

May 11, 1999

FOR: The Commissioners

FROM: William D. Travers /s/
Executive Director for Operations

SUBJECT: EFFECTS OF ELECTRIC POWER INDUSTRY DEREGULATION ON ELECTRIC GRID RELIABILITY AND REACTOR SAFETY

PURPOSE:

To inform the Commission of the staff's assessment of the potential impact of electrical power industry deregulation on grid reliability and reactor safety and to respond to the staff requirements memorandum (SRM) dated May 27, 1997, on this issue.

BACKGROUND:

The deregulation of the electric power industry is part of the ongoing national trend to deregulate major industries such as the airlines, telecommunications and natural gas. The National Energy Policy Act of 1992 allows for the sale of electricity on the open market and for customers to choose their supplier. Also, Federal Energy Regulatory Commission (FERC) Order 888, "Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities, Recovery of Stranded Costs by Public Utilities and Transmitting Utilities," issued in 1996, requires that utility and non-utility generators have open access to the electric power transmission system. Deregulation has the potential to challenge operating and reliability limits on the transmission system and could affect the reliability of the electric power system including the reliability of offsite power to nuclear plants. Consequently, the NRC issued [Information Notice 98-07](#), "Offsite Power Reliability Challenges From Industry Deregulation," to alert licensees to the potential adverse effect of electric power industry deregulation on the reliability of the offsite power source. Also, the North American Electric Reliability Council (NERC) has completed a "Reliability Assessment, 1997-2006," dated October 1997, and a "Reliability Assessment, 1998-2007," dated September 1998. These reports assess future electric generation and transmission reliability on a regional basis and identify regional grid reliability concerns, opportunities for improvement, areas for increased attention, and the need to monitor performance.

The status of staff activities with respect to grid reliability issues was presented in SECY-97-246, "Information on Staff Actions to Address Electric Grid Reliability Issues," dated October 23, 1997. That paper was in response to the SRM dated May 27, 1997, which listed four action items for the staff. The staff reported in SECY-97-246 that three of the items had been completed (make contacts with other agencies; provide information regarding the Summer Nuclear Power Station July 11, 1989, grid disturbance; and make regional contacts with power pool and reliability councils). SECY-97-246 also included the staff's Task Action Plan for work to be performed on the grid reliability issue. This paper completes action on the staff's Task Action Plan and reports the status of staff activities regarding the fourth item in the SRM:

The Commission asked the staff to give greater urgency to ensuring that related health and safety issues within the NRC's jurisdiction are addressed, particularly in reviewing the terms of the licensing basis and validating assumptions about grid reliability.

To address this concern, the staff (1) reviewed the operating experience for offsite power, plant electrical protection systems, and the onsite emergency power systems; (2) performed sensitivity studies for potential changes to initiating frequency and event duration related to station blackout (SBO) risk; (3) reviewed the NERC forecasts for future generation and transmission system reliability; and (4) visited a number of electrical control centers to obtain information regarding system operation during deregulation.

DISCUSSION:

- [Potential Concerns](#)
- [Recent NRC Activity](#)
- [Recent Experience](#)
- [Relative Risk Considerations](#)

POTENTIAL CONCERNS

The principal design criteria, including both deterministic and risk considerations, that provide the licensing basis for the offsite electric power system are provided in [10 CFR 50, Appendix A](#), General Design Criterion (GDC) 17, and [10 CFR 50.63](#), Loss of All Alternating Current Power.

GDC-17 requires that nuclear power plants be supplied by a reliable offsite power system. Before deregulation, nuclear utilities (i.e., NRC licensees) owned both the offsite electric power generating units and the electrical transmission and distribution systems. Many utilities are now divesting themselves of their generating units and the transmission systems are coming under the control of a new system control entity or an independent system operator. In addition, a power market has emerged to sell electricity. The fact that utilities may no longer have direct control of the offsite power supplies and transmission system could decrease the reliability of the grid and increase the time to restore electric power following a loss of offsite power (LOOP).

The deregulation of the electric power industry could be an important concern in the evaluation of potential SBO accidents at nuclear power plants. The expected frequency of the LOOP, the probable time needed to restore offsite power, and the redundancy and reliability of the emergency ac power sources are key factors in the determination of risk from potential SBO accidents. As deregulation proceeds, it is anticipated that more entities will enter the electrical power generation and transmission business resulting in a potential decrease in the reliability of the offsite power system during the transition period.

RECENT NRC ACTIVITY

Members of the staff, with contractor support from Oak Ridge National Laboratory (ORNL), visited a number of nuclear power plants and associated offsite electric power system control centers and regional councils to obtain information regarding system operation during the conversion to open grid access and deregulation. These trips included all of the ten regional councils that are members of the NERC. Prior to the trips, a protocol was developed to request information regarding electric power grid performance, impact on nuclear plant operations, forecasting, emergency conditions, and recovery from offsite power disturbances. Industry support for the trips to the control centers was on a voluntary basis and provided the staff with significant insights regarding the interrelationship between the nuclear plants and the system control centers. The information obtained indicates that there is significant diversity among NERC regions and between utilities within regions in addressing the potential effects of deregulation on nuclear plant offsite power systems. The information also identifies grid reliability concerns that are consistent with grid reliability assessments performed by NERC.

An engineering evaluation of the effects of deregulation, and a review and analysis of the operating experience as presented in licensee event reports (LERs) were performed to assess the principal criteria that provide the licensing basis. The LER review evaluated provisions to minimize the probability of a LOOP and previous protective scheme problems which could complicate offsite power system availability and reliability. Numerous LERs indicate weaknesses in past voltage analysis, testing, and plant surveillance procedures that affect the adequacy of the degraded voltage design, particularly the degraded voltage protective schemes and surveillance procedures. The operating experience also indicates concerns in the scope of the frequency protection, and potential unnecessary cascading during grid events (see recommendation 2a).

RECENT EXPERIENCE

The staff has completed reviews of LOOP events and emergency diesel generator (EDG) reliability. These reviews are presented in NUREG/CR-5496, "Evaluation of Loss of Offsite Power Events at Nuclear Power Plants: 1980-1996," and INEL-95-0035, "Emergency Diesel Generator Power System Reliability: 1987-1993." NUREG/CR-5496 provides an update of the LOOP data in NUREG-1032, "Evaluation of Station Blackout Accidents at Nuclear Power Plants," dated June 1988. NUREG-1032 divided LOOP events into three categories; namely, plant-centered, weather-related and grid-related, and showed that the median duration of a LOOP event is approximately 30 minutes. The NUREG/CR-5496 update shows that the frequency per site-year for plant-centered, weather-related and grid-related events has decreased significantly, with an approximate order of magnitude reduction in the frequency of grid-related events compared to the NUREG-1032 study. NUREG/CR-5496 notes that the recovery times tend to be longer, but the data set is small.

The EDG report indicated that the reliability estimate for the overall population of EDGs at 29 plants reporting under RG-1.108, "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants," with a 0.950 target goal is 0.987. The reliability estimate for the overall population of EDGs at RG-1.108 plants with a 0.975 target goal is 0.985. Although the overall reliability exceeds target goals, the nature of the failures experienced during actual demands differed somewhat from those discovered during monthly surveillance testing, engineering and design reviews. This indicates that the current testing and inspection activities may not be focusing on the dominant contributors to failures during actual demands, and may need to be modified to better consider the conditions and experiences gained from actual demand experience. This has been the subject of a long-planned study within the former Office for Evaluation and Analysis of Operational Data and will continue to receive attention in the new organization. The Office of Nuclear Regulatory Research (RES) plans to update the EDG reliability study with a planned completion date of January 2000 (see recommendation 2b).

RELATIVE RISK CONSIDERATIONS

An evaluation of risk associated with accident sequences initiated by LOOP is provided in NUREG-1032. This report was developed as part of the staff's resolution of Unresolved Safety Issue A-44, "Station Blackout." The report states an objective that the expected core damage frequency (CDF) from a SBO accident could be maintained around $1E-5$ (1 in 10,000) per reactor-year or lower for almost all plants.

The estimated range for the frequency of core damage as a result of SBO is given in NUREG-1032 as $1E-4$ to $1E-6$ per reactor-year. Further studies were performed by RES to assess the potential effect of deregulation on nuclear power plant CDF. The RES studies considered grid-related events and plant-centered, grid-initiated events, such as transmission system load dispatcher errors and nearby transmission line faults. Additionally, the RES studies were based on the postulated frequency of LOOPS and recovery times developed from information obtained during the site visits, and on the data and models in NUREG/CR-5496. Sensitivity studies indicated that the risk significance of potential grid unreliability due to deregulation is likely to be minimal, although individual plants might have an increase in CDF due to deregulation of as much as $1.5E-5$ per reactor-year should grid performance substantially degrade (see recommendations 2c and 2d).

Operation in a deregulated industry may result in different circumstances that change the insights obtained from past risk and reliability studies. The NRC currently analyzes LOOP events as part of the inspection program and the Accident Sequence Precursor (ASP) program. Events that meet or exceed a conditional core damage probability of $1E-6$ receive further analysis. A review of grid-related events from 1980 thru 1996 indicates that all such events have met or exceeded the ASP threshold.

Prompt review of LOOP events as part of the inspection program would provide the NRC an early indication of an event's significance and initiate additional investigation, such as an Augmented Investigation Team, as required. This indication would enable the NRC to take regulatory action, as needed. Additionally, grid-related events generally have a broad public impact that creates pressure for extensive corrective action. This was the case for significant grid transients that occurred on the Western Interconnection in 1994 and 1996 that resulted in, what appears to be, an effective response by electric utilities.

RESOURCES

The resources should be budgeted for the recommendations described in this paper. These activities will be prioritized and scheduled consistent with the Planning, Budgeting, and Performance management process.

CONCLUSIONS

Evaluations performed by the staff indicate that the potential increase in risk resulting from grid-related LOOP events due to deregulation is likely to be low; however, the staff will continue to monitor grid reliability and take action, as needed. For example, the NERC reliability assessments and site visits indicate common grid reliability concerns. While the NRC does not have jurisdiction over operation of the grid, Information Notice 98-07 alerted licensees to the potential adverse effects of deregulation of the electric power industry on the reliability of the offsite power source. Consequently, nuclear power plants are expected to prepare for these concerns by assuring that plant features for coping with LOOP and SBO events are properly monitored and maintained. In addition to the appropriate command, control and communication infrastructure with the grid controlling entity, existing regulatory controls should ensure the reliability of emergency power generators and the adequacy of protective relays and alarms for the switchyard and emergency buses.

The NRC will continue to assess LOOP events on a prompt basis as part of the inspection program and also as part of the ASP program. For events that exceed the ASP threshold of 1E-6, where appropriate, further review will be performed to obtain plant-specific and potential generic insights concerning the event. If the inspection or ASP reviews indicate that additional staff evaluation of the event is needed, the status of the plant response to deregulation concerns will be assessed using as a guide the ORNL protocol developed for the site visits. This information will indicate if further plant-specific or generic attention is necessary.

In addition, review of the NERC grid reliability forecasts and follow-up discussions, as required, appear to be the most practical means of assessing the potential impact of deregulation on the offsite power system. Continued contact with NERC, FERC and the Electric Power Research Institute (EPRI) will also enhance the NRC's understanding of potential deregulation issues related to grid reliability.

COORDINATION

NRR participated in this review and concurs in the recommendations. The Office of the Chief Financial Officer has reviewed this paper for resource implications and has no objections. The Office of the General Counsel has no legal objection to this paper.

RECOMMENDATIONS

Based on evaluation of the initiatives completed to date, the Commission should note that:

- (1) The staff will take no further regulatory action to address grid reliability associated with the deregulation issue.
- (2) To assure that the licensing basis is maintained, the staff will follow-up on the NERC and site visit concerns, risk-based analyses, operating experience, and ASP evaluations as follows:
 - (a) The staff will evaluate the adequacy of (i) the existing technical guidance on offsite power and voltage issues, (ii) the degraded voltage protective relay setpoints, and (iii) the scope of the offsite power system frequency protection, including whether the existing reactor coolant pump under frequency protection could lead to unnecessary trips. These actions are intended to help assure that plant ac safety equipment remains protected from abnormal offsite system voltages and frequencies.
 - (b) The staff will investigate causes of diesel generator unreliability identified from INEL-95/0035. The staff will continue to assess the reliability of the onsite diesel generators to ensure that the reliability is maintained consistent with the risk studies used to develop the SBO rule (10CFR50.63).
 - (c) The staff will continue to assess significant LOOP events that are reported under [10 CFR Part 50.72](#) and [50.73](#), for prompt review as part of the inspection program. The 10 CFR 50.73 LOOP events will also continue to be reviewed as part of the ASP program. Follow-up action will be considered as indicated by the inspection program, for LOOP events that either meet or exceed the ASP conditional core damage probability of 1E-6, or have a duration in excess of the national median of approximately 30 minutes.
 - (d) The staff will remain cognizant of the current status of grid issues, and assess future electric power grid reliability and its potential impact on nuclear power plants' offsite power systems through its continued contacts with FERC, NERC, and EPRI.

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