CASE STUDY

Stanford University—Palo Alto, California

Stanford University Installs Advanced Power System

With an eye on the future and a need to remain self-sufficient should a fault occur, Stanford University's Utility Group upgraded the campus electric power substation and reconfigured controls to implement a power island via the local cogeneration power system.

Palo Alto, CA—To provide a stable electric power supply and meet the burgeoning demands of the 21st century, Stanford University upgraded its primary distribution substation and reconfigured controls to implement a power island via the existing campus cogeneration system.

Located beside Palo Alto in the San Francisco Bay area, Stanford University is more than a medium-size city unto itself. It is a highly developed and complex campus with facilities and services far more elaborate and strategic than those of the typical community of 13,000. Yet, with a profusion of research and medical centers, plus housing, classrooms, and sports, cultural, and shopping complexes, it is one of the most energy-efficient institutions among California's research universities.

The ever-mounting electric energy needs of "The Farm," as the 8,200-acre Stanford campus is known, include providing for a vigorous real estate development plan. There are 678 major buildings at Stanford (12.6 million square feet total), plus 843 owner-occupied housing units for faculty on campus and 628 rental units. The local county Board of Supervisors has approved a new, ten-year university general use permit and community plan, allowing for two million additional square feet of academic facilities and up to 3,000 new housing units to be built on campus. When the plan is fully implemented, The Farm will house thousands of buildings and an even higher population of users who will be highly dependent on reliable electric power.

Figure 1—Located beside Palo Alto in the San Francisco Bay area, Stanford University is more than a medium-size city unto itself; it is a highly developed and complex campus. The ever-mounting electric energy needs include providing for a vigorous real estate development plan. When the plan is fully implemented, the campus will house thousands of buildings and an even higher population of users who will be highly dependent on reliable electric power.

A 50 MW gas and steam turbine cogeneration system, operated by Cardinal Cogeneration, meets much of the university's present power needs and sells power back to the general grid via Pacific Gas and Electric Company (PG&E), backfeeding an average of approximately 20 MW. The faculty residential area is served by PG&E. Stanford Medical Center gets its power from the City of Palo Alto.

The campus's main distribution substation was built by PG&E in the 1950s and purchased by the university in the mid-1980s.

Glyn Lewis, partner and design engineer for Applied Power, a Redwood Shores, California, electrical engineering consultant, was hired by the Stanford High Voltage Shop, which runs the electrical power system, to perform a substation peer review in 2002. Lewis and the High Voltage Shop decided that much of the main substation's hardware would have to be replaced or upgraded to meet future goals. Also, Stanford's Utility Group needed to modify relay protection and communications to implement the power island. The project team divided the work into two phases, and Lewis served as a consulting engineer for the project. Phase One began with replacement of the substation circuit breakers and disconnect switches.

"The circuit breakers had to be replaced. They were 50 years old, and there were no spare parts available anymore," Lewis said. "Secondly, the Utility Group was experiencing trouble with the high-voltage disconnect switches, so they wanted to have those replaced for reasons of safety as well as reliability."

"We split the substation so that we'd have most of it operating during the upgrade," said Steve Briscombe, Stanford power system manager. "We decommissioned one side of the bus and replaced the protection relays, then finished up on the other side. This whole approach enabled us to accomplish the project without shutting down university facilities."

The old 60 kV OCBs (oil-filled circuit breakers) were removed from the substation and replaced with SF6 (sulfur hexafluoride gas) breakers. "We also added potential transformers and isolation switches and did some major rearranging in the bus structures of the substation," said Lewis. "In conjunction with that, we upgraded the old relay and control panels with relays from SEL [Schweitzer Engineering Laboratories, Pullman, Washington]."

The new relays include the SEL-351 Directional Overcurrent and Reclosing Relay (four units), SEL-311 series relay (four units), SEL-551 Overcurrent/ Reclosing Relay (two units), and SEL-587 Current Differential Relay (two units). There are also redundant SEL-2100 Logic Processors to apply the SELOGIC® and communications. SEL-2505 Remote I/O Modules handle the fiber-optic link for remote control from the cogeneration plant, located 2,000 feet away from the substation control room.

"In general, SEL relays are my preference," said Lewis. "One of the main reasons is the support that I get from the Schweitzer personnel. They are very responsive, not only the people at headquarters but also the field personnel." SEL Field Application Engineer Brad Heilman provided support in the initial design. Another factor in Lewis's choice of SEL equipment was the array of features available in a single relay and the fact that SEL relays meet the "utility grade" requirements of PG&E, he added.

The relays and control system are fully redundant (a PG&E requirement for multifunctional relaying), with all the outputs configured in parallel and programmed identically. They feed into dual SEL-2100 Logic Processors. The processors retrieve device status and remote system information using MIRRORED BITS® communications and provide them with optional I/O using SELOGIC control equations to implement advanced protection and control.

"The SEL-2100s perform the function of the bus-differential scheme and for splitting the bus," Lewis said. "Basically we have a dual-feed bus, but it doesn't have a tie breaker. Instead, it has disconnect switches, including a motor-operated load break switch and a couple of other disconnect switches in series with it." The project team created two bus-differential zones just by putting the switches into the SEL-2100 and then automatically converted a single zone to a double zone.

"That was a neat feature," Lewis added. "One of the values of doing it this way is that all the CT ratios are different, so I was able to create this bus-differential scheme using the SELOGIC. I fully tested it before it shipped out from the supplier to prove that the bus-differential scheme works. The SELOGIC and SEL-311s and SEL-351s all talking to each other makes this possible."

Figure 2—The upgrade of old relays and control panels was completed using relays from Schweitzer Engineering Laboratories, Inc. SEL equipment was preferred because of the array of features available in a single relay, and the fact that SEL equipment meets the "utility grade" requirements of PG&E.

Digital synchroscopes were added to the substation controls, and the SCADA system, which is used solely to monitor substation status, was revamped. The remote control from the cogeneration plant was installed to close the breakers at the plant, should the need arise. This was achieved via a dual fiber-optic link with full synchronizing capabilities through the SEL-311 series relays.

"Connie Belonogoff, our relay technician, as well as Mark Hickenbottom and Bob Twoddle, our power system electricians, decided that we would connect the cogen unit at a different location on the bus so it would have improved 'switchability' for maintenance purposes," Briscombe said. "Also, we isolated the substation with the PG&E lines so faults will no longer go all the way through and trip the breakers at the cogeneration plant. In the past, such a fault could darken the whole campus for a period, even though the line from PG&E would be hot. So now we have 'island' capabilities by virtue of the protected cogeneration system."

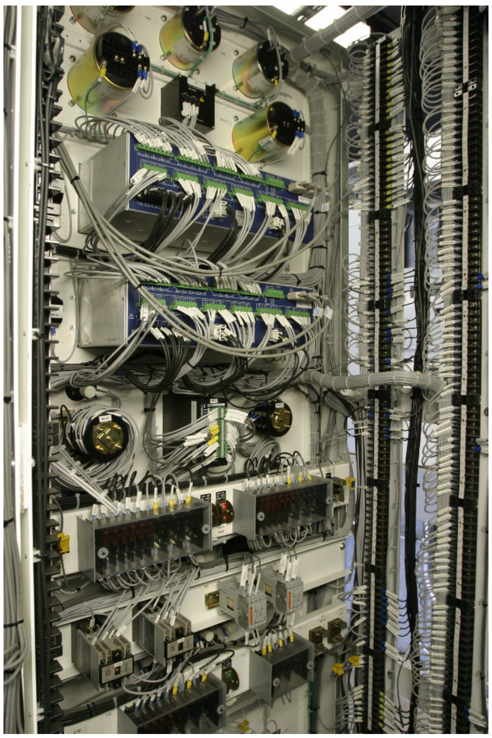

Figure 3—With an eye on the future, Stanford University's Utility Group has upgraded the campus electric power substation and reconfigured its controls. The campus's main distribution substation was built by PG&E in the 1950s and purchased by the university in the mid-1980s.

The primary task for Phase Two of the substation upgrade was to modernize the control panels, replacing the relays. "We decided to build a new control panel and cut the circuits over one at a time," Lewis said. "I wanted to use SEL relays to do the job, but the Stanford engineers were somewhat resistant to that idea. So I persuaded them to go to one of the SEL seminars that are held in the area. They came back from the meeting just absolutely sold. That seminar addressed every misgiving that the Stanford people could've thought of, and then some. They came back ready to go with SEL as the product and supplier of choice."

"If you've got a project like this, with more than ten relays, you also need excellent support," Briscombe added. "To coordinate that many relays, which are segregated in the bus, and have the ability to see faults in different directions and all sorts of similar complications, I believe you have to have SEL or a company like it to commission the project efficiently."

Lewis agreed on the importance of support. "There's a lot more to power system solutions than just employing the right technologies. It is how you deploy the technologies and support them that is important in the end." SEL relays were written into the supply specifications as "NO EQUAL" when the control panel was bid to several different manufacturers. In addition, SEL took responsibility for the SELOGIC programming and training of Stanford personnel. SEL Systems and Services Division's Mike Thompson provided phenomenal support during the system's factory testing and final commissioning.

To that end, SSD provided extensive customer training, settings, commissioning support, and other assistance. SSD helped design a sophisticated directional comparison bus-protection scheme that properly selects and trips zones based on the bus-switching configuration. SSD provided customized documentation, including bus-protection schematics and graphical representation of the programming logic. SSD also supported the Stanford Utility Group in meetings with PG&E, assisted in the initial energization tests, and helped with change orders to cover additional work. Finally, SSD was asked to provide commissioning support in the spring of 2004 when the cogeneration circuit converted over to the new control system. This finally allowed islanding and remote control of the PG&E tie breakers from the cogeneration plant.

“We’ve always wanted someone to come up with a description of how this place operates,” Briscombe said. “Because SEL SSD is fully familiar with it, after doing the commissioning, we issued a supplemental contract to come up with the operating procedure for the entire system. They did an admirable job of that, too. It was exactly what we wanted.”

Because SSD “wrote the book” on the current Stanford power system, various campus Utility Group members have a better understanding of how the system is configured and controlled so they can operate as efficiently as possible and anticipate the needs of the future.

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About Applied Power

Applied Power is a consulting electrical engineering firm located in Redwood Shores, California, and has provided consulting services since 1981. Applied Power specializes in high voltage and power generation engineering, plus short circuit and coordination studies. For more information, contact Glyn Lewis at Applied Power, 790 Mediterranean Lane, Redwood Shores, CA 94065; phone: (650) 596-3417; fax: (650) 596-3439; email: glynjlewis@applied-power-ee.com.

About Cardinal Cogeneration

The Stanford University cogeneration facility is a combined-cycle power plant owned and operated by Cardinal Cogeneration, a subsidiary of General Electric. Commissioned in 1987, the plant consists of a natural gas-powered turbine driving a 39.2 MW generator, a waste Heat Recovery Steam Generator (HRSG), and a steam-powered turbine driving a 10.7 MW generator. Waste heat from the gas turbine combustion process is used by the HRSG to generate high-pressure steam that is in turn used in the steam turbine to generate additional electricity—hence combined cycle. Stanford uses about half the power generated by the plant; the balance is sold to PG&E. For more information, contact Power Systems Manager Steve Briscombe, phone: (650) 725-2036; email: steveb@bonair.stanford.edu; website: www.stanford.edu/group/EMG/.

About SEL

Schweitzer Engineering Laboratories, Inc. (SEL) has been making electric power safer, more reliable, and more economical since 1984. This ISO 9001-certified company serves the electric power industry worldwide through the design, manufacture, supply, and support of products and services for power system protection, control, and monitoring. The SEL Systems and Services Division assists in the application and use of products as well as providing complete systems customized for the specific application. From simple relay settings to substation automation systems to turnkey substation control houses, SEL SSD will add important value to your projects. For more information, contact SEL, 2350 NE Hopkins Court, Pullman, WA 99163-5603; phone: (509) 332-1890; fax: (509) 332-7990; email: info@selinc.com; website: www.selinc.com.

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