Pacific Northwest National Laboratory aims to empower utility customers.

Overview

■ ***Business Challenge***

As part of the U.S. Department of Energy's GridWise® Program, the Pacific Northwest National Laboratory (PNNL) wanted an innovative way to keep the electrical grid healthy in times of stress by managing electrical demand through a combination of intelligent technology and financial incentives.

■ ***Solution***

PNNL set up two parallel studies to test its ideas. In one, the lab teamed with IBM to create a virtual marketplace that allowed consumers to trade flexibility in usage for lower costs. Intelligent devices (such as thermostats) in consumers' homes were tied to the PNNL system, which automatically controlled power consumption based on pricing signals and customer preference. The second study tested "smart" appliances that could sense and respond to stress on the grid by temporarily curtailing electricity use.

■ ***Key Benefits***

- *50 percent reduction in short-term peak electricity distribution loads, helping to avoid power restrictions and cascading blackouts*
- *15 percent decrease in overall peak loads in the course of one year*
- *Consumers saved an average of 10 percent on their electricity bills*
- *US$70 billion projected reduction in infrastructure spending over 20 years through better management of existing resources*

Creating an intelligent electrical grid

The nation's electrical grid is under unrelenting stress, and recent years have borne witness to increasing problems. Power shortages resulting in rolling blackouts have become a fact of life on the West Coast, and in 2003 a massive blackout struck eight states in the Northeast and Midwest, as well as parts of Canada.

Business Benefits

- Reduced short-term peak distribution loads by 50 percent, and overall peak loads by 15 percent
- Decreased consumers' electricity bills an average of 10 percent
- Projected reduction of US$70 billion in infrastructure spending over 20 years through better management of existing resources
- Reduced impact of power shortages and helped avoid black-outs by enabling better control of the electrical infrastructure
- Provided financial incentives to consumers to help ease utility grid loads while increasing freedom of choice
- Permitted accurate determination of the true cost of electricity, demonstrating the feasibility of market-based pricing for electricity

"We're finding that people are actually curtailing their use and saving energy simply because they have greater control."

– Don Hammerstrom, project manager, Pacific Northwest GridWise Demonstration Project

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The U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability has partnered with research institutions and private industry in a nationwide initiative called GridWise to show how information technology can create a better, more robust electrical grid. Many demonstration projects are underway that embody the shared vision that IT has the potential to impact the nation's electrical infrastructure profoundly in the future.

The Pacific Northwest GridWise Demonstration Project

From March 2006 to March 2007, the Pacific Northwest National Laboratory conducted a pair of demonstration studies that showed how intelligent management, enabled by technology and customer involvement, can help ease stress on the electrical grid.

The two studies had complementary goals. The Grid Friendly™ Appliance Project demonstrated how "smart" consumer appliances such as water heaters can sense impending grid failures and autonomously respond by temporarily cutting back on power consumption. The second and larger study, the Olympic Peninsula Project, showed how an automated, market-driven system can ease critical loading of the electrical grid by managing demand: The project made utility customers part of the process and gave them a financial incentive to trade reduced usage for lower costs when there is a shortage of power.

Both studies were highly successful. The Grid-Friendly Appliance Project conclusively demonstrated the technical ability of smart appliances to help avoid power outages without inconveniencing consumers – most participants did not even notice the automatic, momentary reduction in energy use. The Olympic Peninsula Project showed another way to ease stress on the infrastructure while saving money – it not only reduced the peak load on the grid significantly (15 percent over the course of the year-long study), it also rewarded customers for doing so by saving them 10 percent on their utility bills.

The Olympic Peninsula Project: Using the free market to manage demand

The key to the Olympic Peninsula project was the direct involvement of consumers. They were given access to a system that allowed them to trade consumption flexibility for lower costs – those willing to accept a slight cut-back in power use (for example, by having their thermostats turned down a few degrees) when peak rates hit a certain point would reap savings and, at the same time, ease stress on the grid. Consumers also had the flexibility to override their settings at any time.

Ground-breaking custom software from the IBM Watson Research Lab, running on IBM WebSphere® Application Server, is what made the Olympic Peninsula project possible. This sophisticated event-driven software enabled PNNL to have direct control over customers' energy use on an individual basis by setting their thermostats and water heaters remotely in response to current market rates and customer preference.

"The basic idea was to manage demand by creating an open market for power," says Don Hammerstrom, project manager for the Pacific Northwest GridWise Demonstration Project. "Using software from IBM and intelligent devices installed in customers' homes and at certain power suppliers, we created a virtual marketplace. On one side, consumers bid for power – how much they were willing to pay to keep everything running without cutting back – and on the other, suppliers entered bids for how much it would cost them to start up and run for the next five minutes. The point where all those bids meet is the price."

There's a base wholesale price for power that consumers pay when supplies are plentiful. But if there's a shortage, excess power needs to be generated or demand needs to be reduced (or both), and that constrained electricity supply costs more. Bids are being made on this supply. A market mechanism like this helps keep the grid running smoothly because it can dynamically and intelligently respond to stress. It only kicks in when there's a shortage, and curtails only those loads that consumers are willing to shed. Without intelligent control, all loads would be served regardless and a shortage could easily escalate into a crisis.

Naturally it's not feasible for consumers to take part in this process directly – nobody is going to sit at their computer and actively bid for electricity. This is where the sophisticated IBM software came into play. Customers programmed their thermostats and water heaters via the Web, setting temperatures and schedules just as they would if they were manually programming the devices. The twist is that the customer also provided some preference information: how willing they would be to have the temperature altered in the event of a power shortage. The software took that input, combined it with real-time grid sensor data, generation capacity and market-trend information and automatically adjusted each individual device as necessary.

Key Components

Software

- IBM WebSphere Application Server
- Prototype Internet-scale control software from IBM's Watson Research Labs

Why it matters

As part of a U.S. Department of Energy demonstration program, the Pacific Northwest National Laboratory is demonstrating a new, multi-layered way of keeping the power grid healthy by managing electrical demand in times of stress, using a combination of intelligent technology and market forces. Creating a virtual marketplace, connected to consumers' homes as well as to providers of surge electrical capacity, lets consumers trade flexibility in usage for lower costs when there is a shortage – and gives providers the demand information they need to accurately set the actual cost of generation in near-real time.

Benefiting both consumers and the grid – painlessly

"An important part of this project was coming up with ways to make the technology transparent," says Rob Pratt, PNNL GridWise program manager. "We were looking to control appliances that are cycling all the time as a normal part of their operation – things like water heaters, refrigerators and heating/cooling systems. This technology can ease the load without the homeowner ever being aware of it."

The consumer response has been surprising. "In the past," Hammerstrom says, "consumers never had any feedback about how they were using power other than their monthly bill. What we're giving them is information and the ability to control their own usage much more effectively. And we've found they really like it. Our goal was to help avoid problems with the grid, but we're finding that people are actually curtailing their use and saving energy simply because they have greater control."

A new way of looking at utilities

Should this technology be adopted, it has the potential to save a great deal of money. PNNL concluded that if all customers were engaged in reducing peak loads using this technology, peak electricity prices could be substantially reduced and construction of approximately US$70 billion in new generation, transmission and distribution systems could be avoided over the next 20 years.

The technology also has the potential to drive change in the way power is generated. "Imagine an infrastructure where everything is intelligent and connected," Pratt says. "We can apply this approach right down to the local substation level. If it gets in trouble, only those few affected by it would have the technology kick in. We could also leverage a lot of untapped resources – for example, the diesel generators attached to commercial buildings. Right now they're reactive; if the power goes down they run the building. But what if we could control them, and make them part of the grid? The potential is enormous," Pratt says.

For more information

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IBM Corporation
1 New Orchard Road
Armonk, NY 10504
U.S.A.

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