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Editorial

Emerging Technologies for the Energy Systems of the Future

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1. Introduction

The way the world gets its energy is undergoing a rapid transition, driven by both the increased urgency of decarbonizing energy systems and the plummeting costs of renewable energy technologies. The road to the future will not be easy, and indeed, new technologies, markets, architectures, infrastructures, actors, and business models should be developed, and major changes will be required in the regulation of the energy systems to further support new business models and new consumption patterns. Such a transition requires rethinking every single aspect of energy systems, starting from the way energy is produced and harvested to the way that we dispatch and use it. In this area, it is also imperative to understand how to control and manage existing and emerging technologies to enhance the energy economy and efficiency by active participation in different services required by energy networks.

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2. Emerging Technologies for Modern Energy Systems

This Special Issue covers new advances in the emerging technologies for modern energy systems from technical and management perspectives. In this context, an integrated and systematic view on different energy systems from the local energy systems and islands to the national and multinational energy hubs is a necessity that should be studied. From the customer side, it is required to have more intelligent appliances and smart customer services. The customers are required to be provided with more useful information and control options. On the supply side, a key challenge for energy systems of the future is the increased penetration of renewable energy sources. Hence, new operation and planning tools are required for hosting renewable energy sources as much as possible. Considering different aspects involving future energy systems deployment, the Special Issue on "Emerging Technologies for the Energy Systems of the Future" was launched to allow the gathering of contributions in the planning, integration, and management of such systems. In total, 15 papers were submitted to this Special Issue, and out of them, 10 were selected for publication. The accepted articles in this Special Issue cover a variety of topics, ranging from energy forecasting and the techno-economic analysis of renewable-based energy systems [1–3] to their hybridization [4,5], control [6,7] and integration [8–10].

The authors in [1] investigated the impact of wind generation forecasts on the market electricity prices by developing the autoregressive moving average (ARMA), ARMA with exogenous inputs (ARMAX) and a nonlinear autoregressive neural network (NAR), and NAR with exogenous inputs (NARX) artificial neural network (ANN) models of two differently conditioned power systems (Portugal and Poland) with a set of distinguishing

features. It has been noted that the impact of wind power variability on the market electricity prices is caused by the relatively low marginal cost of the energy from wind farms, as wind energy is not burdened with fuel costs.

In [2], the authors proposed a deep learning technique called bidirectional long short-term memory(Bi-LSTM) to properly forecast the short-term load in a rural microgrid in Sub-Saharan Africa and solve the problems related to the reviewed methods, such as convolutional neural networks (CNNs), deep autoencoders (DAEs), recurrent neural networks (RNNs), and deep belief neural networks (DBNNs). The proposed method showed reasonable performance in processing large volume and time series data and dealing with missing data and overfitting during the training phase.

The authors of [3] provided a techno-economic analysis of different renewable energy technologies, including wind, solar photovoltaic (PV), and hybrid PV–wind systems. The objective was based on maximizing the renewable energy sources (RES) fraction, with the levelized cost of electricity (LCOE) being less than or equal to the local grid tariff in the studied system (i.e., Gwanda, Zimbabwe). The results confirmed that the PV–wind hybrid system had the best economic benefits, represented by the net present value (NPV) and the payback period (PBP), and the best technical performance. The authors determined the optimal size of the hybrid system and found that the PBP would be less than four years.

Focusing on hybrid renewable energy and energy storage systems for island power systems, the authors in [4] considered the Greek island power system of Astypalaia as a case study and designed a hybrid system, including a wind energy system and a battery energy storage system. Considering different economic indicators, the optimal combination was obtained, and then stability analysis was done to check the technical feasibility and sustainability of the system.

G.V. Kumar et. al. in [5] reviewed the energy storage system (ESS) participation in the provision of the ancillary services in a microgrid. The ESSs had a number of advantages, such as supply-demand balancing, smoothing of the intermittent generation from the renewable energy sources (RESs), enhancing the power quality and reliability (PQR), and provision of ancillary services like voltage and frequency regulation for the optimal operation of microgrids. In this paper, the status quo, opportunities, challenges, and real-world applications of the ESS application in providing different services in the electric power industry were explained.

The authors in [6] provided a model for secondary voltage control of a 100% renewable electricity system by extracting reactive power from renewable power technologies. Active and reactive power controls are considered based on the grid codes of countries with high penetration levels of renewable energy technologies. Based on a short-circuit calculation and sensitivity analysis, a pilot bus was selected to implement the secondary voltage control, which was based on a PID controller. In order to measure the voltage magnitude of buses with minimum cost, the optimal placement of phasor measurement units (PMUs) was performed. The optimal voltage magnitudes at busbars were calculated to achieve minimum power losses using optimal power flow. Optimization and simulation processes were performed using DIgSILENT and MATLAB software applications on a 100% renewable 14-bus system.

The authors in [7] presented a study of the load frequency control of an islanded marine microgrid composed of wind, tidal, and wave generators. First, they analyzed the impact of different supplementary control schemes on the dynamic performance of the load frequency control. Then, a novel black widow optimization technique was devised to design the hybrid system controllers and tidal supplementary controller. The authors demonstrated that the contribution of the tidal supplementary controller to the load or generation variation was more effective than the wind blade pitch controller in different operating conditions.

In [8], the generalization of solar water heater systems in Morocco and their potential energy-saving, economic and environmental benefits were presented. In particular, the

authors analyzed the thermal performances and economic benefits of direct thermosyphon solar water heaters (TSWHs) for residential requirements in Morocco. Through various studies, it was concluded that the large-scale rollout of TSWHs could supply up to 70% of thermal energy loads and could provide USD 1250 million in savings on the total energy bills. This will also have significant environmental benefits by reducing CO2 emissions.

With the aim of highlighting the potential of solar water heater installations in Morocco, the work done in [9] involved the comparison of active and passive solutions for energy efficiency in buildings. By leveraging TRNsys Studio, a numerical simulation model of solar water heater installations was created considering various hot water demand scenarios (low, standard, and high) in six climatic zones defined in the Moroccan thermal regulation of constructions. The savings made by applying the various solutions were categorized into two parts: energy and financial. A comparison of energy savings showed that solar water heater solutions were superior to those achieved by building envelope actions. Additionally, the financial analysis of the savings on the calculated bills showed that solar water heater solutions were attractive in nonsubsidized butane gas prices.

Finally, the authors of [10] presented a brief review of definitions, research, and challenges in the integrated management of natural resources such as food, energy, and water. In this regard, some facts about demand growth and exponential consumption in these three areas were described, with emphasis on presented statistics. Then, the most critical research published in this field was reviewed, considering that it took a decade or so before the original idea was introduced. The most important policymakers of this emerging concept, including committees and conferences, and finally significant challenges and opportunities to the implementation, along with future insights, were addressed.

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