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Sustainable Energy Systems Planning, Integration, and Management

Amjad Anvari-Moghaddam ^{1,*} , Behnam Mohammadi-ivatloo ², Somayeh Asadi ³,
Kim Guldstrand Larsen ⁴ and Mohammad Shahidehpour ⁵

¹ Department of Energy Technology, Aalborg University, 9220 Aalborg East, Denmark

² Department of Electrical and Computer Engineering, University of Tabriz, Tabriz 5166616471, Iran; bmohammadi@tabrizu.ac.ir

³ Department of Architectural Engineering, Pennsylvania State University, University Park, PA 16802, USA; asadi@engr.psu.edu

⁴ Department of Computer Science, Aalborg University, 9220 Aalborg East, Denmark; kgl@cs.aau.dk

⁵ Armour College of Engineering, Illinois Institute of Technology, Chicago, IL 60616, USA; ms@iit.edu

* Correspondence: aam@et.aau.dk

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1. Introduction

Energy systems worldwide are undergoing a major transformation as a consequence of the transition towards the widespread use of clean and sustainable energy sources. The electric power system in a sustainable future will augment the centralized and large-grid-dependent systems of today with distributed, smaller-scale energy generation systems that increasingly adopt renewable energy sources (e.g., solar and wind) and rely on cyber technologies to ensure resiliency and efficient resource sharing. Basically, this involves massive changes in technical and organizational levels together with tremendous technological upgrades in different sectors ranging from the energy generation and transmission systems down to the distribution systems. These actions constitute a huge science and engineering challenges and demands for expert knowledge in the field to create solutions for a sustainable energy system (both at the energy supply and demand sides) that is economically, environmentally, and socially viable while meeting high security requirements. On energy consumers' side, useful and efficient energy services such as light, heating and cooling, cooking, communication, power, and motion are needed. These services are offered by specific equipment/devices, which use energy blocks either efficiently or inefficiently. Producing energy with high environmental, societal, or health risks is not a cheap way to meet such energy demand, but packages of efficient equipment and energy at least societal costs, which includes external costs, should be the ultimate objective to satisfy the needs of customers. At the supply side, there exists a bunch of opportunities for renewable energy technologies complemented with energy efficiency measures not only to provide local benefits, but also to contribute to sustainable development, which is framed in a three-pillar model: Economy, Ecology, and Society. Thus, the relationship between the use of renewables in energy mix and the sustainable developments goals (SDGs) can be viewed as a set of objectives and constraints that involve both global and local/regional considerations.

2. Sustainable Energy Systems Planning, Integration, and Management

To cover the above-mentioned promising and dynamic areas of research and development, this special issue was launched to allow gathering of contributions in sustainable energy systems planning, integration, and management. In total, 31 papers were submitted to this special issue, out of them 14 were selected for publication which denotes an acceptance rate of 45%. The accepted articles in this special issue cover a variety of topics, ranging from design and planning of small to large-scale energy

systems to operation and control of energy networks in different sectors namely electricity 1, heat 9, and transport 13.

Focusing on wave energy harvesting, the paper authored by Eugen Rusu [1] assessed the most relevant patterns of the wave energy propagation in the western side of the Black Sea considering eight different simulating waves nearshore computational domains. Special attention was paid to the high, but not extreme, winter wave energy conditions. The cases considered were focused on the coastal waves generated by distant storms, which means the local wind has not very high values in the targeted areas. From the analysis of the results, it was first noticed that the general patterns regarding the spatial distribution of the wave energy in the basin of the Black Sea do not substantially change. This means that the western side of the sea still remains its most energetic part. Furthermore, a general enhancement of the wave energy is noticed, and it appears that this enhancement is relatively higher in the western side. Moreover, related studies showed that the coastal environment of the Black Sea, and especially its northern and western side, is fully appropriate for the implementation of offshore wind projects.

The work, done by Wang et al. [2] illustrated the role of the multi-criteria decision making in determining the optimal location for solid waste-to-energy plant installation. To this end, the weight of criteria in the multi-criteria decision-making approach was determined using a hybrid fuzzy analysis as well as based on economic factors, technical requirements factors, environment factors, and social factors. In addition, the comprehensive model presented in that research can be used as a guideline to perform the placing mechanism in many countries to determine the optimal location for installing solid waste-to-energy plants.

The works done by Gebresenbet et al. [3] investigated smart logistics system (SLS) for the management of the pruning biomass supply chain. The major components of SLS including smart box, on-board control unit, information platform, and central control unit were studied. The author extended their work to study the role of smart logistics systems in increasing the efficiency of agricultural subscribers to use pruning biomass for generating renewable energy [4]. The smart logistics systems in the presence of renewable sources was shown to have an undeniable role in decreasing logistics cost, increasing pruning marketing opportunity, and decreasing product loss. Four actors of the presented biomass supply chain include producer, traders, transporter, and consumers. In the proposed model, the initial chain, i.e., producers, were the farmers.

In order to consider the uncertainty related to the wind speed as well as electrical power produced through wind farms, a new short-term wind speed forecasting method was introduced to achieve a more satisfying performance in forecasting data by Liu et al. [5]. In this research, to overcome the shortcomings of some traditional models and enhance the forecasting ability, Ensemble Empirical Mode Decomposition model was developed. The authors also used six evaluation indexes, Willmott's Index, Nash–Sutcliffe coefficient, Legates and McCabe Index, mean absolute error, square root of the average of the error square, and the average of absolute percentage error, to assess the effectiveness of the proposed method.

The work done by Peicong Luo [6] elaborated on an efficient approach to dynamically adjust the datacenter load to balance the unstable renewable energy input into the grid. Their experimental results illustrated that the dynamic load management of multiple datacenters could help the smart grid to reduce losses and mitigate stability issues such as bus voltage variations and the overloading of transmission lines and accordingly save operational costs. As a complement to the proposed system, a forecasting method was also designed, based on the concept of neural networks, to predict renewable energy generation in advance so as to adjust the power of the datacenters as soon as possible and reduce the extra losses.

Authors of [7] studied the effects of the different meteorological variables on the power generation via photovoltaic systems. The investigated meteorological data in this paper included solar radiation, outdoor temperature, wind speed, and daylight time. To obtain a statistical representative model of the generated power by photovoltaic systems, the gradient descent optimization (GDO) was used. It was

shown that the presented statistical method has the capability to minimize the introduced structure error using a linear Least Square Regression. Using the presented statistical structure, the estimation results' error was about 7% compared to the real data.

In [8] a robust strategy based on particle resampling was proposed to select the load identification features for applications in energy monitoring and measurement systems specially in residential sector. Through incorporation of a 2-D fuzzy membership measurement, it was shown that the feature extracted by the resampling method is closer to that of the actual device, and can be applied to load identification. However, a relatively stable switching period of the devices is needed.

The field measurements and numerical simulation was carried out by Zhu et al. [9] to assess the energy performance of a typical rural residential building in the Ningxia Hui Autonomous Region in Northwest China. It was found that application of solar energy resources is an effective approach to improve the indoor temperature. The other influencing factor such as building layout and proper thermal performance of the building envelope could reduce wind velocities and convective heat loss. Besides, insulation materials and double-glazed windows were found to significantly improve energy performance in new buildings.

Recently, Wang and Zhong [10] developed a three-dimensional simulation model to investigate the building heating load with various irregular heating durations and internal wall layouts. The results of the simulation model were validated with collected experimental data. In comparison of daily heating load with operation hours, results indicated a direct relationship between the daily heating load and the peak value. It was also found that the use of continuous heating when the daily operation hours are more than the threshold values is more economical.

In [11], a novel framework was designed for economic cooling load dispatch in conventional water-cooled chillers and to model the uncertain nature of cooling demand in the day-ahead scheduling. Three decision-making modes including (a) risk-neutral approach, (b) risk-aversion or robustness approach, and (c) risk-taker or opportunistic approach were considered in this study. To determine the optimum operating point of the chiller loading in these three modes, the information gap decision theory was used. The developed model has the capability to enable a system operator to enter the energy cost parameter and reduce the daily energy cost to this critical value and also to identify the increase in maximum cooling demand in the robustness model.

In [12], a new methodology was proposed for internal covering designs to enhance the permeable, semi-permeable, and impermeable internal coverings effect over indoor ambiances. The artificial neural network was used to forecast the indoor ambience. The results of this study had a significant impact on the indoor thermal comfort and energy consumption and suggested the permeable coverings as the suitable approach to minimize energy peak demands in the first hours of occupation and improving thermal comfort condition.

The article, authored by Yuhuan Liu et al. [13], studied the operating organization problem with the multi-type bus, namely pure electric buses and traditional fuel buses, aiming to provide guidance for future application of electric buses. Minimization of the energy consumption of vehicles as well as the waiting and traveling time of passengers were considered as the objectives in the work, while vehicle full load limitation, minimal departure interval, mileage range, and charging time window were taken as constraints. The authors also made a comprehensive analysis on the relationship between the bus driving energy consumption and bus dispatching and bus type matching ratio under the background that pure electric buses gradually replace traditional fuel buses, and many routes are operated with mixing pure electric buses and traditional fuel buses.

Focusing on robust planning of energy and environment systems, a dual robust stochastic fuzzy optimization (DRSFO) model was developed in [14] to analyze the trade-offs between system costs and reliability for planning of energy and environment systems while considering associated risks from the stochastic and fuzzy uncertainties. The model was developed using historical annual electricity data to forecast the future demand. To avoid any deviations from the optimized decision schemes even during the electricity shortage, hourly or seasonal electricity load curves were not considered in

the model. It was suggested by the authors to develop a simplified calculation procedure, consider economic aspects of the model, and refine multi-objective models to accurately find the trades-off between energy and environmental systems.

3. Sustainable Energy Systems of the Future

The future energy systems must necessarily match the so-called energy triangle and deliver on all the three dimensions: (1) providing safe, secure, and reliable energy while delivering access to all energy consumers, (2) supplying energy at affordable prices, and (3) assuring sustainable development. Over the past decades, the energy systems that evolved in different sectors have greatly achieved the goal of enabling substantial economic growth. However, due to some reasons, the aforementioned triangle is out of balance in different places around the world. For about 1.1 billion people—14% of the global population—do not have access to electricity according to [15]. Many more suffer from poor quality energy supply. In several places across the globe (such as sub-Saharan Africa and developing Asia), affordability is still an unresolved issue. More importantly, the environmental impact in most countries is beyond what we can sustain, especially as world population heads towards a projected nine billion people. The goal is, however, to create sustainable energy future by installing intelligent, cost-effective, and efficient systems with the lowest ecological footprints.

In the future, integrated models, which take end-use energy efficiency, renewable energy harvesting, and SDGs into account, may be in a favorable position to better link the weak and strong sustainable development paradigms for decision-making processes. By including important and relevant bottom-up indicators in a well-defined structure, integrated models are deemed to explore scenarios for boosting social and economic development and energy access and security as well as mitigating negative environmental and health impacts. In this way, today's energy systems can be expected to transform to sustainable energy systems which are carbon neutral, efficient, accessible, affordable, and secure.

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