Why Two Grids Can Be Better Than One – How the CERTS Microgrid Evolved from Concept to Practice

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Don't let the diminutive name fool you. A microgrid might sound like a tiny achievement. But designing an affordable, reliable integrated power system that can seamlessly isolate from the nation's electric grid during a blackout or a voltage excursion — and then reconnect just as smoothly — is no small feat.

And, as is the case with any brainy and brawny idea, the microgrid concept didn't materialize overnight.

Congress, concerned about the reliability of national electricity transmission, turned to the U.S. Department of Energy (DOE) for guidance in the late 1990s. What started as a conversation about maximizing distributed generation to relieve stress on an overtaxed grid has evolved into on-the-ground applications. Proponents envision limitless industrial and commercial applications.

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"We like to say we bring good ideas to life," DOE senior program manager Steve Waslo said about the government's key role in guiding technologies such as microgrids from the laboratory to the marketplace. "Our philosophy is that when a technology such as the microgrid is ready for prime time, you need to get it out there and test it. That's part of the value added by the Department of Energy."

After years of thorough research, DOE has recently started providing funding to utilities, universities, and industry for deploying microgrid technology in school districts, universities, jails, hospitals, laboratories, military bases, industrial parks and a variety of businesses nationwide.

For instance, Chevron Energy Solutions is collaborating with several partners to deploy a microgrid at the Santa Rita Jail in Alameda County, California. And, a California public power utility will begin testing what it calls a full-fledged microgrid at its corporate headquarters in spring 2011.

The Sacramento Municipal Utility District (SMUD), a longtime pioneer with advanced technologies, will be operating a 310-kilowatt base load microgrid. It couples three 100-kilowatt reciprocating generators with a 120-ton chiller combined heat and power system and a 10-kilowatt photovoltaic system. The project will also integrate storage technology – a 500kW zinc bromine flow battery manufactured by Premium Power Corporation. SMUD's system is based on DOE and California Energy Commission research and development on microgrid control technologies.

Not Just Any Microgrid

Those initial meetings at the Energy Department mentioned above led to the 1999 creation of a microgrid research and development team. Funding for this R&D effort, called the Consortium for Electric Reliability Technology Solutions, came from DOE's Office of Electricity Delivery and Energy Reliability and the California Energy Commission's Public Interest Energy Research program.

The consortium drew on a list of nationwide specialists, including researchers from DOE's national laboratories and industry and was led by Bob Lasseter, a professor of electrical engineering at the University of Wisconsin-Madison with a penchant and passion for thinking outside the box.

"We started from very modest origins and have made major contributions to the definition of the microgrid landscape," explained Joe Eto, a staff scientist with the DOE's Lawrence Berkeley Laboratory in California. "The idea was to articulate the basic concepts and then demonstrate them in a test bed operated by utility staff in a manner that was highly visible and accessible to the technical community."

Early on, these researchers coined the term microgrid to describe their project. Just because they had named the idea, however, didn't mean they owned it. Soon, other power system specialists were engineering their own versions of microgrids. Understandably, that prompted the consortium to christen its own unique invention as the CERTS Microgrid. CERTS, of course, is the abbreviation for the consortium's lengthy name.

"We're not claiming to have the only way to organize or control a microgrid," Eto emphasized. "It's the idea of system integration — treating load and generation as a single, distributed system that can operate both connected to the grid and as a stand-alone electrical island — that's the umbrella under which all of this fits."

DOE Strategy: Let Stakeholders Kick Microgrid's Tires

Taking the CERTS microgrid or any new technology from idea to fruition can be a dicey venture. That's why DOE has an overarching strategy that emphasizes teamwork. The strategy is strong on open communication, effective partnerships and common goals.

"The Department of Energy creates strategic teams of technology owners, universities and labs really well," said Waslo, who has more than two decades of experience with the department. "Our strategy is to encourage buy-in, give all stakeholders a voice and focus on problem solving."

With the CERTS microgrid, Waslo said, utilities and other businesses needed to be at the table so they could explain how and why the research needed to be tailored to meet their specific needs.

"Those stakeholders have a crystal clear understanding of their businesses so they can optimize the technology," he said. "That makes for a more efficient use of resources."

DOE's strategy can keep research projects moving forward when they encounter inevitable hardships, such as technical or sponsorship issues or projects that just have too much risk for the private sector to tackle alone.

"But the government can bring resources to bear," Waslo said. "We can keep worthwhile projects alive that might not have thrived otherwise."

California Jail Project Tackles Energy Challenge

One of those DOE projects Waslo is referencing will be coming on line, at the Santa Rita Jail, a place that can't compromise its need for a steady and reliable power supply. Officials in Alameda County,

California, wanted the jail to be powered with “greener” energy but couldn’t make such a technological leap alone. So the county is partnering with Chevron Energy Systems, Satcon Power Systems and Pacific Gas & Electric to decrease peak load, alleviate grid congestion and reduce its carbon footprint by integrating microgrid technology with the jail’s existing renewable and distributed energy sources.

The innovative microgrid project incorporates a 1.2 MW solar array installed in 2002 and a molten carbonate combined heat and power fuel cell system installed in 2006. Chevron and its partners are coordinating an effort to add several 2 kW wind turbines and a battery to the microgrid system.

Jails are high-security buildings where back-up power cannot be compromised. Instead of relying on diesel generators, DOE officials point out, the Santa Rita Jail can count on a much cleaner sodium-sulfur battery to carry the electric load during outages and offset peak demand. In addition, they are using a clean-energy fuel cell, waste heat utilization and PV for base load power.

Microgrid Pioneer Advances Technology

Traditionally, connecting multiple sources of distributed generation to the grid is complicated, expensive and laborious. Not only do utilities require that each connection be separate and meet particular standards, but all distributed generation also has to be automatically shut down if the grid’s voltage wavers.

How could the CERTS team overcome these obstacles? Enter microgrid pioneer Bob Lasseter.

The UW-Madison professor took the lead in engineering a solution that allows all of the distributed generation to connect to the grid at a single point and to operate 24/7.

First, all distributed generation and local load are tied together on its own feeder using unique interface controls so it presents to the main grid as what Lasseter calls a single, well-behaved energy system. In addition, newly developed automatic switching technology lets the intra-connected distributed generation and load disconnect from and reconnect to the grid without a hitch. This feature allows the microgrid to provide high levels of quality power to local loads.

“Our goal is for this to be plug and play,” Lasseter said. “That way, you plug it in and it works, without a control system on top of it.”

These advances let the researchers move from an economy of scale to an economy of numbers, Lasseter said, because it allows microgrid users to buy dozens of smaller machines instead of a single large one. It also could eliminate an industry’s need to invest in backup generators or batteries.

“I do this because I see it as exciting,” Lasseter said about his 11 years of involvement with CERTS. “The way it’s structured, I get to handle the technical part and think about the subjects I enjoy. That’s what keeps me engaged.”

Passing the Ultimate Test

To gain acceptance by the appropriately conservative electric utility industry, Eto and the rest of the CERTS team recognized that microgrid technologies could only be proven through demonstration at a

full-scale test bed and that the most rigorous evaluations would be those conducted by an electric utility's testing staff.

CERTS was fortunate to find such a research partner in American Electric Power (AEP); one of the largest utilities in the country and one that has a long history of path-breaking R&D success, such as the deployment of the nation's first 765-kV transmission lines. Once AEP expressed interest, the California Energy Commission and DOE stepped forward with funding. The investor owned utility ran the initial round of field tests at its John E. Dolan Engineering Laboratories in Groveport, Ohio from 2006 to 2007. The original CERTS Microgrid Test Bed featured utility inverters and engines manufactured by Tecogen, a Massachusetts company that specializes in manufacturing small generators powered with natural gas. It also featured a static switch assembled by Northern Power Company, a Vermont company that specializes in designing, building, and maintaining isolated power systems with a strong emphasis today on wind turbines.

Tecogen, a recipient of CERTS funding, is also providing the equipment for SMUD's upcoming CERTS microgrid launch.

"What's appealing about the technology is that it is affordable, compact, functions like a synchronous generator and allows users to recycle an engine's waste heat," said Tecogen president Bob Panora.

Why Recycling Waste Heat Matters

That recycling process, also referred to as cogeneration or a combined heat and power (CHP) system, is touted as a key component of the CERTS microgrid. Though cogeneration has long been a staple of systems that are larger than a megawatt, it is only now trickling down to smaller systems.

This flexibility and modular design excites Lasseter because aligning thermal loads optimizes fuel efficiencies, saves wiring and plumbing costs and reduces transmission losses. Generators can be positioned adjacent to heating or cooling loads because they no longer need to be tethered to a constricting electrical tie. In fact, CHP systems can more than double the system's efficiency.
At SMUD's pilot project, waste heat from the three generators will power the absorption chiller system that powers the air conditioning. In the winter, it will be channeled as space heating.

The four SMUD buildings to be hooked up to the CERTS microgrid include two maintenance shops, a facility used as a training center, a backup call center, and a central utility plant that houses primary pumps, controllers, cooling towers and other related equipment.

Mark Rawson, SMUD's senior project manager for energy research and development, is champing at the bit to have his utility's microgrid project go online.

"We see this as a component of the smart grid," Rawson explained. "What's so interesting about the microgrid is that it bridges a gap."

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"Instead of seeing distributed generation as something to be tolerated, with a microgrid approach it can be seen as an asset for utilities and customers," he continued. "It can be a cost-effective way for them to gain higher reliability for an investment in distributed generation."

The yearlong demonstration phase will end in 2012, said Rawson, a research manager at the California Energy Commission before joining SMUD in 2006.

Eventually, Rawson expects high efficiency cogeneration plants will help utilities and customers meet critical peak power demands, slice greenhouse gas emissions and add to customer value and reliability.

What's Next in CERTS' Sights?

"We came up with the grain of the idea," Lasseter said about nurturing the CERTS Microgrid beyond the incubator stage. "Coming through that struggle, we've watched it grow to be implemented and commercialized. And today, we are seeing it almost reach a tipping point."

But that doesn't mean CERTS Microgrid team members are finished yet.

Other activities that DOE's Office of Electricity Delivery and Energy Reliability will be funding include easing the integration of direct connected synchronous generation, wind, solar and other renewables (the SMUD trial will provide photovoltaic data) and giving utilities the opportunity to meet peak needs with off-peak storage.

Eto said it is thrilling and professionally satisfying to be involved with a project that started as a thought exercise by a professor on sabbatical and now has taken on national and international significance. He said he is happy about the payoff of 10-plus years invested of DOE and CEC R&D investments.

"We're helping to advance an industry that will save consumers money, ensure a more reliable grid, and protect the environment," Eto concluded about the CERTS Microgrid. "What more could you ask for than that?"

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