Systems (JSDEWES), an international journal dedicated to the improvement and dissemination of knowledge on methods, policies and technologies for increasing the sustainability of development by de-coupling growth from natural resources and replacing them with knowledge based economy, taking into account its economic, environmental and social pillars, as well as methods for assessing and measuring sustainability of development, regarding energy, transport, water, environment and food production systems and their many combinations.

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RENEWABLE ENERGY SOLUTIONS

The availability of energy can be seen as the basis of general development, especially renewable energy, which can ensure sustainability and a fair transition from today's conventional energy systems [1]. As expected, new methodologies for the design of a sustainable energy future and the transition to 100% renewable energy are developed with a combination of technological, economic, and social changes [2]. However, climate change can reduce the power production of installed renewable capacities, differently affecting places across Europe and various energy system configurations [3]. To address future uncertainties, Sharma [4] analyzed the energy security of renewable energy sources using the Renewable Energy Security Index, which is based on six dimensions: availability, accessibility, affordability, acceptability, energy intensity, and structural change through their associated indicators and computed by deploying principal component analysis. Indicators were normalized and plotted to observe trends and patterns for all dimensions, and the analysis was conducted on a case study of Norway from 2000 to 2017. The results indicate energy insecurity of renewable energy sources in the beginning, then gradually improving to become positive until 2010. Accessibility, availability and affordability of renewable energy highly improve energy security, in relation to investment cost and their levelized prices of electricity. At last, it is shown the most prominent drivers of energy transition are renewable energy investments together with research and development, while environmental concerns do not significantly contribute to the Index. The introduction of renewable energy can also lead to a high percentage, self-sufficient energy communities on small off-grid islands with significant economic savings, increased energy independence and achieving climate neutrality [5]. Nevertheless, the development of renewable energy still encounters resistance and a lack of social acceptance [6], but it is noted that sustainable development in the form of renewable energy sources can lead to innovation, employment and economic growth [7]. To deal with social uncertainty, Tourinho et al. [8] proposed the employment-weighted fair wage potential, a new social indicator for the power sector, relating electricity production technologies to social data. The study conducted a social life cycle assessment of 10 power generation technologies, namely, gas, oil, coal, nuclear, hydroelectric, solar, wind, geothermal, biomass, and waste-to-energy, considering their employment-weighted fair wage potential. Fair wage potential includes the actual wage paid at each process step, compared to a minimum living wage in relation to effective working time, while employment is determined as the sum of direct jobs. As a result, employment-weighted fair wage potential is calculated by relating the fair wage potential with the number of jobs estimated in each life cycle stage. The calculations show fair wage potential based on operation and maintenance stages is the lowest for photovoltaics, 1.32, while it is highest for gas- and oil-based technologies with 3.55 and 3.51, respectively. As for employment-weighted fair wage potential, run-of-river has the fairest wage potential of 3.33, while solar photovoltaics technology has the lowest value of 1.16.

On the other hand, one of the biggest technical challenges for the integration of renewable energy sources is the disbalance between energy demand and the intermittent character of renewables. A well-designed hybrid system of wind and solar energy could prevent storage, peak loads, and energy transport capacity concerns through time supply side energy management [9] and be used for the generation of renewable power, heat, and synthetic natural gas [10]. Hybrid renewable systems can also achieve a more stable profile of overall power production by integrated photovoltaic panels, small-scale wind turbines and double-stage heat pumps for building purposes [11]. To boost renewable systems, Halimatussadiah et al. [12] investigated the impact of fiscal incentives on the feasibility of solar photovoltaic and wind electricity generation projects. The study used a financial discounted cash flow model to simulate the feasibility under different scenarios. The scenarios include policy interventions such as different tax incentives, namely tax holiday, tax allowance and reduction of VAT, and subsidy schemes including cost of fund subsidy, feasibility study expense subsidy and land

acquisition support. The research included 66 solar PV and wind power plant projects across Indonesia. Results show, that each intervention derives a different level of price change but tax reduction policy, specifically the tax holidays and allowance, generates significantly lower electricity prices than subsidy incentives. Additionally, tax allowance results in higher price change followed by tax holiday and value-added tax reduction. From a technology point of view, solar prices are averagely more sensitive to fiscal interventions than wind prices and should be considered as they are essential to promote investment and reduce initial risks. Thus, to maximize the solar potential, it is important to adequately choose solar production technology for different radiation conditions as can be seen in the example of two solar organic rankine circle plant configurations with different energy production regarding location and radiation conditions [13]. Therefore, El Alani et al. [14] investigated the impact of aerosols on global and direct irradiance attenuation under clear sky conditions. The study used aerosol optical depth (AOD), a parameter representing the degree to which aerosols inhibit light transmission through scattering and absorption phenomena. For evaluation, data from a satellite database was used and validated through high-performance meteorological stations installed at two sites in Morocco, and the aerosols were categorized in five groups to determine the dominant types in each location. The results of the study show that aerosols have a significant impact on solar irradiance attenuation under clear sky conditions. For the global horizontal irradiance, the attenuation relative to the global irradiance at the top of the atmosphere is 24% for AOD values of 0.02 and exceeds 53% for AOD of 0.6. For the direct normal irradiance, the attenuation is even more significant, with a decrease of 66% for AOD of 0.2 and 92% for AOD of 0.6. The study also finds that the impact of aerosols on solar irradiance is more pronounced in the summer months, when AOD values are typically higher. Hence, aerosols are an important factor to consider when evaluating solar potential, as various sources of contamination, meteorological conditions and relative air humidity can influence concentrations of water-soluble ions in particulate matter [15]. In the same context, Shariah and Al-Ibrahim [16] investigated the impact of dust and shade on solar panel efficiency. The study developed a simple method for estimating pollution losses that involves measuring the power output of a solar panel in two conditions: with dust and without dust, where the difference in power output between the two conditions is used to calculate the impact on solar panel efficiency. The scenario analysis was made for Jordan, which is highly susceptible to dust storms, with the use of three similar prototype modules measuring the current, voltage, ambient temperature, solar module temperature, solar irradiance, density, and output power under different environmental variables. The results indicate hard shadowing and dust accumulation have a significant effect on photovoltaic modules performance depending on periods of dust accumulation, but module temperature is not significantly impacted. In conclusion, it is shown dust induced reductions in radiation intensity are qualitatively equal to reductions in solar module output power.

To further analyze solar potential and higher efficiency of solar energy systems, comparison of fixed and tracking photovoltaic systems was made, showing tracking system can be half of the size of the fixed one due to balanced energy production, but the sizing of the system configuration highly depends on whether yearly or monthly balance is considered [17]. Also, it is shown that photovoltaic tracking systems are more environmentally friendly, with lower greenhouse gas emissions, land use, and water consumption [18]. Therefore, tracking solutions are being implemented to determine the optimal position of solar panels or mirrors. One of the solutions is the use of latent heat thermal energy storage device for solar tracking purposes through phase change material storage media [19]. Likewise, Pulungan et al. [20] investigated the possibility of using variable mass system and a torsion spring for low-speed orientation to control a solar panel. The study proposed a semi-active water control system to actively adjust the orientation of a solar panel to optimize the tilt angle with respect to the sun. The variable mass system consists of pipe-connected water reservoirs attached on the sides of the solar panel, where water mass is moved from the left to the right side of the panel using electric

pump and a solenoid valve is used for flow direction control. The design was tested in the city of Padang, Indonesia, on total of five positions changing every two hours. Seven different parameters were tracked to evaluate the water flow effect regarding orientation angle, and the test results determined less than 10% difference between the experimental and simulation results. The system had higher generated power by 21.56%, energy demand for water pump was only 0.79% compared to the fixed system and external disturbances did not have an effect to orientation of the solar panel. Higher photovoltaic conversion efficiency can also be ensured with the cooling of photovoltaic panels. An U-tube radiator can be used for cooling with water-glycol liquid mixture, where obtained waste heat may be utilized for domestic hot water preheating or heat pump system applications [21]. A cooling system based on water droplet evaporation in a chimney-like channel attached to the back side of a photovoltaic module, can also be used to decrease cell temperature [22]. In the same line, Sornek et al. [23] have developed and tested water-cooling system to improve performance of photovoltaic panels. The prototype was developed in Krakow and tested under laboratory and real conditions. In the proposed model, solar cells are cooled down by sprinkling water-glycol mixture, while absorbed heat is transferred to the domestic fresh water through heat exchanger. Additionally, system can use rainwater, so it does not require freshwater. The economic analysis includes investment costs of the cooling system and the estimated increase in electricity generation performance. PV panels would cover the energy required by the cooling pump, cooler, and controller, and the cost of water is neglected as it would be rainwater. The use of proposed direct water-cooling system resulted in an increased efficiency of photovoltaic panel by 1.2 - 13.0%, while the average energy production was higher by 10.3%. The payback time for installing the cooling system in typical domestic photovoltaic systems is less than ten years, and the net present value ranges from -60.7 to 178.6 EUR for a ten-year period. Additionally, solar energy can also be used for cooling purposes with a hybrid solar cooling system, consisting of thermal and an electric element integrated in a single unit with the dry-cooler, and accompanied by simplified sizing tool for different configurations and climates [24]. Furthermore, for heating, cooling and power demand, a photovoltaic-thermal based system can achieve higher environmental benefits but also a higher payback time in comparison with separated heating, cooling, and electricity production [25]. Solar energy can also be used for cooling through thermal driven absorption, adsorption refrigeration systems, desiccant cooling absorption or conventional refrigeration to reduce the primary energy consumption [26]. Amaris et al. [27] analyzed the energy and exergy performance of a small-capacity solar refrigerator using refrigerants such as R600a, R290, and R717 in comparison with R134a for solar refrigeration applications. A thermodynamic model was developed to assess a 200 W refrigerator performance, while considering the environmental conditions in the city of Barranquilla. Performance was analyzed regarding different evaporation and condensation temperatures, and internal heat exchanger effectiveness. The results show system coefficient of performance could be higher by 2.6% for R290 and 2.7% for R600a in comparison with R134a, while R717 system was unsuitable due to high compressor discharge temperature. The internal heat exchanger was found beneficial for reducing exergy destruction in the compressor and expansion valve but increasing it in the condenser. The study also found maximum power consumption and recommended internal heat exchanger effectiveness is at evaporation temperatures of -32 °C and -10 °C. Furthermore, solar energy can also be used in the desalination process. Hybrid biomass-solar systems can provide cost-effective improvements, avoiding fuel cost and producing fresh water in a desalination unit using waste heat from the power cycle [28]. Also, from wind or solar desalination system comparison, it is shown photovoltaic system can generate water at lower levelized energy cost [29], and an introduction of water storage basin allows avoiding electric storage systems allowing stable water production and maximizing the water self-consumption in reverse osmosis photovoltaic unit for freshwater production [30]. In the same line, Maftouh et al. [31] reviewed the current applications and future potential of solar desalination in the Middle East and North Africa

region, one of the most water-scarce regions in the world where desalination is a key technology for meeting the region's water needs. The authors emphasized the critical aspects for sustainable desalination plants are available resources, economic viability, and environmental feasibility. They also recognized the main barriers for solar PV desalination acceptance, which are lack of financial and informational resources, subsidies for conventional power and water sector and old bureaucratic structure. Additionally, the two main impacts of desalination plants on the environment are marine and soil pollution by brine rejection and air pollution by greenhouse gas emissions from the plants' energy systems. The authors proposed the plant should incorporate brine disposal methods and solar desalination plants with zero carbon emissions to reduce the environmental hazard from desalination plant. Therefore, it is essential to raise awareness for investors, introduce of renewable technologies subsidies and encourage independent water producers to overcome the challenges of solar desalination technology in Africa region.

For transition from fossil fuels, geothermal potential can also be used as a renewable energy source. It can be integrated into local energy sector, covering heating and cooling demand and recovering process heat by replacing traditional utility systems heated by natural gas [32]. On a country level, there is an increased initiative to identify good potential sites for deep geothermal energy exploration and exploitation [33]. Therefore, for further implementation, new precise geothermal gradient maps are necessary along with temperature depth maps to define local potential sites for direct heat utilization and electricity production [34]. For the same purpose, García Reynaud et al. [35] presented a new method for mapping the occurrence probability of geothermal manifestations at a national scale. The method uses a machine learning algorithm to predict the likelihood of geothermal potential based on surface manifestations according to various predictors, such as distribution of volcanoes, geological formations, faults, aquifers, and surface temperature. The case study was made on 177 surface manifestations in Honduras. For the analysis, five geographic information layers were disaggregated into 23 environmental variables and processed in geographic information system. Derived probability map was evaluated whether sites indicating the presence of geothermal manifestations, which were not used for model training, are geographically located in the areas with the highest calculated probability of occurrence. As a result, a map with an adequate prediction was generated, showing a significant prevalence of surface with high occurrence of geothermal manifestations, where proximity to volcanoes is the variable with highest impact. Likewise, geothermal energy can be used in polygeneration systems with solar and biomass energy for producing power, heating and cooling, while achieving high energy and environmental performance but with significant payback period [36]. Energy from the natural temperature difference between the soil surface and soil depth can also be utilized by thermoelectric generators as it is shown by Jada'an et al. [37]. The study compared power generation from four different thermoelectric generator scenarios using ANSYS simulation tool and considering three factors: heat pipe material, the existence of fins (at heat source and heat sink), and the surface area of fins. Gravity-assisted heat pipe filled with water was employed for this purpose and the module was buried in the soil at the depth of 40 cm. Weather conditions were used for the city of Irbid in the far north of Jordan, where the earth's surface temperature is 25.32°C and 30.86°C at the 30 cm below the Earth’s surface. Results showed that the generated power in the first scenario was 169.68 microwatts, increasing by 2.17, 4.7, and 5.85 times in the second, third, and fourth scenarios, respectively. Therefore, it is shown a thermoelectric systems can be used as renewable energy source for low-power applications especially in remote areas far from the power grid, but there is still a need to improve low conversion efficiencies of thermoelectric modules. Additionally, magnetic field can be also used to enhance power production by stabilizing flow behavior and thermal performance of various ferrofluids. Therefore, magnet layouts are analyzed to assess thermal performance and flow characteristics of ferrofluids in plate heat exchanger leading to reduction of resistance loss [38]. For the performance of a self-evaporating magneto-hydro-dynamic system, Alza'areer et

al. [39] investigated the effect of an annular ejector where electric power generation is achieved by an electrically conductive fluid flowing through a duct subjected to a magnetic field of appropriate strength. The authors conducted parametric study using regarding variations in annular ejector geometry, input heating power, and the mass fraction of the ejector flow. In total, five different cases and four geometrical parameters are taken for the design operation. An optimal solution was found, for which more detailed analyses were carried out for assumed maximum value of power density. Simulated two-dimensional single-loop liquid metal magnetohydrodynamic system driven by a circumferential annular ejector was proved feasible. In conclusion, for an optimized study case, the circumferential annular ejector increased the output power by 8.7 % more than the central axial ejector. Although renewable energy is topic of various research, natural gas is still one of the most important energy sources in Europe, as it accounts for significant part of gross inland consumption. It is becoming more commercially sensitive, and the accurate forecast of natural gas consumption is required to avoid differences between actual gas consumption and reserved gas volumes and transmission system capacity [40]. However, possibilities of implementation and pipeline transmission of hydrogen, hydrogen addition to the natural gas transmission system, and analysis of methane–hydrogen mixtures are also investigated and are expected to evolve in real applications [41]. During transportation of natural gas by pipelines, gas stream pressure is reduced, resulting in exergy losses depending on the thermodynamic parameters of the natural gas stream on inlet and outlet gas pressure regulation and metering stations. With the implementation of the pressure regulator, recovered energy can be used for electricity production, thus increasing economic efficiency [42]. To ensure the correct operation of the system, the natural gas stream should be heated on inlet to expander. Consequently, Cheli et al. [43] investigated the feasibility of integrating renewable energy systems at city gate stations to reduce pre-heating gas consumption. This study conducted technical and economic feasibility analysis of energy savings through simplified model of heat pumps and renewables system. The authors used experimental data from real plant in Italy, to develop ad-hoc thermodynamic model for estimating the pre-heating thermal energy demand. The results show the developed model can successfully estimate needed thermal energy and compared to the conventional systems, the proposed one could save up to 3 tonnes of CO_2 equivalent from unburned natural gas per year. For the considered case study, up to 38%, 32%, or 26% of the total thermal energy can be recovered with a payback time of less than 20 years, 15, and about 13 years respectively, regarding different photovoltaic system size.

HEATING SECTOR

As buildings are responsible for approximately 40% of European Union energy consumption and 36% of energy-related greenhouse gas emissions, they represent the single largest energy consumer in Europe [44]. Currently, around 35% of the European building stock is over 50 years old, and almost 75% is energy inefficient, but only about 1% of the buildings are being renovated each year [45]. On the other hand, there is also an expectation to achieve a certain standard of thermal comfort. New solutions, such as zoned algorithm-controlled system showed more efficient thermal energy distribution to each zone, satisfying thermal comfort and decreasing energy consumption [46]. Thermal performance was also evaluated in the case of natural ventilation of a roof cavity with insulated sub-tile panels on the thermal environment of a dwelling house under Mediterranean summer conditions [47]. To evaluate the thermal comfort, Dębska et al. [48] presented a study on the thermal and humidity perception of occupants in educational buildings in Eastern European climate conditions. The study was conducted in Kielce, Poland, on four educational buildings of which one is energy self–sufficient and involved a total of 222 participants. For the analysis, two measurement methods were used, an indirect one related to the use of a measuring meter, and a direct one related to questionnaires. The authors analyzed the correlation between thermal sensations, preferences, thermal acceptability, and internal temperature. From the measurements, air

temperature ranged from 20°C - 27.5°C and humidity from 18.16% - 50.9%. A little more than 60% of the students rated the humidity as pleasant, and 32% would prefer it to be more humid. Furthermore, thermal comfort was confirmed by 69% of the students, while 31% rated their feeling as uncomfortable. But in the overall assessment, the buildings created good conditions for thermal comfort. Therefore, to ensure thermal comfort and reach the goal of fully decarbonized energy systems, advanced district heating systems are a promising heat supply solution [49]. Accordingly, to assess energy, environmental and economic performance of standard and innovative district heating and cooling systems, a dynamic simulation model was developed [50], and to optimize district heating technology supply capacities and their operation, a minimization of total cost, carbon dioxide emissions and exergy destruction should be made [51]. With the same aim, Pietro et al. [52] proposed a thermodynamic-based method for supporting the design and operation of thermal grids in the presence of distributed energy producers. The Exergy Cost Theory was proposed to quantify exergetic cost of heat by effects of thermodynamic inefficiencies occurring in the production and distribution, compare alternative systems for heat production and monitor the performance of buildings' substation over time. The case study was performed for Sicily on a cluster of five buildings in the tertiary sectors, with a centralized fossil-fueled combined heat and electricity production as the base case, and three alternative scenarios characterized by the presence of waste heat from an industrial process and prosumers. The results suggest that the developed method could be used to identify heat production process parts that highly contribute to lowering the thermodynamic efficiency, thus leading to high operating costs. From scenario analysis, unit cost of heat can be decreased by almost 30% thanks to the improvement of thermodynamic efficiency by moving from the centralized production of heat based on fossil fuels, to a decentralized production with air-to-water heat pumps. Furthermore, for the district heating supply, combination of different heat pump heat sources can achieve a maximum system performance while having a positive impact regarding exploitation of locally available variable renewable energy sources [53], but still lacks in economic justification of significant overcapacity and heat storage for flexibility [54]. However, future renewable based heating systems should take into account heating and cooling demands, and renewable production are influenced by changes under current and future climate scenarios [55]. Hence, Baglivio et al. [56] presented numerical analysis of the air-source heat pumps performance under three climate change scenarios namely, RCP2.6 scenario representing a moderate increase in greenhouse gas emissions, RCP4.5 representing an intermediate increase in greenhouse gas emissions and RCP8.5 representing a high increase in greenhouse gas emissions. Heat pump performance was examined by calculating the seasonal coefficient of performance and seasonal energy efficiency ratio. The study was conducted on two locations, Yakutsk in Russia and Damascus in Syria, characterized by extremely different climates. The study found climate change will shorten the winter period and prolong the summer, resulting in a slight softening of the seasonal coefficient of performance and a reduction in operating hours in winter. In summer, there is a slight increase in seasonal energy efficiency ratio values and hours of operation in summer. Over the years, there is an overheating leading to less wide frequency distributions for winter temperatures and wider for summer temperatures, thus reducing the hours of operation of the heat pump for heating. Authors concluded the use of air-source heat pumps will increase for systems in cold climates and reduce in areas that are too warm and will become even warmer in the future.

Additionally, industrial heating sector was also investigated with the request of increased energy efficiency and decarbonization, where reductions of energy demand, costs and CO_2 emissions can be achieved with integrated thermal energy storage in industrial processes [57]. With cost optimal operation of supply, conversion and thermal storage, flexibility of the energy-intensive industries can also be achieved [58]. Similarly, the potential of energy efficiency and flexibility measures to reduce energy consumption and emissions was investigated by Knorr et al. [59] by electrification of process heat generation in the animal feed

industry. The simulations were performed using pinch analysis and mixed integer linear programming optimization, while economical potential od electrification measures were evaluated under different energy efficiency and flexibility challenges in comparison to the reference natural gas-fired boiler system. The energy efficiency option is represented through heat pump, and flexibility option is simulated by electrode boiler in combination with a thermal storage tank. The results show electrification measures are more economical intensive than the gas reference case, with costs increase between 26% and 176%, with electric boiler being the most expensive option. However, the hybrid option, combining efficiency and flexibility, can reduce the size of the heat pump and benefit from flexible prices. Electrification also leads to high environmental benefits, again hybrid being the best option with 39.9% reduction of emissions compared to the natural gas if the prices are sufficiently correlated with the emission factor of the electricity mix. In conclusion, with the future lower electricity-to-gas price ratio and decreasing investment costs, implementation of those solutions can become economically competitive. As can be seen from above, the fossil fuels greatly influence production costs and the environment aspect in industrial processes, so the new renewable solar thermal industrial applications should be investigated [60]. Further solutions, such as microwave multi-frequency heating was designed and optimized for chemical recycling of plastics [61] as well as a design of heat capturing device of radiant waste heat in the steel making process [62]. Also, Pfeifer et al. [63] analyzed the feasibility of using inductive heating for sustainable press hardening processes, investigating the ecological and economic advantages of induction as an alternative heating method. As an input data, specific energy demands depending on good-mass flow for induction and furnace heating are determined, while inductive heating cost and emissions are compared to conventional gas-fired roller-hearth furnaces for different parameter sets of boundary conditions. The results show for a scenario with 0% standby time, induction heating can save up to 12% of energy compared to furnace heating, further increasing with standby times. Additionally, greenhouse gas emissions reduction could vary between 8% and 20%, and even more in the countries with high share of renewables. The economic feasibility depends on the electricity-to-gas price ratio, meaning countries with a low ratio will profit earlier from implementing induction heating for press hardening processes, indicating the need for competitive electricity-to-gas price ratio to encourage the use of alternative heating methods. Furthermore, use of industrial waste heat increases primary energy efficiency, but the profitability of waste heat integration should be carefully calculated [64]. For that purpose, a number of optimization methods were developed for integration of an organic rankine cycle with low-temperature industrial waste heat supply [65]. A multi-objective optimization model has also been developed to act as decision support tool to identify the most viable solution of district heating network based on waste heat recovery from an industrial facility [66]. On the same line, Alshehhi et al. [67] assessed the potential for waste heat recovery in the steel industry. The steel industry is a major energy consumer, and it produces a significant amount of waste heat rejected from industrial processes, but it can be recovered and used to generate electricity or to provide heat for other processes. The authors investigated the use of high temperature concrete as a means for heat transfer and storage, estimating the heat recovery potential and overall energy efficiency improvement of the process. The analysis consists of mapping the material, energy requirements and CO_2 emissions of current steel production method, investigation and evaluation of waste heat options, and determination of most efficient one based on obtained electric arc furnace off-gas temperature and flow rate profiles. The results show using an oil loop, a 24% of power in the off-gas can be recovered and used to generate electricity**,** and 27% in thermal energy storage coupled with organic rankine cycle. Eventually, these recovery percentages can offset around 11.9% to 13.4% of the electric energy supplied to electric arc furnace in the observed plant. Waste heat can be utilized not just in industry. It is shown, coupling heat recovery ventilation units with an air-to-air heat can achieve great exergy-based coefficient of performance [68]. For that purpose, rotary heat recovery device incorporated with a natural ventilation windcatcher was developed to redistribute the

incoming air enhanced with recovered thermal energy from exhausted air [69]. Similarly, Valdivia et al. [70] presented an energy analysis for hot water production system in a hotel facility, using waste heat in a centralized air conditioning system. The authors proposed a thermodynamic model of a central air-cooled chiller system with condensation heat recovery for domestic hot water production, together with backup devices for water heating and thermal storage tanks. The case study hotel facility is located in Cuba and has two different chillers capacities for recovering condensed heat through a heat exchanger at the compression process outlet. For the analysis, typical day in November with usually lower ambient temperature and more than 90% occupancy was chosen. Additionally, measurements of hot water supply and return flow were made to determine thermal demand. The results show that the system's current operation has insufficiencies with maintaining a constant hot water supply temperature. Comparing the current system with a heat recovery chiller and auxiliary heating, an energy saving of 35,970 USD/year and lower emitted emissions by 253.4 t CO_2/year is achieved compared to a traditional water heating system. However, it is shown that proposed recovery system is not enough at times of high peak consumption, so it is necessary to further investigate operating strategies.

WATER-ENERGY NEXUS

Following increasing urbanization, and environmental and economic concerns, management of urban water systems including water supply, wastewater treatment and stormwater management is in need for integrated approach to deal with decision-making challenges in urban systems [71]. Achieving positive energy districts can be done in urban water fronts combining strategic planning for project management and implementing procedure for energy audits to design the optimal district configuration [72]. Use of multiregional input-output model for water use analysis in a river basin can estimate the water footprint by sectors and regions within the basin [73]. Likewise, sustainability and health of the water coast system was studied by Leiones et al. [74] through bird monitoring and water quality indicators. The study focuses on Juan Angola Channel in Cartagena, Colombia evaluating water quality using physicochemical parameters and birds as bioindicators at four sampling stations and in two sampling periods. The sampling and data quantification was performed via single transect methodology for bird biocounting to determine alpha, beta, and gamma diversity. Monitored physicochemical parameters includes dissolved oxygen, nitrates, alkalinity, pH, transparency, salinity, air and water temperature. In both sampling, ecosystem was overexposed by anthropic factors, airport activities, environmental conditions degradation, and sewage pouring, thus showing notable changes in bird counting and making it impossible to tailor general patterns. On the other hand, the physicochemical parameters showed better results in the second sampling, but also with high degree of human intervention on the channel. With overexposed water resources, reuse water technologies are becoming prominent topic with the emerging water scarcity problems but can lead to reduction of economic benefits in water system utilities. Therefore, to ensure contentment of all stakeholders of the water systems, implementation of different regulatory options and operation conditions should be investigated [75], such as value chain mapping in water and wastewater utility companies to increase operational efficiency and eliminate waste [76]. Thus, Mundim et al. [77] evaluated the environmental and economic performance of wastewater treatment technologies of warm climate regions. Comparative analysis was made using life cycle assessment and life cycle costing method on the case study of four technological routes for different wastewater treatment in Brazil. The wastewater treatment plants were designed to remove carbonaceous organic matter, quantified in terms of biochemical oxygen demand. The life cycle assessments were applied considering nine impact categories and the cost was calculated through an Excel spreadsheet based on the cost components. Results show the worst environmental and economic performance has an activated sludge technology, followed by a trickling filter, while the best performance is achieved by upflow anaerobic sludge blanket reactor resulting in

reduction of the environmental impacts by 3.15−84.53%, depending on the impact category, and reducing costs by 25.03−38.68%. As water management system facilities require large amount of energy for their operation and are responsible for the 3% of the global energy demand, a number of energy optimization modelling tools for the decarbonization of wastewater treatment plants were developed [78]. Energy, exergy and economic analysis showed renewable technologies in form of geothermal energy can be viable and sustainable solution by providing electric and thermal energy for wastewater and sludge treatment [79]. Shifting electricity consumption to period with lower energy prices by storing wastewater during the day, and schedule its operation during the night, can reduce operational costs and increase energy savings while keeping the effluent quality within the requested regulation limits [80]. For further analysis, Hosseinnejad et al. [81] proposed an integrated bottom-up optimization model for allocating resources and assessing combination of technologies based on the watergy optimal point (water-energy nexus) at which the total cost of water and energy is minimized. The integrated model considers the cost of water and energy, the efficiency, and the water and energy requirements of the greenhouse. Six principles to determine water-energy relationship were proposed, and sensitivity analysis was carried out to verify the functions of the model for the case study on the hydroponic rose greenhouse in Iran. The results provided optimal combination of technologies based on the watergy optimal point for production, depending on scarcity of resources, prices of input, substitution, and complementary production factors. Compared to the base case scenario, the maximum achievable reduction in the total cost of production is 31% in the most cost-effective scenario. Also, among the modelled scenarios, the optimal combination of technologies could result in reduction of water, electricity, and fertilizer by 18%, 31%, and 25% respectively. With the industrial development, a global consumption and wastewater disposal have increased, so process integration methods such as pinch analysis have been utilized to decrease water consumption and improve water management strategies of water networks [82]. However, as new linkages in water networks can lead to water shortages, vulnerability of such systems needs to be analyzed to assess robustness and provide insights for development of water systems management strategies [83]. To evaluate the energy consumption of the pumping systems in a clean water plant, Arenas Sarmiento et al. [84], proposed energy performance indicator to assess the energy impact of replacing standard-efficiency with high-efficiency motors, driven by variable speed drives in a pumping system of an industrial cooling tower. The analysis was made on a system of a two-cell cooling tower, four motor pump assemblies, and two extractors at the top of the tower. The technological change include substitution to higher efficient motors with variable speed drives and automatic system flow control. The energy data are obtained from the real measurements, and energy savings were calculated by consumption before and after the technological change. Additionally, monitoring power quality harmonic measurement and analysis were conducted. The results show the replacement of the motors and the variable speed drives, can lower energy consumption by 36%. It was also shown variable speed drives generated an increase of 10% in the total current harmonics in comparison with baseline scenario, thus confirming proposed comprehensive energy diagnosis can be achieved using easily measurable data like electricity consumption and water flow.

Hydropower generation has also considerable influence on ecosystem services and environment, as well as social well-being [85], hence prior to development of hydropower plant, their influence on river basin should be considered and efficiently used [86]. To maximize power output of in-stream turbines, an implementation of spur-dikes can be used to amplify velocity of the stream and prevent bank erosion that can happen if the channel width is physically narrowed [87]. Moreover, during dry season the quality of water can become unsuitable for use [88]. Due to very low stream velocity during dry season, there is a possibility of discontinued operation, thus Abubakar et al. [89] investigated the effect of the water-jumper slope angle on the breastshot wheel performance at various upstream velocities. In the study, the breastshot water wheel for laboratory-scale open channel was designed. The stream velocity

was measured using a digital flow meter, while a tachometer measured the wheel's rotational speed. Furthermore, a disk brake dynamometer was used to obtain the wheel's torque. The experiment was conducted with variety of stream velocities and water-jumper slope angles. The results showed that a water-jumper increases gross head, torque, and hydraulic and output power. However, the highest efficiency is achieved at a slope angle of 10° and stream velocity of 1.3 m/s. The hydraulic power is influenced by discharge and gross head, which increases with the water-jumper slope angle. Significant momentum losses occur at the wheel for stream velocity higher than 1.3 m/s, decreasing the breastshot's output power and efficiency, even as hydraulic power increases. Therefore water-jumper slope can be used to optimize the performance of breastshot wheels. Furthermore, recovery of waste heat and reduction of water consumption can be economically feasible for fossil fuel-based power generation, but it is characterized by significant pollutant emission and water consumption [90]. Thermal power plants pollution in form of grey water footprint is investigated by Vaca-Jiménez et al. [91]. For the assessment, inventory and modelling of thermal power plants and their operation was made, following with estimation of grey water footprint and their comparison to other indicators of anthropogenic use. The study used real data from three operating therm[90]ower plants in Ecuador that produce grey water footprint of thermal pollution. To investigate possible impa[91]n the county water bodies, study defined water pollution level and comparison of water footprint colors, namely blue, green and grey. Blue consist of the volumetric consumption of surface and ground freshwater and grey assesses water pollution by relating it to the volume of water needed to assimilate pollutants. The results show that the grey and blue water footprint is similar for all three power plants, but grey can be up to three times larger than the blue water footprint of the plants, implying that the water bodies must have at least that volume of water to buffer the possible thermal pollution. Furthermore, the difference between water pollution level happens because of available water in two estuaries, as one embrace water from two powerplants and the other one just from one.

Furthermore, topic of wastewater treatment is analyzed not only from energy point of view, but also from chemical treatment side. Different approaches for removal of unwanted impurities were investigated on the ability of Jordan zeolitic tuff to remove a wide range of hydrocarbons from surface water [92] or zirconium impregnated anion exchange resin to remove fluoride from groundwater [93]. As wastewater treatment plants have limitation of allowed chemical oxygen demand of the effluent, post-treatment should be applied to achieve satisfying discharge from wastewater treatment plants [94]. It was shown how combined physio-chemical post-treatment was able to decrease chemical oxygen demand of all tested samples in conventional activated sludge system by treating coke oven wastewater [95]. In the same framework, Mangkoedihardjo [96] presented an in-depth insight review on improving the quality of wastewater through biochemical/chemical oxygen demand (BOD/COD) ratio, which indicates the level of biodegradability of organic matter in wastewater. In the study, zones on the BOD/COD ratio were introduced based on their characteristic effect, limiting the concentration of organic matter that can be safely discharged without a significant impact on the overall quality of the environment. Next, new sequential treatment method from toxic to stable zones was formulated to increase the efficiency of detoxification and stabilization processes of organic matter. The results indicate there are two groups of methods to enhance detoxification and stabilization: physicochemical and biological. The proposed method uses the greatest efficiency of detoxification based on acute toxicity tests, plus the greatest efficiency of respiration based on respiration inhibition tests to assess the feasibility and monitoring of sequential wastewater treatment system configuration which is technically feasible for the minimum concentration of BOD and COD above 500 mg/L. Municipal landfills can also cause leachate generation initiated by rainfall, containing various organic and non-organic pollutants that should be treated in wastewater facilities. Leachate is commonly processed with reagents, and in combination with integrated process of advanced oxidation and biochar adsorption it can achieve safe, environmentally friendly, and higher removal efficiency

[97]. To improve the quality of surface water based on system dynamics and knowledge-based models, Dmitrović [98] developed a computer-based model for landfill water treatment, using randomly selected values from the theoretical probability distribution. The aim of the study is to propose efficient, economically and ecologically profitable treatment of landfill leachate contaminated with organic matter. After the development and validation, the adaptive model was performed on actual system designed in Piškorica, Croatia, to investigate water purification from organic matter concentration in landfill leachate. According to the developed model, the existing system can purify the landfill water by introducing feedback loops, which makes the system adaptive and self-regulating enabling adaptiveness to other values, locations, and types of pollution. Therefore, proposed methodology based on simulation modelling was confirmed as a useful method in environmental protection, keeping all observed values within the legal limit.

BIOENERGY AND WASTE

In the case of sustainable and efficient-sourced biomass, bioenergy is recognized as important factor in the mitigation of greenhouse gas emissions and achieving renewable energy goals in decarbonization strategies, with broad utilization possibilities while stimulating economic activities of local and regional communities [99]. One of the main biomass roles as renewable energy source will be replacement of petroleum-based fuels and chemicals. For that purpose, biomass needs to be converted to desired product, undergoing different processes and pretreatment procedures. Therefore, conversion of lignin to high-quality biofuels is explored by catalysts supported hydrolysis combined with hydrogenolysis [100]. To produce bioethanol and nanocrystalline cellulose, impact of different pretreatment methods was evaluated by integrating sustainable energy with advanced nanomaterial processing [101]. In the same context, Al Zubi et al. [102] provided review on use of nanotechnology to turn lignocellulosic biomass into bioenergy, which would be an economical, easily accessible, and renewable fuel. As stated, conversion technologies still lack in term of sustainable, productive, and cost-effective processes, as it is difficult to convert to bioenergy due to its complex structure and high recalcitrance. However, introduction of nanotechnology can provide cost-effective and ecologically benign solution by emerging approaches, namely nanocatalysts, nanostructured materials, nanocarriers or nanofabricated membranes. The authors recognized nanobiotechnology as an essential component of lignocellulosic biomass pretreatment, but still no clear evidence of the nanoparticle's mechanism in the pretreatment of lignocellulosic biomass has yet been developed. Moreover, bioenergy can be utilized through biogas. Sustainable operation and utilization of biogas power plants in future energy markets without subsidy schemes, can be achievable with coupling technologies like biomethane production [103], while production can be enhanced using pretreatment optimization to increase biogas yield [104]. Additionally, in comparison with mono digestion, a co-digestion of sewage sludge shows advantages regarding biogas production potential, kinetic analysis and digestate valorization [105]. For co-digestion evaluation, Silva et al. [106] investigated the effect of hydraulic retention time on the methane yield and bioenergy recovery of sewage sludge co-digestion with mango peel liquor. The feasibility of implementing full-scale co-digestion of municipal sewage sludge was evaluated through the synergetic effects obtained at the laboratory scale, evaluating the process efficiency for three hydraulic retention times using continuous stirred tank reactor. The study found that the hydraulic retention times have a significant effect on the methane yield and bioenergy recovery of the co-digestion process, the highest yield being achieved in shortest retention time of 13 days. The study also found that the co-digestion of sewage sludge with mango peel liquor resulted in a higher methane yield and bioenergy recovery than the digestion of sewage sludge alone, with methane production nearly doubled under similar organic loading rates.

Therefore, integrated management of biowaste can contribute to achieving bioeconomy targets and sustainable development goals, promoting the sustainability of food production.

Commonly, a geographical information system-based approach is used for assessing spatial distribution, sensitivity and potential of agricultural residues [107] and their further use, such as biogas production [108]. Techno-economic feasibility of biorefinery processes can be also impacted according to the plant configuration. For instance, by making relations across the wood value chain regarding conversion of the wood streams into high-value products [109]. Therefore, Rodríguez et al. [110] investigated the feasibility of biorefinery production of high-value chemicals through an eco-industrial park. The study considered two potential routes of integration: ethanol production in Scenario 1, and methanol, propylene and ethylene production in Scenario 2, with the implementation of heat integration, safety profiles, and environmental assessment. The simulations were performed in respect to crop's productivity, composition of the biomasses, and experimental yields. The energy integration of two biorefineries considers the productive sector, the desired products, and transport logistics for the calculation. After simulation, the energy integration, and safety and environmental analysis of the two biorefineries, network for interaction between processes to increase productivity and to look for a reduction in energy consumption was proposed. The results show reduction in energy consumption is higher in route 2, while route 1 results were more secure, but overall, integration of two processes lead to emission and by-products reduction and increase of high-value products with benefits for both industries. As the increase of efficient biofuel combustion is expected in future development scenarios, there is also a need for additional research on optimization of combustion characteristic and process parameters. There are new proposed models addressing biomass gasification process, such as prediction of bed fluidized biomass gasifier performance, considering the temperature variation on the final product gas composition, and comparing the difference between the predicted and measured values [111], or modelling the biomass devolatilization process that precedes the combustion or gasification based on a combination of kinetic and diffusion model [112]. Similarly, Susastriawan and Saptoadi [113] investigated the effect of air tuyere-grate distance and equivalence ratio on the thermal performance of a downdraft gasifier fed by wood sawdust. The work aims to investigate the axial temperature profile of the reactor, the volume percentage of carbon monoxide, hydrogen and methane, a higher heating value of the producer gas and the cold gas efficiency of the gasifier. Experimental setup of small-scale gasifier was set up and sawdust waste was collected from wood furniture industry at Bantul Regency in Indonesia. The gasifier performance fed by teak sawdust is investigated for an equivalence ratio of 0.15, 0.20, 0.25 and tuyere location above grate of 260, 330, and 400 mm. The results showed the air tuyere-grate distance and equivalence ratio had significant effects on the thermal performance of the downdraft gasifier, and that by optimizing these parameters, the higher heating value and cold gas efficiency could be improved. The maximum higher heating value of the producer gas and cold gas efficiency were found at an optimum tuyere-grate distance of 330 mm and an equivalence ratio of 0.20.

Sustainable development also comes hand in hand with adequate waste management strategies. In European Union, maturity of waste management varies significantly from state to state, but they all have the same golas to achieve. According to hierarchical optimization model for forecasting waste production and treatment, results show how most members will not meet European targets in time with current trend of waste management, which implies an urgent need for changes in existing waste management systems [114]. Impact of those changes can be assessed with time-dependent life cycle assessment based on waste, material, and energy flow tracking framework, and further calculate the material and possible energy production monetization [115]. For that, planning of treatment capacities and waste management policies requires an accurate prediction of waste generation, but predicting models are dependent on quality of data, territorial level, and behavioral, socio-economic and demographic factors [116]. Therefore, Suryawan et al. [117] analyzed the level of public acceptance towards waste to energy technologies to implement waste to energy management by increasing public awareness. The study used quantitative data with simple random sampling techniques, namely factor and

cluster analysis. Questionnaire structure was shaped based on preliminary study and carried out on the number of respondents according to a significance of 5% of the total population in Jakarta, resulting in minimum of 400 samples. The binary regression analysis model was used to determine the willingness to accept waste to energy technology by grouping models from communities with different classes formed by cluster analysis. The results showed that socio-economic aspect, environmental impact and development factors are the ones responsible for defining the public preferences, of which socio-economic factor was found as the most influential one. Level of education emerged as the highest discriminant variable that can encourage the community to develop a better waste to energy perception. Furthermore, The United Nations adopted the Sustainable Development Goals with 17 fundamental areas driving sustainability research in different areas. In proposed goals, most directly or indirectly relate to waste recycling with an emphasis on food security, health, and environment [118]. Recycling of municipal wastewater sludge can serve as a low-grade nutrient source in agricultural lands, addressing both, waste management and food security, but the techno-economical feasibility is crucial for its future development [119]. However, quality of household food waste compost from commercially available household composters differs regarding maturity, the degree of humification and stability of organic matter, compared to preparation from conventional mixture of biodegradable green waste [120]. Therefore, a mixture of different feedstock can be utilized to produce quality compost. Feasibility of co-composting sewage sludge, green waste, and food waste was investigated by Grgas et al. [121]. The study used three different mixtures to assess the possible mixing of mentioned feedstock especially at low carbon/nitrogen ratio, impact of different initial ratios on the effectiveness of the co-composting process and evaluation of produced composts for use in agriculture. Experiments of co-composting were performed during three months by monitoring of temperature, pH, moisture, carbon and nitrogen proportion, carbon/nitrogen ratio, and germination index. The co-composting of sewage sludge, green waste, and food waste even at a low carbon/nitrogen ratio resulted in high-quality composts. All produced composts are appropriate for agriculture use, however, compost of sewage sludge and food waste had the highest germination index (89%), so it would have been the best to use.

Then again, recycling of mixed plastic waste also has a different set of challenges. It's recycling has recently been investigated through various technologies, such as pyrolysis where polymer chains are thermally broken to obtain hydrocarbon materials of different molecular weights and recycling processes. Pyrolysis as a thermochemical recycling can serve as promising clean technology to turn plastic waste into fuel with good quality and potential for further use [122]. Additionally, co-pyrolysis of biomass and polyurethane can serve for utilizing plastic waste as a fuel source with high heating value, but it is important to investigate how temperature, biomass type, and co-pyrolysis ratio impact synergy effect [123]. In the same context, Stančin et al. [124] conducted thermogravimetric and kinetic analysis of heterogenous sawdust in a mixture with polypropylene and polystyrene. To determine the decomposition mechanism and kinetic parameters of investigated mixtures, a thermogravimetric analysis was made to select the appropriate process conditions. Co-pyrolysis was performed on mixtures with different biomass/plastic ratios over a temperature range of 30-550 °C and at four heating rates, with pure argon as a carrier gas. Effective activation energies were determined using model-free methods, pre-exponential factors, and elementary thermodynamic parameters. The results show heating rate has a limited impact on process kinetics, while the mixture composition plays a crucial role in the decomposition mechanism and, consequently, the kinetic and thermodynamic parameters. The highest values of activation energies are noted for the mixture with an equal share of both feedstocks. Authors suggest further research to couple the results from kinetic analysis with laboratory investigation and product characterization. On the other hand, mechanically recycled biobased polymers used for food packaging applications can improve performance during reprocessing to retain thermal stability and mechanical properties [125]. Reusing waste originated from manufacturing process of the product again in

the product production, can bring environmental, economic, and performance benefits, as it's shown on the case of improving acoustic performance in brick blocks with ceramic waste [126]. Therefore, Ali et al. [127] examined recycling and incorporating circular cross-sections polyethylene and polypropylene into cement waste mixtures to produce plastic bricks, eliminating the need for sand, gravel and heat process for the plastic waste. The experimental work was done to attain the preferred composition with Portland cement. The brick mixture is mixed with water until homogeneous, with separate mixtures of polyethylene and polypropylene waste depending on the plastics pellet's dimensions of length and diameter of 3x3 mm, 3.5x3 mm, 4x3 mm, continuing with pressing process, and drying to minimize the moisture content. The proposed method presents a sustainable and eco-friendly solution that decreases plastic waste pollution, producing durable and sturdy bricks, with no fragmentation or scattering. The weight of plastic reinforced bricks was 20% less than traditional cement bricks, but with lower compression strength. The authors concluded the length and shape of the plastic pellets as crucial factors influencing the strength and stability of the constructed bricks.

SMART AND SUSTAINABLE FUTURE

All previous mentioned topics shape the direction for expected sustainable, renewable and smart urban communities. Evaluation of energy services, sources and technologies within urban energy planning in relation to smart energy systems, can provide detailed and easily accessible guidelines to energy planners of urban areas involved in sustainable transition [128]. Therefore, to stimulate innovation and encourage policy learning for more sustainable cities, The Sustainable Development of Energy, Water and Environment Systems (SDEWES) Index was introduced to benchmark and compare city performances [129]. The Index was further implemented to a new sample of 18 cities in South East Europe [130] and used to trail pathways to achieve higher levels of performance in the 2050 on the normative scenario of Rio de Janeiro [131]. In the same framework, Pakina and Mukhamedina [132] investigated the sustainability of the capital city of Kazakhstan, Nur-Sultan, as it joins to the achievement of zero carbon emission until 2050. The research was done using the same SDEWES Index, considerign 35 indicators across 7 dimensions covering energy sector, sustainability, and social and environmental factors of urban areas. It is calculated by normalizing the values of each indicator to a range of 0 to 1 and then aggregating it by double summation. The results placed Nur-Sultan to the group of "Challenged Cities" in comparison with other ranked cities, with a total score of 2.078, indicating city's government should focus on energy and CO_2-saving measures, rising renewable energy potential and water and environment quality, and sustainability policy. Achieving those desired smart and sustainable communities and cities, can be boosted by an educational awareness initiative to reduce energy consumption and obtain energy savings [133]. However, it is shown educational system has a significant difference among specific study programs and study fields indicating everyone will not be equally educated and qualified for future sustainability and environmental challenges [134]. Therefore, online courses can be used as a digital learning strategy to identify the didactic activities to promote education for sustainable development [135]. Dmitrovic et al. [136] investigated the use of color and frame length in environmental educational video materials as a tool for the dissemination of environmental problems and the promotion of effective practices. Proposed model for educational movie production combines theoretical concepts of message composition from communication theory with technical enhancements based on cinemetrics, psychophysiology and statistical methods derived from the simulation modelling. The statistical analysis of two award-winning educational short movies on environmental protection was made based on frame length and distribution of the Red-Green-Blue color spectrum. The results implicate that the videos with a higher color variety and saturation were more engaging and memorable and the successful time frames and transition points follow the similar patterns.

According to the analysis, using similar characteristics, success of environmental educational video materials can be increased.

To push sustainability goals for future cities even further, integration of urban and industrial sector is also expected to establish circular economy, lowering environmental footprint and cost for both urban and industrial site [137]. Circular economy strategies are also set for food production, loss and waste management systems to satisfy human requirements whilst reducing environmental impacts and consumption of resources [138]. With the same goal of adopting circular economy in the society, intersection of blockchain technology and the circular economy was reviewed by Rejeb and Zailani [139]. While circular economy aims to establish synergy between economic activities and environmental protection within production and consumption, eliminating waste and pollution by keeping materials and products in use through the reduce, reuse and recycle principle, blockchain technology can be used to track the movement of goods and materials throughout a supply chain. The review findings indicate literature is revolving around five research themes, namely, the relationship between blockchains and Industry 4.0, the potentials of blockchains for circular economy practices, the role of blockchains in energy management, the role of blockchains in waste management and the impact of blockchains on sustainability. Although, blockchain has become increasingly adopted in various business and functional areas, its application in circular economy is still in an emerging phase but has a potential to provide transparency, traceability, accountability, efficiency, and trust to the circular economy concept. Furthermore, to achieve wanted sustainable and environmentally friendly surroundings, increasing emphasis is placed also on greening of urban places. There are already developed toolkits to support investment decisions of urban green infrastructure that increase resilience and social benefits within urban planning [140]. Small green walls can have an impact on particulate matter concentration, a major concern in urban areas causing a number of health problems, including respiratory infections, heart disease, and lung cancer [141]. Different kind of greening strategies can be assessed against the effects of climate change, evaluating health-related indicator patterns in cities, and comparing them to modelled future indicators [142]. Raihan et al. [143] investigated the effects of climate change on mangrove forests. It utilizes remote sensing, geographic information system techniques and machine learning strategies to analyze changes in mangrove cover and distribution over time. The study examines the relationship between mangrove health and various climate variables, especially land surface temperature and salinity, to potentially predict future changes of mangrove biomass. The analysis was made on eleven major mangrove forests in the United Arab Emirates, and the health and extent of mangrove vegetation was evaluated through normalized difference vegetation index. The result did not find out satisfactory regression values by employing different machine learning algorithms, however, it can be concluded mangroves flourished at a specific temperature range and extreme temperatures can negatively affect vegetation health. So in the context of influence of climate change, further analysis should be made to protect the ecosystem.

Keeping in mind the significant responsibility of the building sector in achieving sustainable goals and reducing energy demand, a number of studies were presented to assess energy demand in buildings [144]. Following the interconnectedness of energy demand and energy efficiency, exploration of dynamic estimation of energy-saving actions was made to propose and compare them as guidelines for the local authorities to implement suitable activities for energy demand reduction [145]. A toolbox was developed [146] to enhance the energy management of municipal public buildings by providing tailored solutions and strengthening the policy-making and strategic planning competencies of local and regional public authorities. In the same framework, Bresa et al. [147] investigated the impact of existing regulations for building performance on the energy demand, cost, and environmental impact of block apartment buildings. A numerical analysis was performed on four scenarios with different energy efficiency measures and heating, ventilation, and air conditioning systems for the block apartment in Pristhina, Kosovo. After implementation of energy efficiency measures

for the case study building, the results show that only by retrofitting the building envelope including thermal insulation of walls, roof, and floors, and by changing windows according to the regulation directives, an increase in energy-saving is achieved by 378% from the walls and 233% from windows alone, and a reduction of heating load by 116.7 MWh/year, fuel demand by 243.49 kWh/year, and 86% of carbon dioxide emission mitigation. Energy efficiency measures could lead to cost savings of 10,535 Euro/year, further increasing the savings with installation of district heating or heat pumps. Policy makers should also improve residential electricity efficiency and adopt strategies specifically for small households, as electricity use differ depending on specific household composition and size [148], as well as level of income [149]. Electricity consumption and market prices were also shaken by the impact of unforeseen global event, COVID-19, as it it shown on the case of Serbia [150]. Likewise, Kawanami and Tabata [151] investigated the impact of increased time at home on household energy consumption during the COVID-19 lockdown in Japan. In the model six types of household models were created regarding the number of household members, the age of the household members, the floor area of the dwelling, the type of dwelling, and the time spent at home. The study found that household energy consumption increased by 4.2% during the COVID-19 lockdown compared to pre-lockdown levels. The increase in energy consumption was driven by increased use of appliances, lighting, and remote working. The authors also found that the increase in energy consumption was larger for households with more members, younger household members, and larger floor areas. Furthermore, household energy consumption also did not return to normal even after the state of emergency had ended. Savings in energy consumption can be achieved with a newly developed smart technological solutions, such as zoned control system based on thermostats and motorized dampers in comparison with commonly used systems for HVAC purposes in the residential sector [152]. Similarly, detection and recognition of windows opening for building ventilation heat losses management can be accomplished with deep learning approach [153]. Additionally, deep learning-based approach can be used to detect and recognize equipment usage and the associated heat emissions in office spaces, and consequently reducing building demand by providing data to energy management system [154]. Al-Khadher et al. [155] presented an overview of non-intrusive load monitoring for identifying appliances' energy consumption within urban places. Without additional sensors, non-intrusive load monitoring aims to separate the aggregated energy consumption signal into the energy contributions of individual appliances utilizing disaggregation algorithms. The authors identified the load monitoring process consists of four steps namely, data acquisition, event detection, features extraction, and load identification. The main limitations of non-intrusive load monitoring were recognized to be the need to re-train supervised algorithms when adding new appliances to the household, the lack of compatibility between systems designed for residential and commercial buildings, the high cost of installing the systems with a high sampling rate, limited scalability of the systems and the difficulty of disaggregating loads that have similar power usage patterns.

To enable links between different sectors, smart energy grid will be backbone technology to fulfill designated requirements. Hence, there is an increase in novel models that analyze charging strategies for electric vehicles simultaneously covering heating, cooling, as well as energy demand of buildings where electric vehicles are available [156]. Moreover, simulation models were developed to evaluate the impact of capacity tariffs and battery storage on the cost and operation of a microgrid together with newly proposed day-ahead dispatch modeling [157], as well as microgrids simulations with proposed management strategy which considers the ageing of storage system while minimizing the costs [158]. Similarly, Karameros et al. [159] proposed and evaluated a microgrid energy management scheme for electric vehicles integration and energy efficiency potential of microgrids. The newly developed process consists of microgrid operational assessment, decision criteria weighting, genetic algorithm optimization and energy management scheme selection based on lowest cost. Calculated energy scheme is proposed to each user and the microgrid management can be approved or

rejected based on the user schedule. Developed model was tested on case study consisting of 10-office building with a 10 kW photovoltaic installation, an energy storage system, four electric vehicle charging stations, electric vehicles, and the houses, equipped with the appropriate equipment for bidirectional energy transfer. The results show energy management scheme has a positive performance, installing new photovoltaic system and utilizing the energy available from electric vehicle batteries, charging the vehicles when the energy price is low and discharge when it is high, especially scheduling discharges between 12:00 to 14:00 when peak demand and a high energy cost may occur. At last, the energy grid cost from the initial state has been reduced by 22.75%.

In comparison made in [160], it is shown how electrification of private transport supports the penetration of renewable energy and can significantly reduce greenhouse gas emissions while keeping transport electricity demand relatively flexible, and additionally providing societal benefits in comparison with internal combustion vehicles [161]. As mentioned, key challenges can be addressed accurately through adequate policies and mobility plans with variety of methods to collect data for the status analysis, including desk research, surveys, and interviews [162]. Retrofit of an existing fuel station with electric vehicle charging infrastructure is expected and can be economically feasible with the help of battery energy storage system to reduce grid connection costs [163]. Charging of electric vehicles was also explored by Karatzas et al. [164] with a multi-factor dynamic optimization model for assisting electric vehicle users in making charging decisions. The proposed model is developed taking into account a variety of factors, including the cost of charging, the availability of charging stations, the distance to the charging station, and the charging time, as well as the user's preferences, thus providing a methodological approach for an EV user recommendation system. The case study was conducted on simulated environment consisting of 20 stations (commercial, residential, and public) and a fleet of 7 EVs in the City of Patras, Greece. The results indicate presented methodology provides sufficient set of optimal choices leading electric vehicle users to charging options at a specific time, while also considering the cost of energy as a time parameter within dynamic pricing. The authors recommend that the model should be further developed and refined, but results can serve to develop new services that will improve user satisfaction, electromobility, urban mobility, and sustainability of cities. Penetration of electric vehicles is not supported only as a way to offer flexibility to the grid, but also to reduce environmental impacts as the transport sector globally contributes to around 14% of greenhouse gas emissions and one-third to the European Union's. Accordingly, life cycle assessment studies in transport can provide guidelines to decision-making processes at various levels [165]. Furthermore, to assess the sustainability of three different vehicle options, a multi-criteria decision analysis was proposed for the sustainability assessment of alternative technologies and fuels for individual motorized transport. Alienation from traditional transportation technologies was also investigated with life cycle of electric vehicles [166]. Similarly, Chovancová et al. [167] used the decoupling analysis to assess the relationship between transport-related greenhouse gas emissions and economic growth in the European Union countries. Method calculates index consisting of economic variable and resource consumption and/or environmental impacts, in this case anthropogenic transport-related greenhouse gas emissions, and the countries can be divided into seven categories: weak decoupling, strong decoupling, recessive decoupling, strong negative decoupling, weak negative decoupling, expansive negative decoupling, and critical. The analysis period covers a 20-year span, from 1997 to 2017 for 28 European Union members. The results indicate that the countries achieved different stages of decoupling within the individual monitored periods, with relative decoupling (55%) and absolute decoupling (34%) being the most common. However, in the long run (20-year study period 1997-2017), only 8 countries achieved absolute (strong) decoupling, which does not seem to be sufficient in the pursuit of the EU´s ambitious climate mitigation targets. Furthermore, particulate transport-related emissions from diesel vehicles, cause issues with health of citizens and prospects of commercial future of technology, so new

solutions such as biomorphic filters are explored [168]. Biodiesel fuels release higher NO_x emissions than fossil diesel, therefore reduction techniques should be used in biodiesel powered engines to reduce them [169]. But as the biodiesel serve as substitute for currently used petrodiesel, one of the challenges of its increasing utilization is excess production of glycerol. Therefore, Chai et al. [170] investigated the use of an acetylation process with palladium on the activated carbon catalyst to convert glycerol into triacetin under microwave irradiation. In the study, the reaction parameters are optimized using response surface methodology to achieve high selectivity for triacetin. The experiment was conducted in a 250 mL three-necked round bottom flask in a microwave reactor setup, and the liquid product was analyzed by gas chromatography and capillary column. Design parameters were measured in fifteen experimental runs for the acetylation of glycerol. The role of the independent factors was determined by the adjusted coefficient of determination, and relationship between them was represented with response surface methodology. The results show temperature has a significant impact on glycerol conversion, while the mole ratio affects the selectivity of triacetin. The optimal parameters for 96.64% glycerol conversion and 0.231% triacetin selectivity were temperature at 110°C, 2:10 mole ration, and 0.718 wt.% catalyst loading. Additionally, lithium-ion batteries are widely used in vehicles and advanced technological devices, and their production will only increase in the near future, imposing a need to investigate recycling treatments [171]. Another energy storage solution is presented in additive enhanced soluble-lead-flow-batteries with high cycle life of more than 7,000 cycles at 40 mA cm^{-2} [172]. To assess the state of health of liquid electrolyte batteries, Palacio et al. [173] conducted the analysis by changes in the transmittance of the electrolyte for the specific frequency. The percentage of optical transmittance of the four central cells of the battery was considered, generating a classification pattern to obtain approximate value of battery health from the transmittance. The experimental setup monitors the current to count consumed amps until the voltage drops to a value where the load cannot supply the programmed current or the active battery voltage reaches approximately 10.5 V as a deep discharge. The analysis was done for 6 batteries using scanning electron microscopy. According to the microscopy results, it can be concluded that the presence of sulfate that adhere to the electrode and account for the reduction in the health status of the battery, can influence the variation of the optical transmittance of the electrode. At last, Bayesian classifier presented a good classification handling four intervals indicating correct classification of 98.5%.

CONCLUSION

Volume XI of the Journal of Sustainable Development of Energy, Water and Environment Systems provides insights into the latest research regarding topics of Renewable Energy Solutions, Heating Sector, Water-Energy Nexus, Bioenergy and Waste, and Smart and Sustainable Future. From everything mentioned, it can be seen that the research collectively highlights progress and the imperative need for transitioning towards a more sustainable, innovative, and holistic energy, water, and environment paradigm. In this work, novel methods, concepts, and solutions are presented, not only from JSDEWES Volume XI but also from special issues from the recent scientific literature and novel research from recent SDEWES Conferences.

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