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Editorial

Special Issue: "Improving Energy Efficiency through Data-Driven Modeling, Simulation and Optimization"

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In October 2014, EU leaders agreed upon three key targets for the year 2030: a reduction of at least 40% in greenhouse gas emissions, a saving of at least a 27% share for renewable energy, and at least a 27% improvement in energy efficiency. The increase in computational power combined with advanced modeling and simulation tools makes it possible to derive new technological solutions that can enhance the energy efficiency of systems, and that can reduce the ecological footprint. This Special Issue includes 10 novel research works that are based on data-driven approaches, machine learning, or artificial intelligence for the modeling, simulation, and optimization of energy systems.

Fang et al. [1] investigated the heat transfer in the enclosure structure of passive houses in cold areas with complex climatic conditions. A three-dimensional model was established to investigate the time-by-case changes of the outdoor temperature and solar irradiation based on the principle of integral change and the method of response coefficient and harmonious wave reaction. The variations in hourly cooling and heating loads with outdoor temperature and solar irradiation were analyzed. A strategic routine was suggested to remarkably decrease the total energy consumption and the annual operation cost of passive buildings.

Walther et al. [2] presented a systematic review of the state-of-the-art of existing approaches to predicting or forecasting energy consumption in the manufacturing industry. A morphology for classifying different approaches in the field of energy prediction and forecasting was developed, based on the identified influencing factors. Seventy-two articles, based on a systematic literature search, were classified according to the defined categories: system boundary, modeling technique, modeling focus, modeling horizon, modeling perspective, modeling purpose and model output. Furthermore, based on the reviewed articles, future research activities were derived.

Marinus et al. [3] presented and validated a data-driven response-surface model of fuel consumption data for turboprop-powered civil airliners. The model coefficients were predicted from empirical correlations based solely on the operating empty weight, and validation was performed on a separate set. The model can accurately predict the fuel weights of new designs for any combination of payload and range within the current range of efficiency of the propulsion. The accuracy of the model makes it suited for the preliminary and conceptual design of near-in-kind turbo-propeller aircraft. The model can shorten the design cycle by delivering fast and accurate fuel weight estimates from the first design iteration once the operating empty weight is known.

Donati et al. [4] proposed a method to optimally combine vehicle CO_2 reduction technologies in cars and other road vehicles to improve their energy efficiency. The incompatibility of these technologies gives rise to conflicting objectives that have to be optimized in a multi-objective way. For this NP-complete (non-deterministic polynomial complete) combinatorial problem, a method based on a metaheuristic with ant colony optimization (ACO) combined with a local search (LS) algorithm was proposed and generalized as the technology packaging problem (TPP). The performance of the proposed method was

Citation: Deschrijver, D. Special Issue: "Improving Energy Efficiency through Data-Driven Modeling, Simulation and Optimization". *Energies* **2021**, *14*, 1543. https://doi.org/10.3390/en14061543

Received: 5 March 2021
Accepted: 8 March 2021
Published: 11 March 2021

compared with a genetic algorithm (GA) and the obtained improvements were shown. Computational tests were also presented to show the effectiveness of this new approach.

Faustine et al. [5] developed a new application recognition method for non-intrusive load monitoring (NILM) that utilizes the recurrence graph (RG) technique and convolutional neural networks (CNNs). A weighted recurrent graph (WRG) generation was introduced that, given one-cycle current and voltage, produces an image-like representation with more values than the binary output created by RG. Experimental results from three different sub-metered datasets showed that the proposed WRG-based image representation provides superior feature representation and, therefore, improves classification performance compared to voltage-current (V–I)-based features.

Chen at al. [6] combined clustering and machine learning for enhancing the efficiency of the energy baseline of a chiller system. First, several machine learning algorithms were reviewed to establish prediction models. Then, the concept of clustering to preprocess chiller data was adopted. Data mining, K-means clustering, and gap statistics were used to successfully identify the critical variables to cluster chiller modes. Applying these key variables effectively enhanced the quality of the chiller data, and combining the clustering results and the machine learning model effectively improved the prediction accuracy of the model and the reliability of the energy baselines.

Szul et al. [7] evaluated the efficiency of habitat thermo-modernization. Several buildings from the end of the last century, which were thermally improved at the beginning of the 21st century, were designed for a comparative analysis of the predictive modeling of heating energy consumption. A specific set of important variables was identified to characterize the examined buildings. Groups of variables were used to estimate the energy consumption in such a way as to achieve a compromise between the difficulty of obtaining them and the quality of the forecast. To predict energy consumption, several neural methods were compared. The most effective method allows one to forecast with great precision the energy consumption (after thermal improvement) of this type of residential building.

Li et al. [8] presented a study of the mechanism of heat load reduction in the thermal anti-icing system of aircraft under the evaporative mode. A GA-based optimization method was adopted to optimize the anti-icing heat load and obtain the optimal heating power distribution. An experiment carried out in an icing wind tunnel was conducted to validate the optimized results. The mechanism of the anti-icing heat load reduction was revealed by analyzing the influences of the key factors, such as the heating range, the surface temperature and the convective heat transfer coefficient. These investigations can provide valuable guidance for the design of the thermal anti-icing systems.

Chrysostomo et al. [9] presented the application of a framework for big data analytical processing and mapping. It was conceived as a decision support tool for industrial business, encompassing the whole big data analytical process. A real-world application is the implementation of a predictive maintenance decision support tool in a hydroelectric power plant. Using the analytical workbench, all variables were properly analyzed. A predictive model was implemented for the predictive maintenance of equipment, identifying critical variables that define the imminence of an equipment failure. The model was combined with a time series forecasting model, based on artificial neural networks, to project those critical variables for a future time. The effectiveness and practical feasibility of the framework were demonstrated.

Guo et al. [10] investigated the change law of side abutment pressure and the movement law of overlying strata when using the fracturing roofs to maintain entry (FRME). A new abutment pressure monitoring device, i.e., a flexible detection unit (FDU), was developed and applied in the field. The paper compared the difference in lateral abutment pressure between the tail entry and head entry by monitoring the abutment pressure of solid coal on both sides of the working face with self-developed and more reliable FDU. Then, the influence of the cutting seam on the lateral abutment pressure of solid coal was explored. On the basis of fully considering the reasons for the change in abutment pressure after cutting the roof, the change in overburden movement caused by the slit was analyzed.

The contributed papers that are included in this Special Issue offer new and valuable insights that can stimulate ongoing research activities in the field. As guest editor, I would like to thank all authors that have submitted their research work to this Special Issue.

Funding: This special issue is supported by the Flemish Government under the "Onderzoeksprogramma Artificiële Intelligentie (AI) Vlaanderen" programme.

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

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