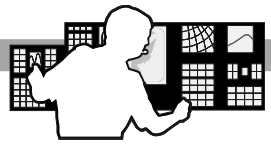

The challenge of offsite power reliability

BY RICK MICHAL

In the restructured electric power industry, can nuclear plants depend on adequate flows of offsite power to operate safety systems if needed?

RESTRUCTURING OF THE electric power industry has the potential to challenge operating and reliability limits on the transmission system and affect the reliability of offsite power to nuclear plants. Last August, the Callaway nuclear plant, in Missouri, experienced a rupture of a reheater drain tank line, which resulted in plant operators' initiating a manual reactor trip. With the reactor down, offsite power was required to supply plant equipment loads. But during this time, grid conditions were such that a substantial power flow was moving north to south through the local Callaway grid, a typical condition in the restructured wholesale electricity market.

This power flow, coupled with a high local demand and the loss of the Callaway turbine-generator as a result of the shutdown, caused switchyard voltage at the site to drop below minimum requirements for 12 hours. What surprised Callaway operators was their inability to see this voltage deficiency until after the reactor had tripped off line, because, while operating, the Callaway generator was supporting the grid voltage in the vicinity of the plant.

Although this occurrence was not safety significant since offsite power remained available to Callaway during the transient, post-trip analysis indicated that had additional onsite loads been in operation at the time of the event, the required voltage after the trip may not have been available to run the plant's safety equipment. If that occurred, onsite diesel generators may have been required to operate.

The Nuclear Regulatory Commission, after conducting an inspection at Callaway on the event, found that other nuclear plants across the country experienced similar circumstances of voltage deficiency from combinations of main generator unavailability, line outages, transformer unavailability, high system demand, unavailability of other local voltage support, and high plant load. Common among all the events, according to the NRC, was the inability of the plant operators to predict the inadequate voltages through direct readings of plant switchyard or safety bus voltages, without also considering grid and plant conditions and their associated analyses.

To prevent another similar occurrence from happening at Callaway, which is operated by Ameren/UE, the plant now uses a computer to do analysis of the Ameren/UE system to predict voltages in the event the plant trips. "System-wide analysis is looking at voltages, power flows, transmission lines, generating units, and then selectively looking at generating units out of service," said Mike Taylor, nuclear engineering manager at Callaway. "It is real-time analysis of what would occur if something would happen to the system."

Callaway also is installing capacitor banks, which will allow offsite power sources to be maintained at lower system voltages than was possible in the past. In addition, there are plans to install load tap changing transformers that permit the plant to control the voltage being supplied to safety buses and accommodate a wider range of voltages on its electrical system.

Added Dave Waller, Callaway's supervising engineer–electrical design, "I think the Callaway event highlighted this situation to the industry. I think there was some knowledge prior to that, but maybe it wasn't as widely recognized as it is now."

The NRC, meanwhile, has recognized the issue of grid reliability and nuclear plant safety by publishing an Information Notice (IN 2000-06) in March informing plant operators of experiences related to a "possible concern" regarding the voltage adequacy of offsite power sources. Said the IN, which does not require that any specific action be taken by plant operators: "As demonstrated by the Callaway event, industry deregulation can heighten the need to update the analyses on a more frequent basis. Some utilities have utilized on-line contingency analysis techniques in their grid control centers and implemented arrangements to be notified when the offsite system to their plant is in jeopardy of not providing its required capability. When the on-line capability is not available, other utilities have provided for updating of the analyses on a more frequent basis and have implemented procedures to identify when the plant and grid conditions are outside the bounds of the assumptions of the analyses, thereby providing the information to take compensatory actions as necessary."

The IN follows the NRC's report, *Effects of Deregulation of the Electric Power Industry on the Nuclear Plant Offsite Power System: An Evaluation,* released last June, and IN 98-07, *Offsite Power Reliability Challenges From Industry Deregulation,* issued in 1998 to alert plant operators to the potential adverse effect of electric power industry deregulation on the reliability of the offsite power source. "It's certainly an issue," said William Raughley, of the NRC's Office of Nuclear Regulatory Research. Raughley, who prepared the *Effects of Deregulation* report, called restructuring "a major change for the industry" and "something that [the NRC has] looked at just for that reason."

Why are nuclear plants now sometimes caught unaware of offsite voltage flows? Because before deregulation, Raughley's report explains, nuclear utilities owned both the offsite electric power generating units and the electrical transmission and distribution systems, and thus had better control and knowledge of the amounts of power being transferred. Now, however, many utilities are divesting themselves of their generating units, and the transmission systems are coming under the control of a new system control entity, such as an independent system operator (ISO). In addition, a power market has emerged to sell electricity, and utilities may no longer have direct control of the offsite power supplies and transmission system, which could decrease the reliability of the grid and increase the time to restore electric power following a loss of offsite power (LOOP).

Evaluations performed by the NRC indicate that the potential increase in risk resulting from grid-related LOOP events due to deregulation is likely to be low. The agency, however, is continuing to monitor grid reliability and take action, as needed. In the *Effects of Deregulation* report, the NRC specifically identifies the following potential impacts of deregulation on the offsite power system:

■ The grid design and operating configurations were established (before the electric power industry was deregulated) to ensure the correct voltages and frequencies on the system. Deregulation may result in unanalyzed grid operating configurations from daily changes in the operable generators. These changes come from implementing the power market and power load flow alterations resulting from the consumer's selection of a supplier, which affects where the power flows. Once the circuit configuration is defined, the laws of electricity, not the power market or consumers, determine how the electric current divides among the different grid paths under each operating configuration. Failure to analyze the grid under changing conditions and to reconfigure the grid to avoid adverse configurations could result in the following:

—Transmission line congestion, that is, individual transmission current flows that do not comply with previously established limits and cause abnormal voltages at the nuclear plants

while the plants are operating (which is the situation in which Callaway found itself).
—Unexpected responses of the grid following faults on the generation or transmission system that cause abnormal voltages and frequencies at the nuclear plants.
—Defaults on generation bids (i.e., failure to meet generation commitments) may erode reserve capacity margins that are needed to maintain system frequency and voltage stability following a disturbance.

■ Assumptions about the availability of the offsite power supplies could change. Nuclear plant operators are selling their generating facilities that supply offsite power to the nuclear plants. In some cases, these operators are selling the power supplies that are used to restore power to the grid following a grid blackout.

■ The duration of a LOOP or a station blackout may increase. Changes in ownership and control of generation and transmission facilities may increase recovery time because of less coordination between generation and transmission facilities following a grid disturbance.

■ Reliability forecasts prepared by the North American Electric Reliability Council (NERC), along with the NRC's Office of Nuclear Reactor Regulation investigation of plants, show that the effects of deregulation on the nuclear plants are regional. A major grid disturbance could affect several nuclear plants simultaneously.

■ Pressures to keep electricity rates competitive may result in a reduction of grid maintenance or a reluctance to invest in transmission system upgrades that are needed to preserve the present level of grid reliability to the nuclear plants.

■ As nuclear units are sold to nonutility entities, the new owners may choose to operate differently to compete in the power market. For example, nuclear generators may need to load-follow, that is, run fully loaded during the week days (peak load periods) and partially loaded at other times. This could potentially have an impact on the plant operator, reactor systems, and fuel performance.

The *Effects of Deregulation* report lays out the following recommendations for the NRC in dealing with grid reliability and plant safety: that no further regulatory action be taken to address grid reliability associated with the deregulation issue; that follow-ups be made on site-visit concerns, risk-based analyses, operating experience, and accident sequence precursor (ASP) evaluations to assure that nuclear plants' licensing bases are maintained; that causes of diesel generator unreliability be investigated; that significant LOOP events be assessed that either meet or exceed the ASP conditional core damage probability of 1E-6 (1 in 1 million per year), or have a duration in excess of the national median of approximately 30 minutes; and that NRC staff remain cognizant of the current status of grid issues, and assess future electric power grid reliability and its potential impact on nuclear plants' offsite power systems through continued contacts with NERC, the Electric Power Research Institute, and the Federal Energy Regulatory Commission.

NERC, which was formed as a voluntary organization in 1969 as a result of a major blackout in the northeast United States, has taken steps to give itself some teeth in the regulatory arena to better ensure grid reliability. As NERC is structured today, "while we have standards and rules, we have no enforcement power to be able to sanction penalties should a utility not do what it is supposed to be doing," said Gene Gorzelnik, NERC communications director.

To that end, NERC, which consists of 10 regional councils that segment the United States and Canada geographically, is trying to restructure as the North American Electric Reliability Organization, which would require passage of legislation in the Senate (S. 2071, the Electric Reliability 2000 Act) and House (H.R. 2944, the Electricity Competition and Reliability Act). That legislation, for which there is no timetable for passage, would, after approval by FERC, establish the new NERC as an electric regulatory organization, and would give it power to enforce grid reliability standards. For example, a utility would be fined if it failed to meet its spinning reserve requirement (which is the extra power needed in the event that weather conditions, plant outages, or other issues cause a shortage of power in a region). Without that ability to enforce compliance with mandatory reliability rules, NERC may not be able to keep the interstate grids operating reliably, Gorzelnik said.

Supporting the move to give NERC teeth is the Department of Energy, which in March released a report prepared by its Power Outage Study Team (POST) on findings and recommendations to enhance grid reliability. DOE's report is based on POST's study of power outages and system disturbances that occurred in summer 1999, in hopes of avoiding such problems in the future. "You always want to pay attention to grid reliability," said the DOE's Paul Carrier, POST chairman. "As the industry restructures, there is increased reliance on competition between the marketers and sellers and buyers of wholesale electric power. As the competition increases, with all the marketers, independent power producers, utilities, and other players, there is less incentive to comply with the standards of grid reliability."

In the western United States, one of NERC's regional councils, the Western Systems Coordinating Council, has developed a contract to encourage members to comply with NERC standards, Carrier said. "However," he lamented, "it's voluntary whether [the members] sign the contract or not, so until we can get some legislation that will set up an industry-run organization to develop the standards, NERC will have no federal oversight."

An ISO has been in place in California for two years now, and its number-one mandate is grid reliability, according to Doug Stickney, manager of controls–electrical at the San Onofre nuclear plant. That mandate seems to be working, Stickney reported, as there have been no significant disturbances to the local San Onofre grid since the ISO took control in March 31, 1998.

But even before implementation of the ISO, Southern California Edison, which operates San Onofre, had developed a program "such that we could never get in a condition where our offsite power requirements weren't met," Stickney said. That program involves schemes based on SCE's internal interfaces regarding grid-control activities. The program became a part of the transmission control agreement signed with the ISO. (A transmission control agreement is the formal contract between the traditional utilities and the new grid operator.)

Within that agreement is captured all the requirements for San Onofre's offsite power supply, including such items as normal operating voltage, minimum and maximum voltage, events that would occur to the local grid if one of San Onofre's two units tripped off line, and frequency of testing switchyard equipment. It also includes issues regarding the way the local grid itself is operated. "Our agreement says that [the grid] has to be operated such that we can't ever get in a Callaway situation," Stickney said.

The tools used for the avoidance of a Callaway situation have actually been in place at San Onofre for 10 years. That's when the internal schemes program was developed, based on analysis of a multitude of system operating scenarios (line outages, transformer unavailability, high system demand, etc.) to determine voltage before and following a reactor trip. Since then, the schemes, run through a computer, sound an alarm when voltage drops below the minimum required to support the plant in such scenarios as when one unit is offline and the other reactor trips.

SCE's contract also calls for the ISO to look at San Onofre's schemes to confirm that they are still valid. In the ISO's most recent review, according to Stickney, six changes were identified on San Onofre's local grid that included installation of new transformers, new transmission lines, and other VAR support. The conclusion, however, was that there was no need to change the original schemes. "So, we're in good shape on that," Stickney concluded. "We can't get into the situation where we're wheeling this huge amount of power that Callaway saw. [Our grid protection is] already built into the way we operate the grid, and it's been there since the early '90s."

The NRC, which unofficially recognized San Onofre for the development of its internal schemes program, contacted the Nuclear Energy Institute in March about getting the industry to start a voluntary initiative to assess the situation of vulnerabilities of grid reliability. The initiative would help the industry understand its risks and decide what, if any, actions need to be taken to assure continued compliance with plant technical specifications and the NRC's General Design Criterion 17, written circa 1970, which describes provisions to minimize the adverse affects of loss of offsite power. NN