Smart Energy Campus: A Smart Grid Testbed for Advanced Modeling, Simulation, and Decision-Making

Xiaochen Zhang, Santiago Grijalva
Georgia Institute of Technology

Abstract – This paper presents an overview of the smart energy campus project at Georgia Tech, which uses a living smart grid test-bed. The test-bed covers 200 buildings with more than 400 smart meters and sub-meters. It has a variety of load components including industrial load, commercial office building loads and residential loads. Renewable energy such as PV system and electric vehicle charging stations are also present in the test-bed. The campus operational information has been recorded through advanced metering infrastructures (AMI) by a 15-minute resolution since 2012. The AMI data streaming has been integrated with research databases, facilities operational systems, and management dashboards. The research databases allow investigators to perform modeling, simulation and data analytics of the electrical and non-electrical energy subsystems on campus.

The physical and sensing testbed has been extended with a simulation environment in which the distribution systems electricity model has been further expanded and calibrated with the AMI measurements, using parametric state estimation methods [1]. Once the model was calibrated, the simulation environment has been utilized to develop various research studies and to test various what-if scenarios. For instance, the historical database was mined to develop enhanced load models capturing the load's PV and QV characters and time-variant properties [2]. The enhanced load model and calibrated network model are being used for more realistic and accurate time series simulations as part of demand response, maintenance, and fuel and electricity purchase operations. Various HAVC load control algorithms have been compared through time-series simulations according to the five-minute price signal from the utility company. A 3-D interactive visualization schema to enhance the situational awareness of the facility operators [1, 3] was also developed. The visualization schema combines the geographic information with power system diagrams allowing users to navigate historical data through a web-based 3-D GUI. This visualization system was extended to mobile platforms and made available to campus students who can learn about the energy consumption and efficiency of the campus facilities.

In the full paper we describe various subprojects that utilize the smart energy campus testbed including:

a) *Campus Energy Planning* to analyze long-term scenarios based on variables such as price of electricity, gas, planned buildings, demand growth, and efficiency programs,

b) *Campus Transportation Electrification*, where future scenario of increased use of electric vehicles and electrification of the campus shuttle system is developed.

c) *Building-to-Grid Interface* to determine control and operational framework for B2G interactions.

d) *Resilient Energy Campuses* involving hardware and software logic to provide service to critical loads as well as assessment of advanced prognostic, real-time health, and performance monitoring, and

e) *Smart Data Center*, where requirements for electricity supply and waste heat removal must be addressed, as well as utilization of datacenter to support further analytics of the campus infrastructure.

References:
[1] J. Peppanen, M. J. Reno, M. Thakkar, S. Grijalva, and R. G. Harley, "Leveraging AMI Data for Distribution System Model Calibration and Situational Awareness," IEEE Transactions on Smart Grid, 2015.
[2] X. Zhang, S. Grijalva, and M. J. Reno, "A Time-Variant Load Model Based on Smart Meter Data Mining," IEEE PES General Meeting, 2014.
[3] J. Peppanen, J. Grimaldo, M. J. Reno, S. Grijalva, and R. Harley, "Modeling of Distribution Systems with Extensive Deployment of Smart Meters," IEEE PES General Meeting, 2014.