Los Alamos NATIONAL LABORATORY

Tech Snapshot

Infrastructure

LA-UR-23-22874

Published: Mar 28, 2023

REAL-TIME ELECTRIC GRID LOAD BALANCING TESTBED

A system for developing a grid that is resilient to intermittent supply

SUMMARY

HVAC, water heating, and other appliances represent more than one-half of the total energy used in U.S. residential and commercial buildings today. As peak electricity demand continues to increase due to population growth, appliance growth, and air conditioning, new transmission infrastructure and conservation solutions are being evaluated. Los Alamos' Real-Time Electric Grid Load Balancing Testbed provides hardware-in-the-loop for testing methods that improve grid reliability by communicating with air conditioners and water heaters to evaluate electric utility load-flexibility and demand response programs. This testbed allows control software developers and power and utility analysts to conduct systematic lab tests of their grid-balancing concepts on a small "village" utilizing appliances in insulated spaces under a wide range of varying electric load conditions. Los Alamos National Laboratory is seeking opportunities for partnerships and collaborations with organizations and companies seeking an advanced residential supply-demand and grid performance testbed to examine controls and development scenarios to maintain electric grid resiliency to intermittent supply.

MARKET APPLICATION

The testbed is used for automated testing of grid-and-consumer coordination strategies that use consumer appliances to help an electric grid stay fully functional during supply-demand fluctuations. Tools to hold system voltage and frequency steady are important for resiliency of the grid. The test bed provides real hardware-in-the-loop and can interact with user-supplied control or simulation software. The test bed may also be used for developing detection methods for cyber-physical security.

BENEFITS

A real-time hardware-in-the-loop that interacts with user-supplied control or simulation software:

- Emulates 20 real houses in the space of a small lab
- Exchanges data with programs without recompiling or linking
- Scenarios and conditions are easily configured and can be replayed
- Heat injection is programmable to emulate human occupancy or external heat sources
- Reduces risk to utilities and customers by allowing scenario testing before applying control algorithms in real-world situations
- Interacts with user-supplied control or simulation software
- Benchmarks new control schemes or modifications to controllers

CONTACT

Steven Stringer
stringer@lanl.gov
505-667-5117

WHY WE ARE BUILDING REAL-TIME ELECTRIC GRID LOAD BALANCING TESTBED

Los Alamos researchers investigate energy security on several fronts, from developing software to manage contingencies on the electrical grid, to collaborations testing solar generation with storage. This testbed collaborative project, led by University of Michigan, was built to unlock the widespread use of residential air conditioning for grid-balancing services. Accuracy and scalability were key concerns in construction. Los Alamos' experience in building medium-scale experiments made it the ideal site to locate the test bed.

WHAT'S BEHIND OUR TECHNOLOGY

The testbed is constructed to represent residential appliance use. The units are constructed entirely from commercially-available components. Each model house has a single-speed window air conditioner as the measured load, plus a small water heater to provide a programmable heat injection against which the air conditioner works. The houses are foam-insulated enclosures, each on a standard shipping pallet so they can be stacked in pallet racks for compactness. Sensors and actuators are controlled through industry-standard data acquisition hardware.

OUR COMPETITIVE ADVANTAGES

This unique testbed can perform experiments at scale using residential air conditioners. Other testbeds running experiments on compressor loads use fewer resources than available in the Los Alamos facility, or do not have controlled loads in the measurement loop. They also do not have advanced controller testing for air conditioners on real systems. While the number of loads that can be tested is smaller than what would be needed for accurate grid regulation services, the loads can be tuned to be more representative of real houses.

OUR TECHNOLOGY STATUS

This testbed has been constructed and validated against data from real houses compiled by Pecan Street, Inc. It was implemented in a Department of Energy funded project led by the University of Michigan to develop and improve load-coordinating controllers. Los Alamos National Laboratory is seeking opportunities for collaboration with academic or industrial partners interested in controls development, to use the test bed in unlocking at scale the use of fleets of residential loads as resources on the grid.

PUBLICATIONS AND IP

Patent Pending (S#xxxxx)