

# **Introduction to the Special Section on Artificial Intelligence in Renewable Energy**

## **Background**

The world's today is in an unprecedented and urgent need to optimize energy consumption and accelerate the transition towards green, low-carbon electricity generation. To face the various challenges in the digital transformation of the energy ecosystem, technologies such as Big Data Analytics, Machine Learning and Artificial Intelligence (AI) are poised to play an increasingly important role in the years ahead. Expanding the adoption of AI technology across the energy sector will enable better control and management of energy consumption, anticipating network malfunctions, or even optimizing infrastructure assets.

The aim of this special section is to disseminate the latest and ongoing research and technological advancements on the application of AI in modeling, control and optimization of Renewable and Alternative Energy Systems and future smart electricity networks.

Out of forty-three (43) submissions, nine (9) papers were selected. Each paper was reviewed by at least three reviewers and went through at least two rounds of reviews. The brief contributions of these papers are briefly summarized below.

## **Articles in the Special Issue**

In the first paper, the authors Asif Khan and Nadeem Javaid propose a new method, based on Jaya algorithm, for the optimal sizing of renewable energy resources, including photovoltaic (PV) panels, wind turbines (WTs), and fuel cells (FCs). The proposed approach aims at reducing the consumer's total annual cost in a standalone system. The methodology has been applied to real solar irradiation and wind speed data collected from the City of Hawksbay in Pakistan. A comparative study between Jaya algorithm, genetic algorithm, backtracking search algorithm, and particle swarm optimization is presented.

The second contribution from Angel Arroyo, focusses on the prediction of the energy generated from a solar thermal system. The author developed a new Hybrid Intelligent Systems (HIS) based on local models and implement both supervised (artificial neural networks) and unsupervised learning (clustering). These techniques are combined and applied to a real-world installation located in Spain. Alternative models are compared and validated in this case study with regular data from a whole year.

The authors, Subhojit Ghosh et al., of the third contribution proposed a protection scheme based on the joint probabilistic modeling of the stochastic nature of solar irradiance and wind speed

to perform fault detection/classification and zone identification. The performance of the proposed protection scheme has been examined for diverse test cases and compared with other computational intelligence techniques in terms of dependability and security. The proposed scheme has been validated in a real-time environment using OPAL-RT digital simulator.

In the fourth contribution, a comprehensive assessment of MLP training approaches consisting of three stages has been performed by Haidar Samet. First, the prediction performance of twelve (12) training algorithms is presented. In the second stage, several optimization algorithms are employed to select the best network parameters obtained from first step. In the third stage, the author proposed a new approach to improve the performance of these optimization algorithms. The proposed methodologies were applied to two case-studies and statistical metrics had been utilized to compare their performance.

In the fifth paper, the author Karl Mason et al. presents a comprehensive literature review on the application of reinforcement learning into the developing autonomous building energy management systems. Energy savings of greater than 20% were reported in the literature for more complex building energy management problems when implementing reinforcement learning. The main direction for future research and challenges in reinforcement learning were also outlined.

A new model has been introduced by Behnam Mohammadi-ivatloo et al. to determine the optimal loading point of the chillers aiming at minimizing the total electrical consumption. To do so, optimal dispatching of multi-chiller plant has been formulated as an optimization problem with constraints. The proposed approach was termed augmented group search optimization (AGSO) algorithm which has been devised to avoid drawbacks of conventional group search optimization algorithm such as trapping in the local minima. The effectiveness and robustness of the proposed approach in comparison with available methods were studied through three well-known test cases. Numerical results demonstrate that AGSO with its strong exploration capability, achieves a lower energy consumption than ~~that of~~ recently published methods with higher convergence speed.

Haidar Samet suggested a new method of fault location in Multi-Terminal High-Voltage Direct Current (MTHVDC) systems based on machine learning strategies. The concept of Extreme Learning Machine (ELM) is adopted to locate various faults in the system. Signatures extracted from various voltage and current waveforms of the system were used to train the ELM. To this end, the models obtained from S-transform and wavelet transform are compared. Different voltage and current signals on both sides of the lines were considered to derive the best signals for this purpose. The accuracy of the technique is investigated for different lengths of the

analyzed window. In order to implement the method in the MTHVDC system, two approaches were considered. In the first approach, a single ELM has been used for the whole length of the line. In the second one, a multi-ELM technique has been applied to different sections of the transmission line with an ELM for each section of the line. The results showed that the performance of the method was improved when a multi-ELM was employed. Furthermore, the results of the ELM approach were compared with those using ANN and SVR techniques. The proposed technique was proven to provide more accurate fault location and was robust against noises and variation of fault resistance or parameters of the transmission line.

Diwaker Pathak proposed an application of fractional order fuzzy-proportional-integral-derivative (FOFPID) controller for pitch angle control to maintain the output power of a direct-drive Wind Energy Conversion System (WECS) at its rated value of 2-MW under dynamic wind conditions. The performance criteria used to assess the proposed controller were rise time, settling time, overshoot and total harmonic distortion (THD). The results are compared with conventional and other intelligent controllers. Furthermore, the proposed controller has been well-tuned using teaching learning based optimization (TLBO) algorithm. The performance of the TLBO has been also compared with the genetic algorithm (GA).

In the final paper of this issue, the authors Sajad Madadi et al. presented hybrid methods for the evaluation of probabilistic small signal stability (PSSS) in power systems. These methods are based on clustering approaches and Monte Carlo simulation (MCS) which has been deployed in a probabilistic problem to achieve acceptable results. Hybrid methods have two steps for the evaluation of PSSS. Clustering methods divide stochastic sets into small sets; the member of small sets has been deployed to calculate eigenvalues similar to MCS. Consequently, this method is faster than the MCS. Two case studies that are based on IEEE 9-bus and 39-bus test systems for the evaluation of the proposed method. It has been shown that the proposed methods have accurate results and are faster than MCS.

### **Final Thoughts**

The guest editors hope that the research contributions collected in this special section will be beneficial to the readers and will stimulate further developments and open-up new ideas in this exciting multidisciplinary area of research. We are immensely grateful to the Editor-in-Chief Dr Manu Malek for offering us the opportunity to organize this special section. We would like to express our sincere thanks to the editorial office staff for their professional work and excellent support. We are also very thankful to all the authors for their valued contributions and to the reviewers for their constructive recommendations.

## Guest Editors

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## **Accepted Articles**

- [1]. Asif Khan, Nadeem Javaid, "Optimal sizing of a stand-alone photovoltaic, wind turbine and fuel cell systems"
- [2]. Nuño Basurto, Angel Arroyo, Rafael Vega Vega, Héctor Quintian, Jose Luis, Calvo-Rolle, Álvaro Herrero, "A Hybrid Intelligent System to Forecast Solar Energy Production"
- [3]. Murli Manohar, Ebha Koley, Subhojit Ghosh, "Optimal Random Forest based Microgrid Protection under Weather Uncertainty Using Joint Probabilistic Modeling of Solar Irradiance and Wind Speed"
- [4]. Fatemeh Marzbani, Mohammad Reisi Esfarjani, Haidar Samet "Comprehensive Evaluation and Implementation of MLP-based Methodologies for Short-term Wind Speed Forecasting"
- [5]. Karl Mason, Santiago Grijalva, "A Review of Reinforcement Learning for Autonomous Building Energy Management"
- [6]. Behnam Mohammadi-ivatloo et al. "An Augmented Group Search Optimization Algorithm for Optimal Cooling-Load Dispatch in Multi-Chiller Plants"
- [7]. Haidar Samet, et al. "Multi ELM Approach for Fault Location in Multi-Terminal HVDC Systems; a Comprehensive Assessment"
- [8]. Diwaker Pathak, et al. "An Adaptive Fractional Order Fuzzy-PID based Pitch Angle Controller for a Direct-Drive PMSG assisted Wind Energy Conversion System"
- [9]. Saja Madadi, et al. "Probabilistic Small Signal Stability Evaluation of Power Systems with High Penetration of Wind Farms"

## **Biography of the Guest Editors**



**Mustapha HATTI** received his graduated diplomat from Houari Boumediene Sciences and Technology University of Algiers (USTHB), Algeria in Electronics, Magister and Doctorate in sciences in Electrical Engineering from Mohamed Boudiaf Sciences and Technology University of Oran, Algeria.

He worked as electronic engineer for The HCR (Haut Commissariat à la Recherche) at CDSE (Centre de Développement des Systèmes Energétiques), Ain Oussera, Algeria, for CRD (Centre de Recherche et Développement) Sonatrach, Hassi-Messaoud, Algeria, for the COMENA (Commissariat à l'Energie Atomique) at CRNB (Centre de Recherche Nucléaire de Birine), Birine, Algeria and as senior researcher for CDER (Centre de Développement des Energies Renouvelables) at UDES (Unité de Développement des Equipements Solaires) until now.

Editor of three books, several chapters and around thirty research papers and four patents. He leads the "Tipasa Smart City" initiative and is an IEEE Senior Member.

As Researcher Director, its main area of expertise includes modelling, control and simulation on an artificial intelligence, smart cities, IoT, smart energy management, renewable energy, storage energy and innovative

energetic systems, smart sustainable energy systems, fuel cell, photovoltaic, optimization, intelligent embedded systems.



**Mouloud DENAI** graduated from the University of Science and Technology of Algiers and Ecole Nationale Polytechnique of Algiers, Algeria in Electrical Engineering and received his Ph.D. in Control Engineering from the University of Sheffield, U.K.

He worked for the University of Science and Technology of Oran (Algeria) until 2004 and the University of Sheffield (U.K.) from 2004 to 2010. From 2010 to 2014, he worked for the University of Teesside (U.K.). He is currently with the University of Hertfordshire (U.K.) since 2014.

Dr Denai's main fields of expertise are in modelling, optimization and control of engineering and life science (biological and biomedical) systems. His current research interests in energy include intelligent control design and computational intelligence applications to efficiency optimization in renewable energy systems with particular focus in the management of smart homes and dynamic scheduling, optimization and control of future smart grids, condition monitoring and asset management in electric power networks; Energy storage systems integration into the grid; Smart meter data analytics using machine learning techniques for efficient energy management; electric vehicles integration into the distribution grid and V2G/G2V management.