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Editorial

Special Issue on "Design and Control of Sustainable Processes"

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Sustainability has been one of the key drivers for technological innovation in this century. With the fundamental motivation of ensuring the fulfillment of current needs without compromising the needs of future generations, sustainability targets goals in economic (such as improved process and energy efficiency), environmental (such as minimization of carbon and waste footprint), and social (such as process safety) perspectives. These goals have given rise to a large number of sustainable process and energy systems such as reactive distillation, microreactors, CO_2 capture and sequestration, smart grids and microgrids, and smart manufacturing, and the quest for new designs is ongoing at a rapid pace.

At the same time, such systems pose unique operational challenges due to the presence of multiple length or time scales, multiple conflicting objectives, and interconnection of multiple agents [1]. These call for efficient control strategies to realize sustainable benefits into practice. In this context, integrated design and control of sustainable processes can allow balancing the trade-off between process economics and operational flexibility.

Motivated by this, the current special issue on "Design and Control of Sustainable Systems" incorporates recent developments in the area of design and/or control of sustainable process and energy systems. There are a total of 11 contributions in diverse application areas such as solar thermal systems, hydropower, wind power, thermal power plant, mining industry, wastewater treatment, water pollution, batch process energy integration, and carbon storage.

In the area of renewable energy production, the contribution by Venegas-Reyes et al. [2] focuses on the design and analysis of solar thermal system. It presents a parametric methodology to size stationary solar collector fields. Their methodology allows for optimal sizing of solar heating systems by comparing the technical-economic behavior of the different solar collector fields in series-parallel arrays. Specifically, it determines the number of collectors, optimal series-parallel array and volume of storage tank based on the thermal load. The work by Zhang et al. [3] focuses on small, decentralized small hydropower (SHP) systems integrated with the distribution grid. Specifically, the operation of mountainous distribution network with SHP is considered, which often trips the tie line. Island operation of such SHP systems is studied and an integration strategy (using fast busbar automatic transfer switch (BATS) to quickly connect this off-grid SHP to the distribution network) is analyzed. Payne et al. [4] deal with monitoring of distributed energy resources (DER) network. Specifically, a real-time thermal condition monitoring system using wireless sensor network is designed for a DER network consisting of renewable resources of solar and wind energy. The system is shown to be able to simultaneously send multiple alert notifications for control remedial solutions. Last, Sang et al. [5] deal with robust operation of off-shore wind farms connected with on-shore main grid. Specifically, a perturbation estimation-based nonlinear adaptive control strategy is developed to enhance the fault ride-through (FRT) capability of wind energy conversion systems (WECS). The control strategy can adapt to model uncertainties, time-varying disturbances and unknown time-varying

nonlinearities of power-electronic system. The control strategy is shown to provide robustness against system uncertainties and rapid response to deloading process and thereby enhancing the FRT capability.

In the context of emission and effluent management, Chen et al. [6] focus on the water pollution evaluation problem. The paper aims at effective coordination of multiple evaluation methods to obtain a consensus decision to aid policy makers. Specifically, the paper develops a hybrid ensemble learning evaluation method by combining Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS), Grey Relational Analysis (GRA), Analytic Hierarchy Process (AHP), and Takagi–Sugeno (TS) fuzzy neural network. This study illustrates the usefulness of multi-Multiple Criteria Decision Making (MCDM) approach in combination with ensemble vote as an effective tool for evaluation of water quality in the context of water pollution. Zhang and Liu [7] focus on wastewater treatment. Specifically, the optimal control of wastewater treatment plants to improve effluent quality and reduce operating cost is pursued within the framework of economic model predictive control (MPC). To mitigate challenges posed by large computational requirements of economic MPC, reduced order model-based controllers are designed. Two model reduction techniques are presented and the corresponding performance is compared through simulations. Last, Oncioiu et al. [8] focus on environmental sustainability. Specifically, the work facilitates implementation of green business process management in the mining industry. Ultimately it will assist managers to identify new opportunities to improve performance by optimizing green business processes. This work underscores the importance of green business process management to reduce cost of depollution and performance improvement.

In the context of process integration, Jogwar et al. [9] focus on scheduling aspects of energy-integrated batch process systems. The paper shows that energy integration constraints result in repeating patterns in the optimal schedules. Using these patterns, the scheduling problem can be very efficiently solved for longer/shorter horizons. Furthermore it highlights interesting relationships between scheduling horizon and intermediate inventory or equipment utilization. From an operational perspective, it demonstrates that such a pattern-based method can be integrated with conventional mixed integer optimization to achieve order of magnitude reduction in solution time.

In the context of carbon capture, Fu et al. [10] focuses on the effect of urbanization on carbon capture. Specifically, it investigates the spatiotemporal dynamics of carbon storage and analyzes the impact of urbanization on carbon storage in a specific region of China. Based on this, key contributors for carbon stock losses as well as factors to increase carbon storage are identified. This study aids in the development of sustainable urbanization.

In the context of improving performance of conventional energy production systems, Li and Wang [11] focus on performance assessment of coal fired boiler using actual operational data. Specifically, key variables affecting performance of the boiler combustion control system are identified and using Principal Component Analysis (PCA), their respective contribution rates are obtained. Ultimately this information is consolidated into a performance assessment index. The article provides reliable and rapid performance assessment method and describes suggestions to improve performance of the boiler combustion process. While the previous paper dealt with thermal control system, the second paper by Li and Wang [12] deals with the power generation system of a thermal power plant. The paper develops a control-relevant model for power control system (PCS). Three control architectures based on traditional PI control, internal model control (IMC), and feed forward (FF) control elements are developed and their dynamic performance is compared in detail. Through simulations, it is shown that a combination of IMC with PI control mode gives better and robust performance compared to traditional PI plus FF control strategy.

Overall, this special issue contributes towards key sustainability drivers such as renewable energy production, emission and effluent management, carbon capture, and process integration towards the realization of sustainable development goals. From systems engineering perspective, this issue contributes towards design, modeling, simulation, dynamics, scheduling, control, monitoring, and performance assessment of sustainable processes.

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Guest Editors

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