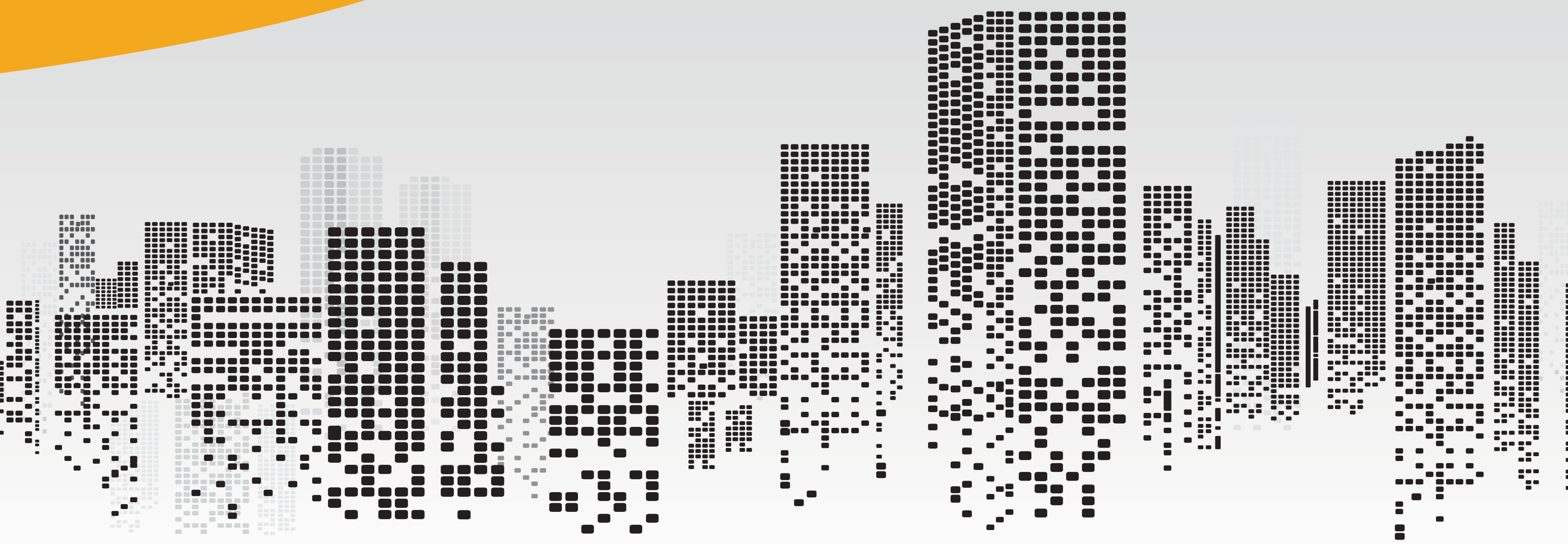
ILC

Pacific Northwest NATIONAL LABORATORY



INTELLIGENT LOAD CONTROL:

A SMART WAY TO MAKE BUILDINGS MORE RESPONSIVE TO THE GRID

America's buildings consume large amounts of energy. It's estimated as much as three-fourths of the nation's electricity is used to keep commercial buildings and other structures warm, cool, lighted and functional. But while buildings use a lot of energy, they also represent a major opportunity for more effectively balancing electricity supply, demand and costs. A Pacific Northwest National Laboratory-developed technology, Intelligent Load Control (ILC), offers a solution for achieving this balance.

ILC is an algorithm, or a set of actions, deployed via VOLTTRON™, a software platform, to a building's control system. The ILC technology can automatically adjust building energy use by coordinating heating and cooling, lights and other building functions, while maintaining occupant comfort. In addition to bringing flexibility and responsiveness to building energy consumption, ILC benefits the grid by turning buildings into resources that assist in balancing electricity supply and demand. This could help address some of the challenges of adding intermittent resources such as wind and solar power to the energy supply mix.

ILC employs the Analytic Hierarchy Process—a method for prioritizing actions to achieve the best results. For example, AHP strategies can help determine whether shutting down or turning on heat pumps in a certain sequence will achieve optimum energy reductions.

The ILC technology has been successfully tested in PNNL buildings and is being deployed in other U.S. locations. To date, tests are focused in three capability areas:

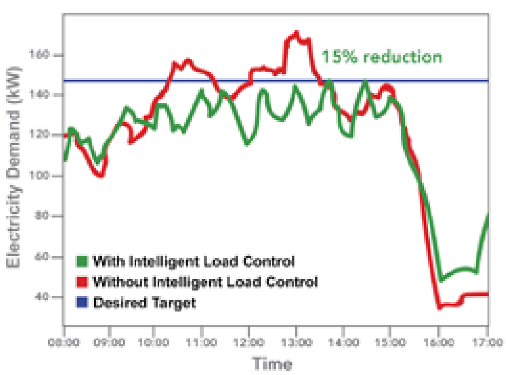
- *Management of Peak Power Loads*
- *Capacity Bidding*
- *Transactive Control.*

These capability areas are described in more detail on the following pages. As ILC evaluation and development continues, researchers are working to make the technology easy to configure and scale to buildings with different types of end uses, ultimately to enable management of large numbers of buildings.

> *ILC can be deployed to control HVAC, lighting and other building systems to manage electricity consumption to a desired level.*

ILC CAPABILITY: MANAGEMENT OF PEAK POWER LOADS

When demand for electricity rises across the grid, so do costs. ILC can manage building devices in a way that reduces more expensive peak power use periods. Many utilities, including the one that serves the PNNL campus, charge not only for the energy (kilowatt hours) consumed, but also for the peak power (kilowatts) consumed. The peak is generally calculated as a rolling average over any 15-minute or 30-minute period during a billing period, typically 30 days. To manage the building peak under this scenario, the peak consumption over the 30-day billing period has to forecasted. PNNL has developed an agent that forecasts power using historical consumption of the building, as well as future weather.



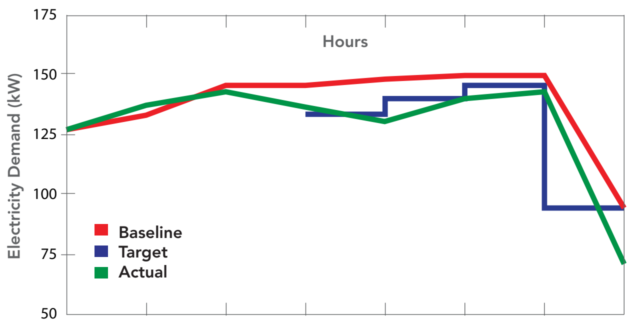
In a PNNL building, ILC demonstrated that during peak electricity use periods, building devices can be managed to reduce load and achieve desired targets.

Applying this approach in one PNNL building, ILC has controlled the operation of multiple heat pumps serving offices and other work spaces. Results have shown that when energy consumption peaked at different times—such as first thing in the morning while the building was being readied for the workday—ILC quickly prioritized operation of heat pumps, shutting down some units while running others, and returning the building to normal operations when the peak demand period passed. The approach successfully reduced demand to meet an established limit, which benefits power grid operations, and no loss of service levels was reported. PNNL also is using ILC to manage lighting in another building.

ILC CAPABILITY: CAPACITY BIDDING

Capacity bidding is a method in which buildings agree to use less energy over certain periods, providing relief to the power grid at times when electricity demand is high. Under this approach, building management would reach a monthly agreement on a certain amount of capacity, or "relief," the building can give up, if requested to do so by the grid. The capacity amount can be constant or cover specific blocks of time. In return, electricity suppliers would provide incentives for the relief.

PNNL has tested and validated ILC's capacity bidding capability. The entire process is fully automated, including generation of a baseline that is used to quantify the amount of relief the building has provided. Another feature enables building owners/operators to see building performance in real time. Finally, the measurement and verification (M&V) process that validates building energy use and calculates the amount of compensation, is also fully automated. As soon as the event ends, the M&V report is automatically generated and can be e-mailed to relevant parties.

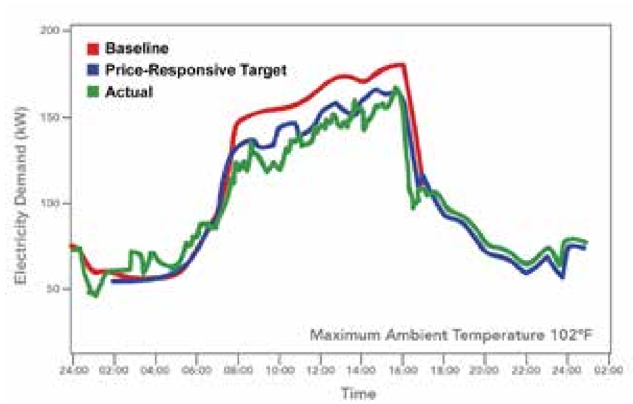


***Capacity Bidding**: Once the call comes from the grid for relief, ILC automatically begins coordinating device operation to achieve consumption levels below the target, while concurrently ensuring building safety and comfort levels. In testing, ILC readily achieved objectives, reducing electricity use for the correct time intervals.*

ILC CAPABILITY: TRANSACTIVE CONTROL

ILC has demonstrated its ability to support the transactive control concept, which in the future is expected to revolutionize operation of the nation's energy system. Transactive control enables energy-using devices to continuously exchange electricity consumption and price information with suppliers and negotiate and respond to that information to optimize energy use in real time.

Under ILC's transactive control capability, a price-capacity curve is established for individual buildings. The curve, which represents how much energy a building is willing to use based on the price at a given time, is communicated and proposed to the power market. Once the market accepts, a "cleared"—or approved—price is established and ILC begins managing devices to the capacity limit that corresponds to the cleared price, while maintaining safety and comfort. If the energy cost is low, the building can buy more power and perhaps perform tasks in advance, such as pre-cooling. It's envisioned the transactions between buildings and the power market will occur in short time intervals (e.g., every five minutes), enabling improved grid planning, flexibility and efficiency.



***Transactive Control**: Under ILC, testing at PNNL has shown that actual electricity use can be managed over an eight-hour period to meet an agreed-upon, price-responsive target below baseline consumption.*

VOLTTRON™ IS CENTRAL TO ILC CAPABILITIES

The ILC algorithm is deployed from VOLTTRON™, an open-source distributed sensing and control software platform also developed at PNNL. VOLTTRON™ provides an environment for applications, or "agents," like ILC and serves as a single point of contact for interfacing with devices (rooftop units, lighting, other building loads and systems, meters, etc.). VOLTTRON™'s ability to manage data, devices and decision-making has provided new options for coordinating the integration of buildings, the grid and renewable energy sources.

One of the key advantages of VOLTTRON™ is that it can be installed on and deployed from inexpensive computing devices.

ILC DEVELOPED VIA CLEAN ENERGY & TRANSACTIVE CAMPUS PROJECT

The ILC technology has been developed and tested through the U.S. Department of Energy- and State of Washington-funded Clean Energy and Transactive Campus project (CETC). CETC, initiated in fiscal year (FY) 2016 in Washington state and involving PNNL, the University of Washington and Washington State University, is focused on creating a blueprint to replicate and scale up transactive control methodologies for application in buildings, campuses and communities across the nation. CETC also is establishing a clean energy and responsive building load research and development infrastructure in Washington state. In FY 2017, CETC expanded to Ohio to include the involvement of Case Western Reserve University (which will conduct a portion of its work at the NASA Glenn Research Center) and the University of Toledo.

About PNNL: *Interdisciplinary teams at Pacific Northwest National Laboratory address many of America's most pressing issues in energy, the environment and national security through advances in basic and applied science. Founded in 1965, PNNL employs more than 4,000 staff and has an annual budget of approximately $1 billion. It is managed by Battelle for the U.S. Department of Energy's Office of Science.*

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