RECENT PROGRESS IN SUSTAINABLE ENERGY-EFFICIENT TECHNOLOGIES AND ENVIRONMENTAL IMPACTS ON ENERGY SYSTEMS

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Energy sectors of all the countries around the world are faced with a big challenge: the energy transition under the imperative of continuous reduction of carbon dioxide emissions. The energy transition and the sustainability constraints pose a significant challenge for engineers, researcher and scientists developing new and clean energy-efficient technologies. Energy production and transformations, along with its storage, distribution and consumption, are achieved by utilising new and clean energy technologies, with the goal of the continuous increase of energy efficiency, the growth of renewable energy sources utilisation, the uninterrupted switch from fossil fuels to alternative energy sources, and the continued reduction of CO2 emissions. This editorial paper addresses the latest progress and the findings in research and developments in the sustainable energy technologies, energy and environment systems from selected papers of the conference on Sustainable Development of Energy, Water and Environment Systems held in 2019.

Keywords: energy technologies, environmental impact of energy systems, climate change, energy savings in buildings, process optimisation, simulation tools

1. Introduction

The 14th Conference on Sustainable Development of Energy, Water and Environment Systems SDEWES 2019 was held in Dubrovnik, Croatia during October 1st - October 6th, 2019. The main goal of the international scientific SDEWES conference was to discuss the recent progress in sustainable development, including the energy, water, and environment. The conference has brought together 570 scientists and experts in the area of sustainable development of energy and environment. It is well known that the energy sector is in a state of the accelerated energy transition, moving toward cleaner low carbon energy-efficient technologies to meet the set energy and climate targets. The necessity to research and develop new innovative cleaner technologies in energy systems and to reduce environmental impact is a great challenge and massive responsibility for the international scientific community. Therefore, the objective of this special issue of Applied Energy was to bring together papers from scientists that were presented at Sustainable Development of Energy, Water and Environment Systems conference held in 2019. This editorial is based upon 16 papers selected from among 601 contributions presented at the conference covering following topics: i) Energy Planning and Energy Potential, ii) Energy Savings in Buildings, iii) Energy Storage and iv) Energy Conversion and Environmental Impacts.

This special issue is a continuation of the successful collaboration between the Sustainable Development of Energy, Water and Environment Systems Conferences and Applied Energy Journal [1–3].

2. Energy Planning and Energy Potential

In the past SDEWES conferences, numerous research papers were devoted to energy planning for techno-economic analysis of existing national energy systems, but also to previse the future implementation of renewable energy systems (RES) and their smart integration with conventional energy technologies [4]. As a result of such work, numerous researches were conducted to identify the optimal penetration of RES in different national and regional energy systems. Although numerous results on the topic of RES penetration in existing energy systems based on fossil fuels were published, the integration between RES and fossil fuels energy systems is still a challenge [5]. In order to increase sector coupling of supremely centralised energy systems and decentralised RES, the modelling of coupled power, heating and cooling sectors is commonly used [6]. Another example of the energy planning application is an investigation of coupled RES and the water supply sector. In the geographical locations where the water demand corresponds to energy supply, the implementing photovoltaic (PV) panels for powering desalinisation plants increase the flexibility of PV panels up to 10% of the total electricity demand [7]. That is primarily visible in the case of islands that utilise hydro storages and reversible-pump turbines in the hydropower plants. For the energy system in Italy [8], the authors showed the integration of transport sector and residential heating through the electrification. Additional sector coupling employing energy planning was performed by Askeland et al. [9], to determine the interaction between the district heating sector and hydropower sector. Their results showed decreased demand for dammed hydropower plants with the installing the heat pump for electrifying the heating sector, where the increased flexibility of hydropower plants can also be applied on small scale turbines as in [10].

The results showed that electrification and coupling of transport and residential heating could reduce CO_2 by 25-30%. For the better overall efficiency, in the current energy systems, centralised district systems are imposed as the primary solution, which does not correspond to decentralised RES.

The integration of centralised conventional energy systems and decentralised RES systems was examined in combination with several waste heat technologies, where absorption and electric chillers were integrated into the industrial district cooling network [11]. The feasibility of district heating systems that utilise excess heat with the energy systems such as cogeneration power plants, solar collectors, heat pumps, storages and boilers demonstrated that the overall utilisation could be minor to the availability of waste heat [12]. The capability of excess heat usage in district heating systems applying method of levelized costs proved financial, but also an environmental profit when the excess heat is exploited as a heat source in district heating systems [13]. The main advantage of coupling heating and power sector was shown by authors [14], where the influence of installed thermal power plants compared to combined heat and power (CHP) plants was determined. The authors concluded that the transfer of existing thermal plants to CGP would enlarge the energy system efficiency for 17 percentage points.

Consequently, the RES integration in district heating systems is disproportionate with the system stability and cost-effectiveness, without building new interconnections, responsive demand technologies or increasing the grid flexibility. The application of numerical models for operating PV modules combined with thermal storages on micro and small grids that are interconnected with the CHP systems can significantly minimise electricity and heat consumption of the overall system [15]. If such a demand-responsive predicating model based on the forecast is applied with linear programming optimisation, the most cost-efficient scenario can be determined.

Owing to the different operating modes of conventional energy sectors and RES systems, the employment of complex numerical models is crucial for the RES integration. An advanced numerical model for coupling energy systems called JRC-EU-TIMES models input technologies and arrangement of their synergy against the energy systems is developed by the authors [16]. The JRC-EU-TIMES was initially employed for assessment of the energy utilisation of electric vehicles (EV) and estimation of the power load based on the energy consumption statistics. Notwithstanding, for the optimisation of dispatching power on a single energy unit, Dispa-SET software is commonly used [17]. In [18], the authors for the first time linked JRC-EU-TIMES and Dispa-SET models, where the results showed that Dispa-SET model is capable of being augmented with additional subdivisions in the energy transformation flows, that ensure to give a good overview of the energy system for the synthesis and employment of e-fuels. As opposed to complex models for quantifying technology integration in energy planning, tools such as energy concept maps were developed to give a better understanding of a relationship between different energy planning concepts, and to develop an active information-communication tool for acknowledging the efficiency of coupling sectors [19]. The additional software that is commonly applied for the determination of RES penetration in the existing energy systems is EnergyPLAN. The authors [20] showed that for the isolated cases such as islands in Scotland and Denmark the electricity storage technologies are compatible with heat storage technologies and that the main link between heat and electricity sector is in heat pumps, which significantly reduce the overall fuel consumption.

Furthermore, for isolated systems such as islands, the smart operating of energy systems is a crucial factor for increasing the share of RES [21]. In [22], authors applied deep belief, neural network model, for predicting the electricity load of North Macedonia. According to the demonstrated results, the mean absolute percentage error (MAPE) was decreased up to around 8% with the implemented model. In comparison, the forecasting of peak consumption is improved for around 20% compared to the traditional models by the system operator. For case related to hospital building [23], the authors used artificial intelligence techniques featuring multiple linear regression for forecasting the overall electricity demand. The implemented model considered all meteorological data for conducting the heating, ventilation, and air conditioning (HVAC) systems, such as irradiation and duration of sunshine, ambient temperature, wind speed humidity, but also the number of patients in the hospital. Compared to the statistical values of the MAPE, which was around 15%, the MAPE predicted with artificial intelligence techniques decrease its value up to around 9%. In terms of the electricity price, the adaptive hybrid model for short term prediction was developed by Zhang et al. [24]. For case related to the Australian electricity market, the authors showed a reduction of electricity price by a third of the price, for the best scenario, when the deep belief network model is used for forecasting the electricity price. Since the correctness of electricity balance dictates the electricity price, the predication models have to include the safeness and economic aspect of the electricity grid, as in [25]. The gap of the presented model is that it accounts the electrical demand, which results in the enlarged computational time that can be minimised by employing variational decomposition techniques. If the sustainability aspects are considered in the forecasting models for electricity price, the better agreement between electricity generation from RES and demand will be achieved, as shown in [26]. The consideration of variational decomposition in the electricity price showed a decrease in forecast standard deviation in the case of Favignana Island for up to 50%. The fluctuation in electricity price tends to be more frequent, and with the higher amplitudes owing to the penetration of variable RES. That is why the use of neural networks is expected to develop in the near future to guide for maximising profit of prosumers and consumers.

With an extensive penetration of RES in existing systems, challenges with balancing the system and electricity market come to expression. In [27], it is demonstrated that the current electricity network should reach the right electricity price to accelerate the flexibility modes that make RES technologies cost-effective. In systems that are dominated by electricity production from wind, such as in the case of Denmark, the electricity price based on hourly values can contribute with benefit for customers that decide to operate on the day-ahead market [28]. On opposite side, with the increase of more flexible prosumers and consumers, the benefits from hourly electricity price are decreasing, which could result in consumers switching back to flat price. A proposed solution to overcome this drawback is the implementation of numerical optimisation models for regulation of operating modes on the hourly electricity market [29]. The main request of implementation such an optimisation model in electricity consumption system management is their fast responsiveness. On the national level for the examination of the electricity market, the more complex models are required, such as commonly applied computable general equilibrium model. With such a model, the impact of new energy policies on the national electricity market can be evaluated. The example of applying the computable general equilibrium model on the national level can be found in [30], where the authors investigated three different energy policies for the Spanish electricity network.

Notwithstanding, with the application of electricity tariffs, the electrification of the heating sector through technologies such as heat pumps, electric boilers and heat storage can be significantly accelerated. In [31], the authors concluded that with the right plan for employing the electricity grid tariffs, the flexibility, but also and economic viability of power to heat (P2H) systems could be achieved. P2H systems possess an excellent interaction with the RES, where the production and thus the price of electricity is a variable parameter. Electrification of heating and cooling systems as the approach for decreasing carbon footprint in the environment becomes more attractive since the heating system flexibility can handle the peak excess in electricity production [32]. That is why the interaction between the electricity and heating sectors on the national and local level are required to be optimised by applying complex computational models.

When the energy planning of the energy system and water system from the supply side is observed, the combination of new carbon-free technologies and desalinisation plants can arise as economically viable solutions. Calise et al. [33] demonstrated the techno-economic analysis of installing PV panels and water storages in seawater desalinisation plants. For the calculation of water and energy conservation, the WAVE software was employed, which proved that payback time for the case of Island Pantelleria in Italy is one year and few months, due to the current high transport cost of water. Another carbon-free technology that can be incorporated with the desalinisation plant combines solar and geothermal technologies for trigeneration [34]. Such a trigeneration system is mainly powered in an organic Rankine cycle, where the solar energy correlates with peaks in water demand during the summer, and geothermal sources are essential for obtaining higher system efficiencies. Additionally, some publications investigated the exergy and economic analysis of existing CHP systems, where they are combined with newer desalinisation technologies, thermal vapour compression [35]. It is shown that the exergy of a freshwater system is increased when the concentrated brine is used for recovery. Tamburini et al. [36] developed the model for estimating the efficiency of thermal vapour compression desalinisation systems, that were employing the existing CHP systems. Higher efficiency of such systems can be achieved with retrofitting of CHP plants fuelled by fossil fuels, where the low-pressure steam can be extracted. In another work demonstrated in this special issue, [37] the wave energy potential for powering desalinisation plant was analysed. For the Canary Islands in Spain, results showed that nearly all wave technologies are able to satisfy the yearly energy demand of the desalination plant, but in combination with PV panels, the hourly agreement between water supply and demand can be improved.

In another work demonstrated in this special issue [38], the comparative analysis of two different PV technologies for floating applications was performed. The research results demonstrated the outperform in energy generation of bifacial modules for approximately 14 % compared to monofacial modules, despite the higher insensitivity of monofacial panels to albedo and lower impact of geographical location. Such a novel application of the PV panels for floating applications was firstly introduced by the Trapani et al. [39], where it was compared to conventional renewable offshore technologies. The authors concluded that offshore PV modules have a similar return of the investment as offshore wind energy for geographical latitudes ranging up to 45° on both hemispheres. In [40], the authors performed simulation analysis between offshore and land-based PV modules, where results showed around 13 % higher electricity generation at offshore PV panels compared with land-based, which can be mainly attributed to lower temperatures that increase the system efficiency. A potential increase in degradation of the floating PV panels was investigated in [41], where it showed that average performance ratio is 1.5 % for offshore PV modules, compared to the land-based modules. In the review paper [42], the parameters estimation techniques for simulating PV panels are listed, which application can further optimise and increase the performance of floating PV panels systems.

In order to increase the energy efficiency of district heating system and CHP systems, it is required to improve the efficiency of the waste heat exchanger network. Typical utilisation of waste heat in the cement industry, where a new heat exchange network would increase the overall process efficiency for referent cement plant in Croatia [43]. The analytical analysis of heat exchanger network was performed by Rauch and Galović [44], in which the maximum heat flux through the counterflow heat exchangers is determined for the case of a thermal power plant. Other investigations aimed to increase the efficiency of the heat exchanger network by the regulation of their flow rates. For a controlling the heat exchanger network, a dynamic model developed in MATLAB/Simulink proved an increase of 1.5 % in energy efficiency when the proportional-integral-derivative controller is employed compared to installed proportional-integral controllers in crude distillation unit [45]. Other researches aimed to increase the efficiency of heat exchanger network with minimising temperature disturbances [46]. The authors presented guides for increasing energy recovery, where the primary assignment is lowering the temperature difference between hot and cold flow rates. Chin et al. [47] demonstrated the simultaneous optimisation of heat exchanger network retrofit, where investment and maintenance costs are considered. The authors concluded that the maintenance or replacement of the fouling heat exchanger network is imminent on a twenty-year operation period.

Even though electrification is the dominating the current energy transition, it is still of significant importance to utilise the carbon-neutral biomass, owing to its low price and compatibility with conventional fossil fuel energy systems. The main disadvantage of biomass is its dislocation to the power plants, which significantly increases its price and makes it difficult for harnessing its potential [48]. The measurement of biomass potential is essential for assessment of future energy demand. Therefore, the new methods are being developed for the determination of final biomass energy consumption. In [49], the authors developed a new statistical approach for prediction of firewood and fuelwood in South-East Europe countries. According to the statistical model, which is based on a survey on energy consumption in households, there is a significant discrepancy with the official data, which can be attributed to the inadequate legislation on renewable energy. A similar approach based on the survey was used in [50], where for case related to Italy, the district system based on biomass was observed. In [51] district heating based on biomass was coupled with the PV panels and heat pumps in order to propose a decarbonised solution for the energy system. From the performed research, it was stated that system low with share electricity generated from PVs in the period of relatively high heating demand and the absence of CHP, requires the higher amount electricity from the grid.

The potential of low-cost biomass substrates in combination with a sugar beet processing plant of the small scale was demonstrated in [52], where the produced biogas and biomethane are proposed as potential solutions for working in the day-ahead market. Another example of biomass potential for biogas production is in the residual grass near riverbanks, that can be used as anaerobic digestate [53]. From the life cycle analysis, it was concluded that the residual grass has the potential for improving ecosystem quality compared to conventional biomass digestate. Alternative utilisation of biomass production is its combination with the polystyrene in the co-pyrolysis process for the production of bio-oils that feature similar properties as conventional fuel [54]. In the review paper [55], the biomass protentional was identified to remain a high share energy source in countryside areas, while its demand is expected to be double by 2030. For the assessment of biomass for biogas production that accounts the spatial distribution, but also and seasonality, the geographical information system (GIS) method was developed by Lovrak et al. [56]. The results showed downgrade of storage capacity up to 40%, compared with the assessment based on the annual approach.

3. Energy savings in buildings

In 2017, the total energy consumption of the household sector was 288 million tonnes of oil equivalent, which is around 27% in total energy consumption as stated in the annual report of the European Environment Agency. It is expected that climate change will further increase the energy demand of the household sector, and that is why the evaluation of building heat and electricity demand depends on climatic parameters is essential. The fast response demand numerical models are essential to overcome changeability in climate conditions, in order to reduce the energy consumption and decrease harmful pollutants from buildings. In [57], the authors proposed a method for assessing the building energy demand based on three climate input parameters through the correlation between heating degree-day and heating energy performance. The review paper [58] shows that the utilisation of weather data sets and changes in climate conditions in the simulation of building energy demand results in the lower average heating demand and increase cooling demand compared to the test reference year in a residential household in Prague, Czech Republic. The simulation results showed a trend in climate warming, where the energy demand for a cooling rise to 20% more than the reference year. The intelligent control of building HVAC systems with climate data-driven model showed the advantage over machine learning models that feature insufficient seasonal dependency [59]. The authors concluded that the predictive model control of HVAC system in buildings with more data could increase the machine learning efficiency significantly. Assuming the life cycle assessment of energy systems in buildings together with the predictive control presents the potential for minimising the overall environmental impact of building, when not only the energy efficiency of building energy system is considered, but also energy consumed during the lifetime of building [60]. The results showed significant potential for reduction of annual energy consumption intensity by about 45%, the environmental impacts by 30%, while consumption of life cycle energy can increase the cost by 50%. Additionally, when the carbon footprint is introduced as a parameter for the assessment of environmental impact in buildings, the RES technologies have an immediate impact on decreasing the fossil fuel demand [61]. In the case of a school building in the Mediterranean, around 70% of fossil fuel can be decreased with the implementation of RES technologies but also significantly by modifying consumption habits.

In [62], the authors proved that the difference in energy demand predicted from forecast and the actual energy demand can be around 30% for Spanish public buildings. In Japan [63], the final electricity demand of the household building was calculated by consumers survey. The estimation of heat losses of the building energy system based on a typical day in the European standard was used to obtain the total energy demand [64]. The authors of [65] defined the total building demands based on the meteorological statistic of the last four years. Compared to a novel approach where authors developed a methodology for detecting the peak consumption in electricity [66]. The methodology focuses on the operating conditions of HVAC and lighting systems of tertiary sector buildings.

Researches were also conducted on historic buildings where the implementation of new technologies is restricted by government energy policies, in order to increase their energy efficiency and conserve the building heritage. The review paper of energy retrofit in historical buildings in Italy showed that benefits and drawbacks of retrofitting energy actions require to focus on building historical area, and database of retrofit actions such as UNESCO standards and national regulations [67].

Muñoz González et al. [68] suggest an increase in energy consumption up to 50% for human comfort and artwork preservation than the energy consumption of existing systems. By 2050 it is expected that annual energy consumption will increase around 15% for the preservation of valuable historical objects of art, primarily owing to an expected increase of relative humidity, which is connected to global warming.

An advanced method in the installation of ventilation systems is imposed as a solution to increase the efficiency of buildings. The natural ventilation as the oldest method can significantly decrease cooling demand in buildings for Mediterranean summer conditions. In [69], the authors imposed naturally ventilated roof that increases the dissipation of irradiance heat, which can also be interconnected with PV modules to decrease further the air temperature and the operating temperature of panels. Another passive cooling technique was introduced in publication [70], where strength-weaknesses-opportunities-threats analysis is performed for green roofs, that will have a similar effect on the cooling demand inside the observed building.

The retrofitting of balconies' envelope in buildings to augment natural ventilation in sunspace can be utilised as the preheating chamber of a ventilation system to decrease heating demand [71]. When the heat pumps are implemented in the building, the coupling of heat recovery ventilation together with the evaporator can significantly increase energy efficiency. Kilkis [72] showed that exergy optimum of such systems does not improve significantly with the currently available heat pump technologies if the heat recovery ventilation is installed.

In contrast to the installation of new air ventilation technologies, there is an increasing trend in controlling ventilation using neural networks [73]. The initial implementation was performed on underground systems, where the monitoring of the air quality was set as an input parameter for the operating mode of the HVAC system [74]. For the HVAC subways systems, the installation composed of screen doors would decrease operating cost for approximately 20% [75]. In the Beijing subway, an autonomous HVAC controlling system based on the linear regression model was employed, where the air quality, temperature and humidity were set as input parameters of the controlling system.

When the application of the neural network for predictive control ventilation system is introduced in building systems, the energy-efficient optimum can be easily achieved based on meteorological data [76]. Additionally, the authors showed that the responsive ventilation system based on neural networks could improve building overall energy efficiency for approximately 15% and the quality of the indoor air for residents. In [77], the authors applied neural networks together with GIS for retrofitting the energy efficiency of public buildings, such as schools. The automated procedure identifies the geometries of public buildings based on their values, and retrofitting costs, which are in correlation with the regional retrofit policy.

Additional application of neural networks usage can be applied for controlling HVAC systems in dependence on heat from information technology equipment in office buildings [78]. The demonstrated approach combines the neural networks and camera recognition of heat sources, which can result in a reduction of cooling demand by approximately 19%. The further developments are required to successfully detect and recognise the usage of electrical equipment in the office building, that will grant the HVAC system to respond quickly on ambient changes [79].

Furthermore, at the SDEWES conference, the fruitful discussions were held on the topic of optimal building design for a specific geographical area. In the Italian building sector, the influence of different insulation thermal conductivity was observed, where polyisocyanurate isolation showed the most outstanding performance and variability than the other isolation materials [80]. For case related to South Germany, connecting household appliances with the heat pump and ventilating system in a low energy building can reduce up to 200 kWh of electricity per year [81]. In the Mediterranean, a techno-economic analysis of a residential building was performed, where the work concludes that existing climate regions influence the results when the various thickness of thermal insulation on the building is assumed [82]. Lešnik et al. [83] performed non-linear optimisation of timber glass modules on buildings case studies in Maribor, Slovenia. The results proved that combining glazing façades shares, which are south oriented are between 20% and 30%.

Mathematical models for assessing the energy efficiency of the public buildings in Brazil are demonstrated in [84], where the newly developed method called building information modelling reduce the calculation time for energy efficiency calculation. The reduced time is based on the organisation of information that Brazilian Institute collected through past years. An additional mathematical model for the assessing energy efficiency in the buildings was demonstrated by the authors in [85], where the main focus was on the impact of heat storage on overall air heating system efficiency. The developed model was validated against the experimental results and computational fluid dynamics (CFD) simulations, where the discrepancy of few degree Celsius is shown between CFD simulations and developed model. In [86], the authors performed the sensitivity analysis of energy efficiency indexes in a selected building in Istanbul for the matrix of various combinations of scenarios, energy-consuming parameters and interventions. The performed analysis showed a reduction in energy demand for around 26%, and heat pump operation around 16%.

4. Energy Storage

In the past SDEWES conference, many research papers were devoted to energy storage technologies for reaching the increased energy system stability and distributing energy without peaks in demand and supply. With the increased share of RES systems in the energy systems, stability of existing energy systems depends mainly on the dynamic variability of energy produced in time, but also on the conversion efficiency of energy storage systems [87]. The review paper [88] showed that the expensive interconnections between energy systems are not currently feasible. That is why it is necessary to consider the still expensive and undeveloped energy storage technology, whose price dropped significantly over the years and in which scientific research area, a large amount of work is actively published.

In the past decade, a lot of new technologies were introduced for energy storage, from a simple heat source for heat pumps to complex batteries. In [89], several heat sources such as air, groundwater and seawater were investigated, to determine the optimum combination of their mixture for achieving the highest seasonal coefficient of performance (SCOP). The optimum heat source for heat pumps, that holds the highest SCOP value changes during the seasons of operating mode, where the highest share of groundwater is present during the whole season. In the areas where the groundwater is not available, wastewater as a heat source can be used. In the case of Brussels, the techno-economic analysis showed that the equivalent global warming impact would be 13% lower than for air heat pumps and around 50% lower than for gas boiler heating systems [90]. The disadvantage of this is the expensive investment costs for the installation of pipelines that would use heat sources from wastewater. An additional techno-economic feasibility study was performed by Ahmed et al. [91], which proposed sensible-latent heat storage. The sensible-latent heat storage contains solid rod construction of cheap naturally material with phase change material located between the rods, where distribution and method of stacking between tubes were studied. Besides the capsulated phase-changing material, the latent thermal energy storage can also be made from bimetallic heat exchanger tubes, such as in [92]. The experimental results showed a perfect fulfilment regarding manufacturing, joining and operating temperatures up to 340 °C. One of many applications of phase change for decreasing energy consumption is in buildings, where the low-price night electricity can be used for storing heat in internal storage energy. And then later can be consumed during the day when the peaks in heating and cooling demand are present [93]. In a review paper regarding phase change materials [94], the authors stated that despite numerous advantages, phase change materials are still more expensive than water, have doubtable health impact and overheating issues. Therefore, advanced numerical models are developed and applied to describe the operational process of phase change thermal storages numerically. In this special issue, the development of a numerical model based on the lattice Boltzmann method was used for the optimisation of heat source positioning [95]. The results showed that the optimal positioning is achieved, for the location where the charging time and the energy storage rate are the same.

Other exciting technologies for energy storage are combined thermal and energy potential storage, where the air is compressed stored using sand as thermal material of storage [96]. Besides the diverse chemical and biochemical potentials of the sludge [97], the sewage sludge can be employed as energy storage, where the excess of electricity is consumed in the gasification [98]. Modern carbon capture technologies were also analysed as heat storage materials, as Calcium looping, where carbon dioxide can be further used for oil enhancement. In [99], the authors showed the possible integration of concentrated solar power plants and calcium looping storage technology, where the high efficiency of 45% are achieved. Oluleye et al. showed in [100] the dispatching model for integration of thermal storages with a micro CHP unit. Finally, in the review paper [101], the authors give a literature overview of aqueous batteries and their potential for utilisation as energy storage systems for an existing grid.

In another work demonstrated in this special issue [102], the CFD was employed for investigating the flow inside acid-based battery. The battery flow simulation was based on the pH and salinity field gradients. Similar salinity model was used for a completely different application in CFD, where the sulphur oxides apportion in different salinity concentrations was investigated [103]. For the wall membrane function, the convective heat transfer boundary conditions were used similar to [104, 105]. For the modelling of osmotic and electro-osmotic transport in the battery, the active transport equation was applied, which general applications can also be used for phenomena such as radiative transfer [106]. Nevertheless, the promising results of flow batteries currently endure from high operating and manufacturing price, and environmental issues as harmful pollutant emission in the conventional energy system.

The massive capability of EVs as distributed electricity storages that can cover peak variable differences in demands and loads possess tremendous future potential [107]. Together with the optimised battery storage and EV charging grid, the transport system can be electrified entirely [108], which entail certain uncertainties such as unknown penetration arrival time of EV and their energy demand, and distribution of fast-charging stations. In [109], the authors stated that hybrid electric vehicles are a transition solution that has approximately three times fewer investment cost and can decrease fuel consumption up to 17%. For case related to Brazil, the life cycle assessment of transport sector powered by conventional internal combustion EV and hybrid electric plug-in technology showed the inversely proportional influence of EV's lithium ions batteries as human toxicity against pollutant emissions from internal combustion engines [110]. Work [111] demonstrated in this special issue showed the optimisation process of advanced hybrid EV that features series and parallel power-train system. The results showed that cascade optimisation achieves improved numerical precisions, but also up to eight-time lower convergence time.

5. Energy Conversion and Environmental Impacts

The dependence of the world's energy production on fossil fuels has caused negative environmental effects and climate changes. Numerous investigations have been done to find improved more clean combustion technologies by using alternative fuels in internal combustion engines, boilers, and industrial furnaces, such as syngas derived from biomass gasification. The sustainable utilisation of these alternative fuels is significant in today's energy transition to accomplish new low carbon combustion technologies which can mitigate the overall clean energy demand. In that context, within this special issue, Costa et al. [112] demonstrated that by using advanced numerical simulation tools it could be performed optimisation of the syngas combustion process inside combustion chamber to obtain at the same time high efficiency and low pollutant emissions. Different numerical modelling approaches can be used to perform engine optimisation by modelling of combustion of liquid and gaseous fuels by using various approaches such as Eulerian-Lagrange method [113] and Euler-Euler method [114] in combination with simple and detailed combustion chemistry [115]. The results of investigation of Costa et al. [112] show that the optimal solution regarding combustion process in syngas internal combustion engines was achieved by higher air-to-fuel ratio than stoichiometric ration and by including a small portion of exhaust gases during the combustion process to improve the energetic and the environmental performance.

In the name of tackling climate change and energy transition to low carbon energy systems, the potential of biomass usage has become more and more important [116]. It is relatively simple and cheap to convert existing solid fuel-fired boilers and industrial furnaces to burn biomass. Therefore, the understanding of the complex chemical and physical processes in biomass combustion continues to be a major challenge for researchers and scientists [117]. Various modelling approaches were developed that involve consideration of various multiphase solid fuel combustion process [118], and pollutant formation [119]. One of the approaches for predicting combustion process in the industrial grate boiler is presented within this special issue [120]. The main objective of this study was to investigate the impact of the grate inlet conditions at the top surface of the fuel bed on the numerical simulation of the combustion and heat transfer in the biomass fired grate boiler. The comprehensive numerical analysis of the industrial grate-fired boiler was performed, and numerical results were compared with measurement data, showing a good potential of using numerical simulations as a tool to describe reacting flow in real combustion configurations.

6. Conclusion

In this editorial paper, some of the recent progress in sustainable energy-efficient technologies and environmental impacts on energy systems is addressed. It is based upon 16 papers selected among 601 contributions presented at Conference on Sustainable Development of Energy, Water and Environment Systems SDEWES 2019. It is readily apparent from this editorial paper review when considering sustainable energy and environmental issues that our scientific community focuses on research and development of advanced energy clean technologies by solving and overcoming many various challenges, such as improving energy efficiency, reducing carbon dioxide emissions, improving energy storage technologies, a further increase of renewable energy sources, improving energy savings in buildings, finding and improving new alternative fuels and mobile energy sources.

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