The Summer Undergraduate Research Fellowship (SURF) Symposium
4 August 2016
Purdue University, West Lafayette, Indiana, USA

Dynamic Modeling and Validation of micro-CHP systems

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ABSTRACT

Micro-Combined Heat and Power (micro-CHP) units locally generate electricity to simultaneously provide power and heat for residential buildings. Apart from the potential benefits of reducing carbon emissions and increasing robustness to brownouts and blackouts, micro-CHP systems can be controlled to meet energy demands. Micro-CHP systems consist of a prime mover that generates electricity, such as a fuel cell, an internal combustion engine, or a Stirling engine, and a waste heat recovery system that enables utilization of heat generated as a byproduct of electricity generation. Often, a thermal energy storage system is integrated with micro-CHP systems, thereby decoupling, in time, the recovery of the thermal energy from its utilization to meet demand. However, in order to effectively meet time-varying electricity and thermal demand through coordinated use of the prime mover and thermal energy storage system, the dynamics of each of these subsystems, and their interactions, need to be modeled. A low order dynamic model is derived for a micro-CHP system with a PEM (proton exchange membrane) fuel cell as the prime mover and a hot water tank as the thermal energy storage unit. Both steady-state and transient data is collected from an experimental micro-CHP testbed to validate the fuel cell and hot water tank models. Validation of the thermal energy storage model is performed for four distinct modes of operation: charging, discharging, simultaneous charging/discharging, and idling. Future work will include validation of the combined fuel cell and thermal energy storage models, as well as model-based control design for micro-CHP systems.

KEYWORDS

Dynamic Modeling and Validation, Thermal Energy Storage, micro-CHP