FEEDER Foundations for Engineering Education for Distributed Energy Resources

Spring 2019 Seminar Series

A Computational and Experimental Study for Low-cost Low-income Near Net-Zero Energy Residences

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Abstract: Net zero energy (NZE) homes are designed in order to produce and feed net-metered electrical energy to the grid as much as they consume on a yearly basis. Challenges brought by NZE homes include the reduction of electricity demand from utility, and optimal sizing of the capacity for the PV system and potential energy storage units. These add to the typical problems related to the nature of solar generation, including the intermittence and the “duck curve” for the electric power system. A subdivision with twelve near NZE homes has been recently developed in southern Kentucky. These field demonstrators, which are capable of monitoring real-time load of different appliances and apply dynamic controls, serve as the experimental basis for ongoing studies related to the NZE topics.

This presentation summarizes this field development and further introduces a newly developed Co-simulation framework entitled INSPIRE+D, for modeling the single NZE homes with advanced controls, as well as for simulating the electric distribution system and for optimizing the power flow for the subdivision. The energy model for a single NZE home was validated based on the available experimental data. A hybrid PV energy storage system (HyPVESS) incorporating a battery and an electric water heater (EWH) is introduced in order to absorb surplus PV generation around noon. The EWH operates as a “uni-directional” energy storage, and is optimally sized and controlled in order to reduce the required battery size. It is shown that under certain conditions, the battery capacity is reduced to half as compared with the conventional case, while allowing the NZE home to perform as a dispatchable generator or load for long duration of time. Further simulation results show that for the examples considered, the “duck curve” phenomenon on the electric power distribution level system is alleviated by incorporating the proposed HyPVESS.

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Biography: **Huangjie Gong** is a Ph.D. student in the SPARK Laboratory, Electrical and Computer Engineering Department, University of Kentucky. He received his M.S. degree in Control Theory and Engineering from Southwest Jiaotong University, Chengdu, China in 2016 with a thesis on the maximum power point tracking of PV systems. He currently works towards his Power and Energy Institute of Kentucky (PEIK) graduate certificate and on research projects on topics of co-simulation framework for smart grid and houses, power system protection, net-zero-energy buildings, water heater and battery modelling and control.