Pacific Northwest Smart Grid Demonstration Project
SUCCESS STORIES

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UNIVERSITY OF WASHINGTON

UW's electric grid gets smart with living laboratory

Higher education happens at the University of Washington in more ways than one. For students, it's academics. For facilities, it's smart grid. More than 250 buildings on the university's Seattle campus are temperature conditioned. That's more than 13 million square feet of comfortable space to conduct research. And it goes to good use, because UW has one of the biggest research budgets among schools nationwide.

That foundation made the campus a great candidate for the Pacific Northwest Smart Grid Demonstration Project — the largest of its kind in the nation.The scholastic setting provided a unique perspective for the five-year, $178 million Department of Energy demonstration, led by Battelle Northwest. More than 20 million people are enrolled in higher-education programs across the country. That's a lot of students, not to mention researchers and faculty. For that reason, college campuses make an ideal environment for advancing smart grid technologies.

"Finding solutions to real work problems is a really important part of today's educational environment," said Norm Menter, UW's energy conservation manager. "Our student population demands that the university be involved in projects like this."

UW is one of two universities, five technical firms and 11 utilities across an unprecedented five-state region selected to participate. DOE matched funds invested by the utility participants, including the Bonneville Power Administration's $10 million contribution. The university was awarded $5.1 million in federal funds to complete its $10.2 million project.

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Seattle, Washington

- Seattle City Light's second largest commercial customer
- Population of 60,000
- 38 megawatts of demand
- Electricity bill of $1 million a month

INVESTMENT IN PNWSGDP:
$5.1 million

HIGHLIGHTS:
- Energy dashboard
- Living laboratory
- 5-megawatt steam generator

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By the numbers

The average daily population on campus is 60,000, and the average daily electrical demand is 38 megawatts. This costs the university about $1 million a month — making it Seattle City Light's second largest customer. Even so, the campus also has its own five megawatt steam turbine generator. The power is distributed through a network of underground utility tunnels.

Energy dashboard drives decisions

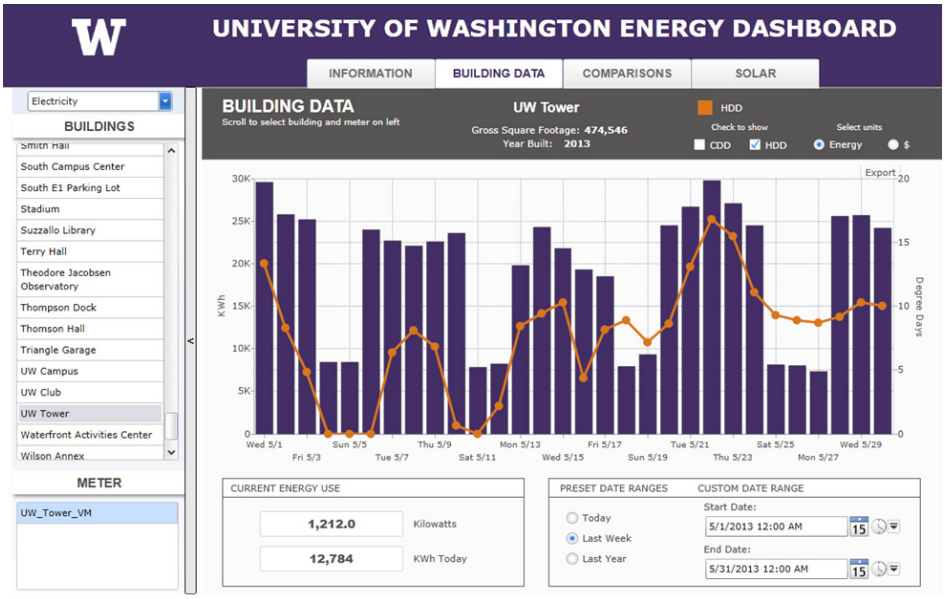
Before the project, UW had just seven meters on its Seattle campus to monitor energy use. Now, there are more than 200 smart meters acquiring near real-time data about energy consumption every five to 15 minutes. These meters transmit the data to a central repository. To see the data and more accurately predict future energy use, the project team built a console to analyze and display the information collected.

Data is analyzed and displayed on "dashboards" that provide an at-a-glance, graphical presentation of the energy use, within just minutes of its consumption. Anyone can view the data online and compare a year and a half worth of information on each building's energy consumption during any hour, how much that energy costs and patterns of use over time. Engineers at the university also use software tools to analyze the data collected, helping UW eliminate waste and save money.

One feature allows a comparison of energy use by building at different times of the day or year. That information is vital to determining how to reduce energy use and eliminate energy waste.

"The surprising thing we learned was that energy waste is not the same thing as energy consumption." said Menter. "Waste occurs just about everywhere, but just because you have high consumption in a particular building doesn't necessarily mean that it's being wasted. The information is valuable for decision-making, but it's not the whole story."

The dashboard raises awareness about a buildings overall efficiency and provides the opportunity to have a conversation about why changes need to be made to a building. This dialogue builds a common understanding so that decisions are made together across campus.



Sharing of data equals a need for improved cyber security. As a public university, UW has an open network. So coming into this project, the university had to overlay a private network onto its existing system. That cost quite a bit of extra money. But it was worth it. After all, having data, and being able to store that data securely and make it available to the public, is immensely valuable to the research mission of UW.

A student energy intervention

Of those interested in the data were — no surprise — the students. The energy use of freshmen in two residence halls was looked at by fellow students to see if a "technology intervention" could reduce the freshmen's energy consumption, compared to a manual intervention.

In one hall, students received weekly energy-saving tips to encourage conservation and to gain qualitative data. In the other, volunteers received EnergyHubs, which measure, communicate and control individual energy use in real time. When small appliances, electronic devices, TVs or laptops are plugged into EnergyHub power strips or outlets, the cost of using each is displayed on a desktop monitor. The monitor also displays daily energy use, current energy in kilowatt hours, and monthly cost projections per appliance. And they allow the user to set up schedules for the appliances or remotely turn them off through a smart phone app.

Using its smart meter infrastructure, the research team was able to collect weekly energy consumption data, analyze the students' energy use over 10 weeks, and compare the energy use of students in the two residence halls. But the study yielded inconclusive differences between the two groups, perhaps due to one aspect of studying students' energy use in a university residence compared to adults in their own homes: a lack of monetary motivation.

"One important long-term outcome of the research was to raise student awareness of the personal energy choices we all make every day," said Kelly Hall, a UW graduate student on the research team.

The team believes the university should not rely on student actions to reduce energy consumption, but move towards using more automated and integrated systems.

A regional transactive role

One part of the project, which spans an unprecedented five-state region and 60,000 metered customers, is automating the system for a regional benefit.

UW connected its steam turbine generator to the demonstration project's transactive control system. Transactive control uses an interactive, market-based signal to increase or decrease energy consumption to achieve greater efficiency in grid operations. The signal is sent over a multiple-utility footprint. Participants in the project test the feasibility of increasing energy use when wind energy is abundant, typically at night, and reducing use during peak hours when energy is most expensive.

"We integrated the steam turbines with the system, so that the turbines would respond and go into a nighttime setback mode when they received a transactive control signal," said John Chapman, UW executive director of Campus Engineering and Operations. "The steam turbine generator concept has potential. I can see how we could use it to vary the operation of our generators to help the region integrate renewables into the grid."

> **"These assets represent an investment that's going to be here for many years. We can use the data to build a greater understanding about how buildings use energy, and to make the entire campus community more intelligent about how we use energy. It's a change in our relationship with electricity."**
>
> NORM MENTER
> UW ENERGY CONSERVATION MANAGER

But UW's current generating system is constrained in terms of how it could contribute to a transactive control system. It's a cogeneration system: after the steam goes through the turbine to generate electricity, it then goes on to heat the campus. In the summertime, there's not much steam demand. Only during the winter is there some flexibility on the output.

Conceptually, UW could replace its generator with something that has the ability to interact with new technologies.

"With that type of system, we could bring on maybe an additional 10 or 12 megawatts anytime of the year to feed into the grid whatever time of day it was required," said Chapman. "And we could do that for a reasonable price, I think."

UW also connected two standby diesel generators to the transactive control system as part of this project. But they are more expensive to operate than the steam turbines.

"I don't think the economics would ever pan out to run those and generate electricity," Chapman added.

There are also environmental requirements that limit the use of diesel generators, so UW will focus on its steam turbine.

UW created a demand reduction operation strategy for five buildings on campus. As part of the transactive control system, the university could opt in to reduce electrical demand at three different levels. These strategies included changing discharge air temperature set points, reducing fan static pressure and limiting control valve positions.

5-megawatt steam turbine

WHAT'S NEXT for University of Washington?

As far as the impacts on operations, the university is just getting started, but a solid foundation is now place.

Tools such as the dashboard allow UW's energy engineers to look for anomalies in energy consumption and determine which buildings they should take a look at first. The dataset builds a greater understanding about how the campus buildings use energy. And, the improved infrastructure makes the entire operation more efficient, which means there is potential to reduce the costs of education.

"That makes the entire campus and the entire community more intelligent about how we use energy," said Menter. "It's a change in the relationship with electricity."