Smart Grid Today: UC San Diego gears up for 'smart microgrid'

SAN DIEGO, Calif. – March 1, 2010 – The University of California at San Diego can't claim to be a smart grid but it most definitely is a microgrid — with its own power generation, monitoring and security. Microgrids are a key step toward achieving a smart grid, Kurt Yeager, executive director of the Galvin Electricity Initiative, told us last month.

"We are a prototype for a small city for the future, a microcosm of a society 20 years from now," Rajesh Gupta, a professor of computer science and engineering who researches campus energy efficiency, told us during a series of recent interviews.

The 1,200-acre, 450-building campus, with a daily population of 45,000, runs two 13.5 mw gas turbines, one 3 mw steam turbine and a 1.2 mw solar-cell installation that together supply nearly 80% of the campus' annual power, said a paper released last year by three computer science professors. The turbines produce 75% fewer emissions than conventional gas power plants, the university said on its website. For HVAC, it uses a 40,000 ton/hour, 3.8 million-gallon capacity thermal energy storage tank, plus three chillers driven by steam turbines and five driven by power.

The balance of campus power — up to 10 mw — is bought on the open market under California's deregulated market and served by SDG&E. Campus-generated power is cheaper even than open-market power, since UCSD's heat, power and cooling systems are highly efficient, Byron Washom, director of the university's strategic energy initiatives, told us last week.

The huge campus, four miles square, is linked to SDG&E by a single 69 kv substation, which "really confines and defines the microgrid as everything behind the substation," Washom said.

UCSD is building added energy storage and is working to improve its internal grid's efficiency.

UCSD today tracks its grid using a "straight SCADA system" partly from Johnson Controls for building systems and from Schneider Electric for energy, plus "a variety of other vendors we've brought in over time — a progression of different systems. We've been responsible for making sure they communicate with each other," he said. "Our microgrid is very efficient but we're going to have a significant improvement in how we optimize our resources."

The university has entered a power purchase agreement for a 2.8 mw molten-carbonate fuel cell that uses methane piped onto campus from a local wastewater-treatment plant, Washom said. And it just concluded a solicitation for about 2.8 mw of on-campus power storage. Washom declined to identify the technology used since the technology is so closely identified with the vendor and negotiations are ongoing.

Under a contract from the state's energy commission, UCSD is installing a new, "very sophisticated, very high-end" master controller — Paladin from EDSA of San Diego. Paladin will control and monitor all UCSD generation, storage and loads plus hourly computing that should be used and to what extent, to optimize a balance of economics and environment. It can receive as many as 260,000 data inputs/second and is "very rigorous from a power-engineering point of view," Washom said.

To help direct Paladin's decision, UCSD will use VPower software from Viridity Energy of Conshohocken, Pa, that receives and processes dynamic market-price signals, weather forecasts and the availability of resources.

Together, Paladin and VPower "will help us determine the optimal balance of which systems should be generating, how much we should be importing, when we should be reducing load, whether we should be charging or discharging energy storage,"

Washom said. “Paladin will understand how our microgrid should be operating and when the grid starts to deviate, it can anticipate, analyze and take corrective action.”

Simulations using day-old data are slated to start in the third quarter. Their estimated $2 million cost will be split evenly between the university and the California Energy Commission. UCSD has applied to the California Solar Initiative for $1.2 million in added funding to start live operation.

“I can’t wait to start simulating, as well as going live, with this system!” exclaimed Washom. “This is a major advancement for us.”

About 200 power meters on the main lines and at buildings’ main circuit breakers, track use minute-by-minute. A website produced by the school’s Microelectronic Embedded Systems Lab allows viewing power use graphically for the entire campus, selected schools and four mixed-use buildings. The computer science building is metered by individual computer and monitor so those devices’ use can be viewed graphically. The building meters are three-phase commercial-grade units from Schneider Electric, sending data several times/second to a central server over a wired network.

The computer science building, with 750 PCs and a room filled with servers, is measured more intensively. Meters on 15 separate circuits report power use by lighting, HVAC, plugged-in devices and servers.

Solar work wins DOE cash

Some of the $1 billion in on-campus research every year is devoted to power and DOE just gave UCSD a grant to model smoothing the effects on the distribution system from the ramping up and down of PV output as clouds pass overhead. Abrupt boosts or drops in solar output can unbalance a grid’s load, whether the grid serves a campus or a community, Washom said. EDSA’s Paladin will assist in this effort.

UCSD today tracks its grid using a “straight SCADA system” partly from Johnson Controls for building systems and from Schneider Electric for energy, plus “a variety of other vendors we’ve brought in over time — a progression of different systems.

We’ve been responsible for making sure they communicate with each other,” he said. “Our microgrid is very efficient but we’re going to have a significant improvement in how we optimize our resources.”

The technology involves a “sky imager” that tracks the movement and opacity of clouds. Mounted high on a building, it sees from directly overhead to the horizon, in all directions, covering 25 square miles, Kleissl told us Friday. The imagers are 20-year-old technology, “but everyone forgot about them and now we’re taking them back up,” he said. They were used in cloud-cover research but not solar forecasting.

Just as important are image-processing algorithms that identify and track clouds, plus a database with many thousands of examples of how clouds move, form, and thicken or thin. Using the technology on campus “is a microcosm of what a large utility feeder might need,” Kleissl said.

Knowing the output of a solar array an hour in advance could help determine whether storage should be charging or discharging,” Washom added. “Right now we have no smarts with which to control that algorithm.”

Efficiency is top job

Separately, the campus is embarking on its “number-one priority”: a $72-million, three-year energy efficiency program, Washom said.

UCSD participates in SDG&E’s DR program and has shown the ability to cut grid imports by 40%. On a daily basis, the campus load shifts 7-14% of its daily on-peak demand by using chilled water for its HVAC from its thermal energy tank, charged overnight by five chillers. During the San Diego wildfires in 2007, UCSD went from a 3 mw importer to a 4 mw exporter in under 30 minutes, to support the local grid when transmission access was threatened, Washom said.

The campus' single substation can put power back into the grid but UCSD does not do so regularly and Washom said he does not foresee the time when it will. "We would need metering and would have to be in communication with … [the California ISO] as a participating market load. But our interest is more in meeting campus demand than in being a wholesale power generator."

Freedom from grid unlikely

Despite its prolific generating power, whether UCSD can become electrically self-sustaining is apparently a matter of debate. The school aims to achieve that goal by mid-2011, according to the three computer scientists' paper. But Washom said UCSD will likely never be completely grid-independent.

"The campus has a $200 million-per-year building expansion program, so every year we increase our demand," he said. "Each time a professor here wins a supercomputing contract award, for which we're constantly bidding, it could increase our demand by 6 mw. It would be presumptuous to say at some point we will be 100% grid independent, because all it takes is that one successful scientist to upset our supply-demand balance."

About EDSA Micro Corporation
EDSA is a privately held developer of software solutions for the design, simulation, deployment, and preventative maintenance of complex electrical power systems. Founded in 1983, the Company's Paladin® software products are used by thousands of commercial, industrial, governmental, and military customers worldwide, to protect more than $100 billion in customer assets. Headquartered in San Diego, Calif., the Company's worldwide operations include 30 sales, distribution, and support offices located throughout North America, South America, Europe, Asia, and Africa. For more information about EDSA and its products, visit www.edsa.com.