Journal of Engineering for Sustainable Buildings and Cities

Editorial

Editorial for Special Issue: Grid-Interactive Efficient Buildings—Part 2

This issue of the ASME *Journal of Engineering for Sustainable Buildings and Cities* (JESBC) is fully dedicated to peer-reviewed papers specific to technologies and applications of Grid-interactive Efficient Buildings (GEBs). As defined by a series of publications by the U.S. Department of Energy (DOE) [1–5] and outlined in Part 1 of the editorial in JESBC's August 2020 issue [6], GEBs are efficient, connected, smart, and flexible buildings. This GEB special issue covers several technologies and applications for grid-connected buildings and communities. Some of technologies included in this special issue include dynamic insulation systems for building envelopes, building-integrated fuel cells, and rooftop photovoltaic (PV) systems. Moreover, this issue outlines the designs and cost-benefits of net-zero energy (NZE) buildings and carbon-neutral communities in the United States. Specific summaries of the seven papers included in this issue are as follows:

- First, the review paper "A Review and Categorization of Grid-interactive Efficient Building Technologies for Building Performance Simulation" summarizes from the currently available literature the possible technologies for GEBs and their potential benefits, including providing grid services. In addition to discussing the reported performance of the reviewed GEB technologies, the paper outlines the ability of a state-of-the-art building energy simulation tool, EnergyPlus^{TM}, in modeling energy efficiency, peak shaving, and demand shifting benefits.
- The paper entitled "Optimal Control Strategies for Switchable Roof Insulation Systems Applied to US Residential Buildings" discusses the potential benefits of using dynamic insulation systems when applied to attics of U.S. homes. Dynamic insulation, unlike static insulation, allows the building envelope to change its thermal resistance depending on climatic variations and indoor conditions using a desired cost function. In this paper, the performance of optimal controls for specific dynamic insulation, referred to as switchable insulation systems or (SISs), is evaluated against simplified control strategies using only high and low R-value settings. The analysis results summarized in the paper confirm the energy efficiency benefits of SISs integrated into attics, especially when optimally controlled. Specifically, the results show that SISs could achieve annual energy savings up to 32% when optimally controlled, compared to those obtained from simplified operation strategies for a home located in Golden, CO.
- The paper "Transitioning from Net-Zero Energy Homes to Carbon Neutral Grid-Connected Communities" demonstrates the benefits of shared energy communities when on-site renewable power generation systems are operated to serve the energy needs of an entire residential community rather than individual homes. The analysis is based on optimization approaches based on life-cycle cost analysis to determine both energy efficiency measures and PV systems to design NZE homes as well as a carbon-neutral residential community located in Boulder, CO. The analysis indicates that the design specifications and costs of NZE homes depend significantly on occupant behavior. Indeed, the capital costs for NZE can range from a baseline behavior to 10.4% higher or 21.3% lower depending on energy use patterns of occupants. Moreover, the analysis confirms that sharing on-site PV systems within a community is more cost-effective for reaching carbon neutrality than having individual homes with their own rooftop PV systems.
- The study described in the paper entitled "Feasibility Assessment of a Grid-Connected Carbon Neutral Community in Midland Texas" assesses the cost-effectiveness of designing a grid-connected carbon-neutral community in an oil-rich U.S. city like Midland, TX, through the optimized selection of energy efficiency measures and on-site renewable generation systems. The community consists of office buildings, detached homes, and apartment buildings. The analysis shows that among the distributed energy resources, PV systems can be cost-effective, whereas wind and combined heat and power are not competitive compared to the current grid energy prices. In particular, the optimization analysis indicates that a shared PV system could meet carbon neutrality at the lowest life-cycle costs. However, the cost of energy for the carbon-neutral community would need to be \$0.194/kWh, almost double the current grid electricity price. Only when capital cost is lower by 70% from its current level can PV systems be cost-competitive against the grid in Midland, TX, and help the community achieve carbon neutrality status.
- A feasibility analysis is presented in "Benefit Cost Analysis of Electrification of Urban Districts: Case Study of Philadelphia, PA," evaluating the energy, economic, and environmental benefits of electrification and renewable energy integration for an urban district of Old City, Philadelphia. The analysis considers first the deployment of cost-effective energy efficiency measures for existing buildings. Then, an optimized set of renewable power generation systems is presented that meets the energy needs of the grid-connected district with and without electrification options. The analysis indicates that power generated from wind turbines and hydropower could reduce the cost of energy for the non-electrified district to be below the current utility rate, with the added benefit of lowering carbon emissions by 10%. The analysis then considers the case of an electrified district. The analysis shows that electricity consumption decreases by 14%, peak demand by 19.5%, and CO_2 emissions by 18% compared to the existing conditions.
- The paper entitled "Optimal Energy Dispatch Controller for Fuel Cell-Integrated Multi-Zone Building" outlines the potential energy benefits of an optimized energy dispatch controller to operate fuel cells when integrated into buildings. In particular, the controller utilizes the model-based control approach to manage the heat and electricity generated by the fuel cells in order to minimize the energy costs of buildings as well as providing grid services. The performance of optimized dispatch controllers is evaluated for two building types, a hotel

and an office located in Baltimore, MD. The analysis indicates that the optimized controller could save up to 19% in energy costs compared to the baseline cases with no fuel cells. These savings, as well as the grid services of the energy dispatch controller, depend on several factors including fuel prices, fuel cell capacity, heating and cooling equipment, and load forecasting accuracy.

- The paper "A Framework for Optimal Placement of Rooftop PV: Maximizing Solar Production and Operational Cost Savings in Residential Communities" demonstrates a model-based analysis approach for optimally placing rooftop PV systems for residential buildings and communities. The analysis framework accounts for the shading effects on the rooftop PV panels, the energy use profiles of buildings, and utility rate structures. The optimal placement of rootop PV systems is determined to maximize the PV power generation as well as to minimize energy costs for individual buildings and entire communities. The analysis framework is applied to optimally place rooftop PV panels in a residential community to be constructed in Fort Collins, CO. The analysis indicates that the community can save up to 23% in energy costs and shift the PV generation toward the afternoon utility peak hours when the PV arrays are optimally placed compared to the baseline case.

We hope these papers will provide examples of technologies and approaches to make buildings energy efficient with integrated renewable power generation technologies, making them capable of effectively interacting with the grid to achieve the ultimate objective of minimizing overall energy consumption and lowering carbon emissions.

Editors for the GEB Special Issue.

Conflict of Interest

There are no conflicts of interest.

Data Availability Statement

The data sets generated and supporting the findings of this article are obtainable from the corresponding author upon reasonable request. The authors attest that all data for this study are included in the paper. Data provided by a third party are listed in Acknowledgement. No data, models, or code were generated or used for this paper.

Moncef Krarti
Professor
Building Systems Program,
Boulder, CO 80309
e-mail: moncef.krarti@colorado.edu

Xin Jin
National Renewable Energy Laboratory,
15013 Denver West Parkway,
Golden, CO 80401
e-mail: xin.jin@nrel.gov

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[6] Krarti, M., and Jin, X., August 2020, "Editorial—Special Issue: Grid-Interactive Efficient Buildings—Part 1," ASME J. Eng. Sustain. Bldgs. Cities, **1**(3), p. 030201.