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Editorial

Recent Advances and Challenges in Emerging Power Systems

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Diminishing fossil fuels, the continually increasing demand for energy due to rapid urbanization, pollution caused by the increased generation of electricity using fossil fuels, the consequent environmental effect, and concerns about man-made global warming have prompted a call for renewable energy solutions. This has led to the development of renewable energy sources for the generation of electricity and their integration within conventional power networks. Lack of control on the renewable energy sources results in the intermittent generation of electricity from these sources.

Differences in the characteristics of the generation of electricity from conventional and renewable energy sources offer challenges, and major restructuring in the operation, control, and protection practices of the entire power network is currently taking place to integrate the two in a seamless and efficient manner. It also offers a tremendous opportunity to rejuvenate the practices that have developed over the past 140 years and enhance the entire grid operation, making it more efficient and reliable considering the newly developed technologies.

Many investigators in all parts of the world are now working on developing new ideas and schemes from this perspective, and many advances in emerging power systems are being made. The objective of this Special Issue of *Inventions* is to provide a platform where all researchers can contribute their ideas on the new developments in electricity generation from renewable sources and the challenges encountered in the integration of conventional power systems with the electrical energy generated using various renewable energy sources with wide ranging characteristics.

The first volume of this Special Issue contains a total of 16 papers—1 review paper and 15 research papers—covering a broad range of topics related to the recent advances in power systems and the challenges faced by emerging power systems. All 16 papers are available at https://www.mdpi.com/journal/inventions/special_issues/Power_Sys (last access date 30 April 2024).

Titles of these papers and a brief description of their contents are given below.

The first article, "A Review of Perspectives on Developing Floating Wind farms", by Mohamed Maktabi and Eugen Rusu provides a review of floating wind concepts and projects around the world, which will show the reader what is going on with the projects globally. The main aim of this work is to classify floating wind concepts in terms of their number and manufacturing material, their power capacity, their number, their characteristics (if they are installed or planned), and the corresponding continents and countries where they are based. Additional available data that correspond to some of these projects, with reference to their cost, wind speeds, water depth, and distance to shore, are also classified.

The second article, "Coordinated, Centralized, and Simultaneous Control of Fast Charging Stations and Distributed Energy Resources" by Dener A. de L. Brandao et al., investigates the technical issues related to changes in the voltage profile of grid nodes and to feeder current overload in electrical power systems caused by the growing penetration of fast charging stations (FCSs) for electric vehicles and distributed energy resources (DERs). A coordinated and simultaneous control of DERs and FCSs based on a power-based control

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strategy, efficiently exploiting FCSs in a microgrid model, is proposed. The results show that, with the coordinated control of DERs and FCSs, the control of the power flow in a minigrid is achieved both in moments of high generation and in moments of high load, even with the maximum operation of DERs.

The third article, "IIR Shelving Filter, Support Vector Machine and k-Nearest Neighbors Algorithm Application for Voltage Transients and Short-Duration RMS Variations Analysis" by Vladislav Liubčuk et al., presents a unique and heterogeneous approach to the assessment of voltage transients and short-duration RMS variations by applying AI tools using databases of both real and synthetic data. The fundamental grid component and its harmonics filtering are investigated with an IIR shelving filter. Also, both SVM and KNN are used to classify PQ events by their primary cause in the voltage–duration plane as well as by the type of short-circuit in the three-dimensional voltage space. To avoid the difficulty in interpreting the results in the three-dimensional space, a method is developed to convert them to two-dimensional space. Based on the results of a PQ monitoring campaign in the Lithuanian distribution grid, this paper presents a unique discussion regarding PQ assessment gaps that need to be solved.

In the fourth article, "Development and Application of an Open Power Meter Suitable for NILM", the authors Carlos Rodríguez-Navarro et al. introduce an Open Multi Power Meter, an open hardware solution designed for efficient and precise electrical measurements to address the challenge of the global energy sector's increasing reliance on fossil fuels and escalating environmental concerns. The power meter, engineered around a single microcontroller architecture, features a comprehensive suite of measurement modules interconnected via an RS485 bus, to ensure high accuracy and scalability. A significant aspect of the developed meter is the integration with the Non-Intrusive Load Monitoring Toolkit, which utilizes advanced algorithms for energy disaggregation, including Combinatorial Optimization and the Finite Hidden Markov Model. The analyses performed validate its design and capabilities. Studies demonstrate the device's effectiveness, characterized by its simplicity, flexibility, and adaptability.

The fifth article, "Load Losses and Short-Circuit Resistances of Distribution Transformers According to IEEE Standard C57.110" by Vicente León-Martínez et al., describes expressions developed for the short-circuit resistances of three-phase transformers according to IEEE Standard C57.110. Considering that these resistances cause load losses of the transformer, two types of short-circuit resistance have been established: (1) the effective resistance of each phase (Rcc,z), closely related to the power loss distribution within the transformer, and (2) the effective short-circuit resistance, a mathematical parameter. Applying these to a 630 kVA oil-immersed distribution transformer, it is concluded that both types of resistances determine the total load losses of the transformer. Rcc,z accurately provides the load losses in each phase. Rcc,ef can give rise to errors depending on harmonic currents.

In the article, "Optimal Dispatch Strategy for a Distribution Network Containing High-Density Photovoltaic Power Generation and Energy Storage under Multiple Scenarios" by Langbo Hou et al., it is shown that the application of energy storage devices in the distribution network realizes peak shaving and valley filling of the load, and also relieves the pressure on the grid voltage generated by the distributed photovoltaic access. At the same time, photovoltaic power generation and energy storage cooperate and have an impact on the current distribution of the distribution network. Since photovoltaic output has uncertainty, the maximum photovoltaic output in each scenario is determined by the clustering algorithm, while the storage scheduling strategy is appropriately selected so the distribution network operates efficiently and stably. Optimization of the distribution network is carried out using an improved Particle Swarm Optimization algorithm with the objectives of minimizing network losses and voltage deviations. Studies on a 30-bus system optimally dispatched under multiple scenarios demonstrate the necessity of conducting a coordinated optimal dispatch of photovoltaics and energy storage.

In the article, "Fault Location Method for Overhead Power Line Based on a Multi-Hypothetical Sequential Analysis Using the Armitage Algorithm" by Aleksandr Kulikov

et al., a method of fault location (FL) on overhead power lines (OHPLs) is proposed based on a multi-hypothetical sequential analysis using the Armitage algorithm. The inspection area of the OHPL is divided into many sections and the task of recognizing a faulted section of an OHPL is formulated as a statistical problem. The developed method makes it possible to adapt the distortions of currents and voltages on the emergency mode oscillograms to the conditions for estimating their parameters. Studies show that the implementation of the developed method has practically no effect on the speed of the FL algorithm by emergency model parameters. This ensures the uniqueness of determining the faulted section of the OHPL under the influence of random factors, which leads to a significant reduction in the inspection area of the OHPL.

In the article, "A Rank Analysis and Ensemble Machine Learning Model for Load Forecasting in the Nodes of the Central Mongolian Power System" by Tuvshin Osgonbaatar et al., a new method is proposed to predict power consumption in all nodes of the power system through the determination of rank coefficients calculated directly for the corresponding voltage level, including node substations, power supply zones, and other parts of the power system. An ensemble of decision trees is applied to construct a daily load schedule and rank coefficients are used to simulate consumption in the nodes. Initial data, obtained from daily load schedules, meteorological factors, and calendar features of the central power system, account for most of the energy consumption and generation in Mongolia for the period of 2019–2021. The daily load schedules were constructed using machine learning with a probability of 1.25%.

The contribution of the article "Inductive Compensation of an Open-Loop IPT Circuit: Analysis and Design" by Mario Ponce-Silva et al. is the inductive compensation of a wireless inductive power transmission circuit with resonant open-loop inductive coupling. Variations in the coupling coefficient k due to the misalignment of the transmitter and receiver are compensated with only one auxiliary inductance in the primary of the inductive coupling. Experiments were conducted on a low-power prototype with an input voltage of 27.5 V, output power of 10 W, switching frequency of 500 kHz, output voltage of 12 V, and transmission distance 'd' of 1.5 mm, by varying the distance "d" with several values of the compensation inductor, demonstrating the feasibility of the proposal. An efficiency of 75.10% under nominal conditions was achieved.

In the tenth article, "Performance Analysis of Harmonic-Reduced Modified PUC Multi-Level Inverter Based on an MPC Algorithm" by Umapathi Krishnamoorthy et al., a multi-level inverter for an application is selected based on a trade-off between cost, complexity, losses, and total harmonic distortion (THD). A packed U-cell (PUC) topology, composed of power switches and voltage sources connected in a series–parallel fashion, that can be extended to a greater number of output voltage levels requires fewer power switches, gate drivers, protection circuits, and capacitors. A converter is presented with a 31-level topology, switched by a variable-switching-frequency-based model predictive controller that helps in achieving optimal output with reduced harmonics. The gate driver circuit is also optimized in terms of power consumption and size complexity. A comparison of the 9-level and the 31-level PUC inverters shows that the THD for a nominal modulation index of 0.8 is 11.54% and 3.27% for the 9-level multi-level inverter and the modified 31-level multi-level inverter, respectively.

In the article, "A Decentralized Blockchain-Based Energy Market for Citizen Energy Communities" by Peyman Mousavi et al., a decentralized blockchain network based on the Hyperledger Fabric framework is introduced, enabling the formation of local energy markets of future citizen energy communities (CECs) through peer-to-peer transactions. It is designed to ensure adequate load supply and observe the network's constraints while running an optimal operation point by consensus among all the players in a CEC. The proposed framework proves its superior flexibility and proper functioning. The results show that the proposed model increases system performance, reduces costs, and reaches an operating point based on consensus among the microgrid elements.

In the article, "Robust Control and Active Vibration Suppression in Dynamics of Smart Systems" by Amalia Moutsopoulou et al., a smart structure with piezoelectric (PZT) materials is investigated for its active vibration response under dynamic disturbance. Numerical modeling with finite elements is used to achieve that. Vibration for different model values is presented considering the uncertainty of modeling. Vibration suppression was achieved with a robust controller and with a reduced-order controller. The results presented for the frequency domain and the state space domain demonstrate the advantage of robust control in the vibration suppression of smart structures.

In the article, "Compromised Vibration Isolator of Electric Power Generator Considering Self-Excitation and Basement Input" by Young Whan Park et al., two performance indices of the vibration isolator are introduced to evaluate the vibration control capability over two excitation cases, self-excitation and basement input, using the theoretical linear model of the electric power generator. The proposed strategy is devoted to enhancing the vibration control capability over the basement input, owing to the acceptable margin for self-excitation. Modification of the mechanical properties of the vibration isolator focuses on the isolator between the mass block and the surrounding building. The simulation results show that an increase in the spring coefficient and a decrease in the damping coefficient of the vibration isolator beneath the mass block could enhance the vibration reduction capability over the basement input.

In the article, "Organization of Control of the Generalized Power Quality Parameter Using Wald's Sequential Analysis Procedure" by Aleksandr Kulikov et al., considering the requirements set by industrial enterprises with respect to power quality parameters (PQPs) at the points of their connection to external distribution networks, a rationale is provided for the transition from the monitoring of a set of individual PQPs to a generalized PQP with the arrangement of the simultaneous monitoring of several parameters. The joint use of the simulation results and data from PQP monitoring systems for PQP analysis using the sampling-based procedure produces the desired effect. An example of a sequential decision-making process in the analysis of a generalized PQP based on Wald's sequential analysis procedure is provided. With this technique, it is possible to adapt the PQP monitoring procedure to the features of a specific power distribution network. The structural diagram of the device, that implements the sampling-based monitoring procedure of the generalized PQP, is also presented.

In the article, "Research of Static and Dynamic Properties of Power Semiconductor Diodes at Low and Cryogenic Temperatures" by Mikhail Ostapchuk et al., new requirements imposed on power conversion in systems with high-temperature superconductors are investigated as the main part of the losses in such systems is induced in the semiconductors of the converters. The possibility of improving the static and dynamic characteristics of power semiconductor diodes using cryogenic cooling is confirmed with a loss reduction of up to 30% achieved in some cases.

In the article, "Energy-Saving Load Control of Induction Electric Motors for Drives of Working Machines to Reduce Thermal Wear" by Tareq M. A. Al-Quraan et al., the influence of reduced voltage on the service life of an induction motor is investigated. An algorithm, developed for calculating the rate of thermal wear of induction motor insulation under a reduced supply voltage depending on the load and the mechanical characteristics of the working machine, determines the change in the rate of thermal wear under alternating external effects on the motor (supply voltage and load) and allows the forecasting of its service life. It is determined that the rate of thermal wear of the induction motor insulation increases significantly when the voltage is reduced compared to its nominal value with nominal load on the motor. The results of the experimental verification of the obtained rule for "Asynchronous Interelectro" series electric motors confirm its accuracy. Based on the obtained correlation, the rule of voltage regulation in energy-saving operation mode is derived.

Concluding remarks.

Concern about the effect of fossil fuel-based electricity generation on the environment has resulted in very significant advances in the use of renewable sources of energy to

generate electricity. These advances have inevitably been accompanied with challenges, and tremendous efforts are being devoted to overcoming these. This has become evident from the interest shown in this Special Issue and the number of papers that have been received from a wide variety of geographical areas, encompassing a diverse range of research and elucidating the richness of the research field.

Considering the above, further papers are being invited for a second volume of the Special Issue "Recent Advances and Challenges in Emerging Power Systems".

Conflicts of Interest: The author declares no conflicts of interest.