February 27, 2004

MEMORANDUM TO: Ledyard B. Marsh, Director
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

FROM: Patrick W. Baranowsky, Chief */RA/*
Operating Experience Risk Analysis Branch
Division of Risk Analysis and Applications
Office of Nuclear Regulatory Research

SUBJECT: TRANSMITTAL OF PRELIMINARY ASP ANALYSES FOR PEER REVIEW (August 14, 2003 Grid event)

This memorandum provides eight preliminary Accident Sequence Precursor (ASP) analyses of plants that lost offsite power and tripped as a result of the grid event of August 14, 2003. Nine plants lost offsite power due to an electrical disturbance on the grid. Eight plants (Fermi, Fitzpatrick, Nine Mile Point 1 and 2, Perry, Ginna, Indian Point 2 and 3) were at power, while Davis-Besse was in cold shutdown. Oyster Creek tripped, but did not lose offsite power to the vital buses. The eight analyses are summarized in Attachment 1 to this memorandum. The issuance of this package is part of our input to NRC's Action Plan for Resolving Electrical Grid Concerns (Green Ticket G20030756).

NRC peer review requested. Please review the preliminary ASP analyses and provide us with any comments that you may have. In order to facilitate incorporation of licensee and staff comments and preparation of the final report in a timely manner, consistent with the NRR and RES agreement on peer review, please provide your comments to us within 60 calendar days from the date of this memorandum.

Licensee peer review requested. We are also requesting NRR/DLPM to send the preliminary ASP analysis to the licensee for peer review. Since each preliminary ASP analysis undergoes an in-house independent review before it is sent out by OERAB, peer review by NRR and the region can be performed concurrently with the licensee's review. This process is also consistent with the NRR/RES peer review agreement. The analyses and a transmittal letter will be provided separately by the ASP Program Manager (Marc Harper) to the NRR ASP Program liaison (Tanya Mensah). This letter reflects the modifications made by NRR/DLPM based on recent preliminary analyses sent to licensees, as well as the instruction added to the letter regarding the transmittal of comments by the licensee that may contain potentially sensitive information.

Results of analyses. The conditional core damage probabilities (CCDPs) of these eight events range from 3×10^{-5} to 5×10^{-4}, with five analyses with CCDPs greater than 1×10^{-4}. Table 1 summarizes the risk at each plant, the duration of the loss of offsite power and the operating or design issues that affect the risk calculations. Note that these CCDPs are mean estimates.

More detailed information on the events, as well as with uncertainty bounds for the CCDP calculations are included in Attachment 1.

Table 1: ASP Analysis Summary

Plant	Reactor type	Complications modeled	**Mean CCDP**	Length of time until power was available to the switchyard
Fermi 2	BWR-4 Mark 1	Gas turbine failed to start - recovered in 3 hrs	2E-4	6 h-19 m
Fitzpatrick	BWR-4 Mark 1		9E-5	2 h-49 m
Ginna	West 2-loop	PORVs opened once; MDAFW failed to start	2E-4	0 h-49 m
Indian Point 2	West 4-loop		1E-4	1 h-37 m
Indian Point 3	West 4-loop		7E-5	1 h-37 m
Nine Mile Pt 1	BWR2 Mark 1		3E-5	0 h-56 m
Nine Mile Pt 2	BWR-5 Mark 2		5E-4	6 h-24 m
Perry	BWR-6 Mark 3	RCIC manually isolated at 3 hrs; LPCS and RHR pump B affected by keep fill system problem	5E-4	1 h-27 m

The reasons for the plant-to-plant CCDP variations are primarily due to the different durations of the loss of off-site power at each site, the minor problems with mitigating systems in several plants, and design differences among the plants. The offsite power recovery times used in the ASP analyses are based on the times when permission was given from the grid control center to use the power, as reported in the LERs and/or the questionnaires (ML0324102160 and ML0324102370) prepared and compiled by the Regions. Additional time to get power from the switchyard to a safety bus and the probability of failing to successfully restore the power was also considered in the ASP analyses of accident sequences.

An important plant design feature with respect to station blackout risk is the time to battery depletion. Battery depletion times used in the Standardized Plant Analysis Risk (SPAR) models which were used in the ASP analyses were derived from licensee PRA studies. Other important design features include the configuration of emergency diesel generators and alternative power sources, and the availability of turbine-powered mitigating systems.

Final ASP Analysis and Report. Within 2 months after the receipt of comments from the staff and licensees, the ASP analyses will be revised, as necessary, and issued in accordance with ASP Program procedures. Within 2 months after the completion of the technical analyses, a

report summarizing the results and risk insights learned from the ASP analysis of these events will be issued for public and staff use.

Sensitive information. These ASP analyses are classified as "SENSITIVE - NOT FOR PUBLIC DISCLOSURE." This classification is based on the guidance provided by the EDO in the memorandum to the Commission (dated April 4, 2002) concerning the release of information to the public that could provide significant assistance to support an act of terrorism. In particular, Criteria 1 was determined to apply to ASP analysis reports:

> Plant-specific information, generated by NRC, our licensees, or our contractors, that would clearly aid in planning an assault on a facility. An example might be drawings depicting the location of certain safety equipment within plant buildings. Examples may include portions of Final Safety Analysis Reports (FSARs), Individual Plant Examination (IPE) material, and other risk and facility vulnerability information.

This classification could change in the future based on revised Agency guidance and office (NRR and RES) procedures in response to the Staff Requirements Memorandum, "Staff Requirements - COMSECY-02-0015 - Withholding Sensitive Homeland Security Information From the Public," dated April 4, 2002. Future changes in the transmittal of ASP analyses will be coordinated with the NRR ASP Program liaison.

If you have any questions about the individual analyses, please contact Gary DeMoss (415-6225).

Attachments: As stated

cc:
Cornelius Holden
Charles Ader

MEMORANDUM DATED: 2/27/04

SUBJECT: TRANSMITTAL OF PRELIMINARY ASP ANALYSES

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DOCUMENT NAME: A:\MEMO–LOOP ASP TO ALL.WPD

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Attachment 1: ASP ANALYSES

This attachment summarizes the assumptions, approach and results of eight ASP analyses of the plants affected by the grid disturbance of August 14, 2003.

LOOP Analysis Approach and Assumptions

The following is a brief summary of the approach to analyzing these events. The general approach is relatively standard for ASP events. LOOP event analyses are a type of initiating event assessment frequency performed in the ASP program. Specific analysis steps that are unique to ASP analysis of these LOOP events are included here.

1. Determine significant facts associated with the event

1.1 Determine when the LOOP occurred
1.2 Determine when stable offsite power was first available in the switchyard
1.3 Determine when offsite power was first restored to an emergency bus
1.4 Determine when offsite power was fully restored (all emergency buses powered from offsite, EDGs secured)
1.5 Identify any other significant conditions, failures, or unavailabilities that coincided with the LOOP

2. Model power recovery factors associated with the best estimate case and any defined sensitivity cases

2.1 For the best estimate case, the LOOP duration is the time between the occurrence of the LOOP and the time when power was available in the switchyard to restore power to a safety bus plus the estimated time required to restore power from the switchyard to emergency buses. Input from the regions (Blackout Plant Data provided to the Grid Concerns Group) (ML0324102160 and ML0324102370), along with plant LERs was used in the analysis.
2.2 If EDGs successfully start and supply emergency loads, plant operators do not typically rush to restore offsite power to emergency buses, preferring to wait until grid stability is more certain. Therefore, a typical upper bound sensitivity case considers the LOOP duration as the time between the occurrence of the LOOP and the time when offsite power was first restored to an emergency bus.

3. Model event-specific mission durations for critical equipment for the best estimate case and any defined sensitivity cases. (For most equipment, SPAR model failure probabilities are not functions of defined mission durations and are therefore not affected by this analysis step. Notable exceptions include EDGs and, for PWRs, turbine-driven auxiliary feedwater pumps.)

3.1 For the best estimate case, mission durations are set equal to the assumed LOOP duration as defined in Step 2.1 above
3.2 For a typical upper bound sensitivity case, mission durations are set equal to the time between the occurrence of the LOOP and the time when offsite power was fully restored to all emergency buses. (Note these mission durations are longer than the assumed LOOP duration defined in Step 2.2 above; they are intended

to represent the longest possible mission duration for any critical equipment item.)

Assumptions: The following major assumptions significantly effect the quantitative risk estimates:

1. Offsite power recovery:

   a. ***Information source.*** Used inputs from the regions (Blackout Plant Data provided to the Grid Concerns Group) (ML0324102160 and ML0324102370)

   b. ***Best estimate***. Time when the regional reports indicated that power was first available to restore power to the safety bus.

   c. ***Upper bound sensitivity***. Actual time that offsite power was restored to the first emergency bus. This calculation is provided along with each ASP analysis package.

2. About 1 hour is required to restore power to emergency loads after power is available in the switchyard - Used SPAR Human Reliability Assessment method.

3. SPAR models do not credit offsite power recovery following battery depletion in station blackout sequences.

LOOP Analysis Results

Figure 1 summarizes the results of the ASP analyses and the uncertainty range associated with each analysis. Table 2 summarizes the results by tabulating the key plant and power recovery information. The plant-by-plant analysis summaries follow the figure and table. The risk is dominated by individual and common-cause failures of diesel generators and offsite power recovery times. Since these events have larger parameter uncertainties than most PRA events, the uncertainty bounds are relatively large.

Figure 1: ASP Analysis Results
August 14, 2003 Events

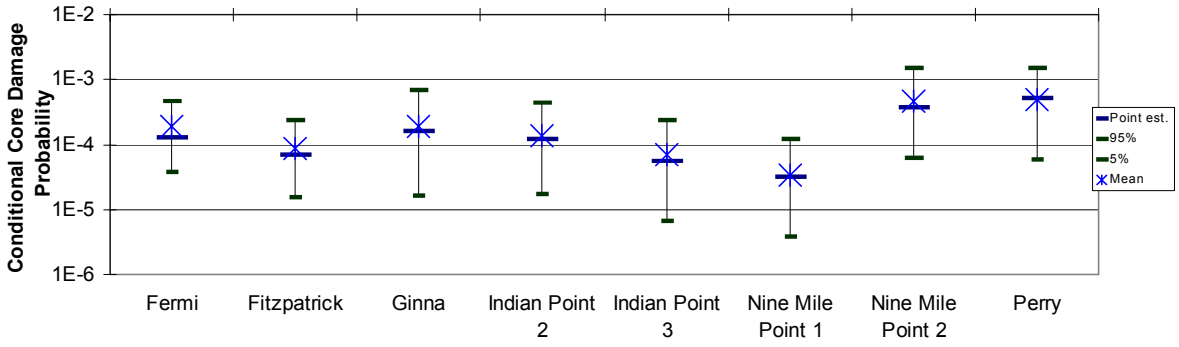

Table 2 -ASP Analysis Summary Table

Plant/ LER	Battery depletion (assumed in IPE)	Important LOOP/SBO systems	CCDP (Recovery time, hr:min)		Comments
			Best est: Power to switch yard	Upper bound (point est): Power to 1st vital bus	
Fermi 2 341/03-002	4 hrs w/o shed	4 EDGs; 1 combustion gas turbine	2E-4 (6 h-19 m)	2E-4 (9 h-42 m)	From state of Michigan Report - Between 10:00 p.m. and 10:30 p.m., the Allen Junction--Majestic--Monroe interconnection between Detroit Edison and First Energy was used to establish a restoration path from Monroe to Brownstown to Fermi (Used 10:30)
Fitzpatrick 333/03-001	6 hrs w/ shed	4 EDGs (no LOCA)	9E-5 (2 h-49 m) w/ load limit	3E-4 (6 h-56 m)	The system was recovered at 19:00 when ECC provided a 5 MW load limit.
Ginna 244/03-002	4 hrs w/o shed	2 EDGs; 5 AFW pumps	2E-4 (0 h-49 m)	4E-3 (4 h-58 m)	Offsite power was never lost. The grid voltage was unstable from the onset about 1611 and became relatively stable at about 1700. Operators conservatively declared the offsite power sources inoperable with respect to Technical Specifications between the hours of 1611 and 2108, even though the system was only considered degraded.
Indian Point 2 247/03-005	3 hrs w/o shed	3 EDGs; 3 gas turbines	1E-4 (1 h-37 m)	3E-4 (3 h-34 m)	As reported by load dispatchers.
Indian Point 3 286/03-005	2 hrs w/o shed	3 EDGs; 3 gas turbines; App R diesel	7E-5 (1 h-37 m)	4E-4 (4 h-01 m)	CEDO informed CCR that 138 kV breaker was closed and feeder was in service
Nine Mile Pt 1 220/03-002	8 hrs w/ shed	2 EDGs; Isolation condenser; Diesel fire pump	3E-5 (0 h-56 m)	4E-4 (7 h-28 m)	At approx. 5:07 pm, 115 kV lines 1 and 4 were reconnected to the NMP1 normal buses. (Licensee report.)
Nine Mile Pt 2 410/03-002	8 hrs w/shed	2 EDGs; 1 EDG-HPCS; Diesel fire pump	5E-4 (6 h-24 m)	3E-2 (9 h-11 m)	The line was degraded until 10:35 pm as reported by load dispatchers.
Perry 440/03-002	22 hrs w/ shed & crosstie	2 EDGs 1 EDG-HPCS	5E-4 (1 h-27 m)	5E-4 (2 h-03 m)	Offsite power was restored to the Perry Unit 1 Startup transformer at 1737 when one transmission yard breaker was closed. This restored one source of offsite power to the plant. (Inspection report)

Fermi

At 1610 hours on August 14, 2003, Fermi experienced grid instability and a subsequent reactor trip while operating at 100 percent power. Loss of offsite power (LOOP) occurred at 1611 hours. Plant emergency diesel generators (EDGs) started and supplied power to safety-related plant loads until offsite power was restored. (Refs. 1 and 10).

Other conditions, failures, and unavailable equipment. The Combustion Gas Turbine Generator (CTG) failed to start from the control room due to the failure of a battery-powered inverter. The CTG was manually started 3 hours into the event using a portable generator as an alternate source of starting power.

Recovery opportunities. Offsite power was first available at 2230 hours. Power from offsite was restored to the first emergency bus at 0153 hours on August 15th.

Analysis Results. The mean CCDP for this event is 1.9×10^{-4}. The complete ASP analysis can be found at ML040580625.

Fitzpatrick

At 1611 hours on August 14, 2003, Fitzpatrick experienced grid instability and a subsequent reactor trip while operating at 100% power. Loss of offsite power (LOOP) occurred at 1613 hours. Plant EDGs started and supplied power to safety-related plant loads until offsite power was restored. (Refs. 2 and 9).

Other conditions, failures, and unavailable equipment. No other conditions, failures, or unavailable equipment occurred during the event.

Recovery opportunities. Offsite power was recovered over a period of time, commencing at 1900 hours on August 14, 2003 with restoration of the 115 kV transmission system with an imposed load limit and ending at 2400 hours on August 14, 2003 with restoration of 115 kV transmission system to full capacity. Offsite power was restored to the first emergency bus at 2307 hours and to the second emergency bus at 2328 hours (Ref. 1).

Analysis Results. The mean CCDP for this event is 8.6×10^{-5}. The complete ASP analysis can be found at ML040580544.

Ginna

At 1611 hours on August 14, 2003, Ginna experienced grid instability and a subsequent reactor trip while operating at approximately 100% power. Offsite power was never completely lost to the buses supplying the power block area; however, the operators determined that the offsite power supply was unreliable and manually started and loaded the plant EDGs onto the

emergency buses. The EDGs supplied power to safety-related plant loads until offsite power was deemed stable. (Refs. 3 and 9).

Other conditions, failures, and unavailable equipment. One of the auxiliary feedwater motor-driven pumps (Pump B) was inoperable due to damage sustained because of an error in pump alignment on startup of the pump. Both Pressurizer Power Operated Relief Valves (PORVs) lifted and re-closed to limit the pressure transient. (Ref. 1).

Recovery opportunities. Offsite power was considered stable at 1700 hours. Power from offsite was first restored to an emergency bus at 2108 hours.

Analysis Results. The mean CCDP for this event is 1.9×10^{-4}. The complete ASP analysis can be found at ML040580564.

Indian Point 2

At 1611 hours on August 14, 2003, Indian Point 2 experienced grid instability, a reactor coolant pump trip on under-frequency, and a subsequent reactor trip while operating at 100% power. Plant EDGs started and supplied power to safety-related plant loads until offsite power was restored. (References 2 and 9).

Other conditions, failures, and unavailable equipment. No other significant conditions, failures, or unavailable equipment occurred during the event.

Recovery opportunities. Con Edison System Operators informed the control room that power was restored to the 138kV Buchanan yard feeder at 1749 hours. Offsite power was restored to the first emergency bus at 1945 hours, to the second emergency bus at 2002 hours, and to the third emergency bus at 2021 hours. (References 4 and 9).

Analysis Results. The mean CCDP for this event is 1.4×10^{-4}. The complete ASP analysis can be found at ML040580577.

Indian Point 3

At 1611 hours on August 14, 2003, Indian Point 3 experienced grid instability and a subsequent reactor trip while operating at 100% power. Loss of offsite power occurred at 1611 hours. Plant EDGs started and supplied power to safety-related plant loads until offsite power was restored. (Refs. 5 and 9).

Other conditions, failures, and unavailable equipment. The auxiliary feedwater (AFW) flow control valves lost pneumatic control; however, the valves fail open on loss of instrument air so that flow was not lost to the steam generators. Therefore, this condition was not modeled in the assessment.

Recovery opportunities. Offsite power was first available at 1749 hours. Power from offsite was first restored to an emergency bus at 2012 hours.

Analysis Results. The mean CCDP for this event is 7.1 x 10^{-5}. The complete ASP analysis can be found at ML040580590.

Nine Mile Point 1

At 1611 hours on August 14, 2003, Nine Mile Point 1 experienced grid instability and a subsequent turbine trip followed by reactor trip while operating at 100 % power. Loss of offsite power occurred at 1613 hours. Plant EDGs started and supplied power to safety-related plant loads until offsite power was restored.(Refs. 6 and 9).

Other conditions, failures, and unavailable equipment. No other significant conditions, failures, or unavailable equipment occurred during the event.

Recovery opportunities. Offsite power, with permission from regional load dispatchers to use the power for plant auxiliary loads, was first available at 1707 hours. Offsite power was restored to the first emergency bus at 2339 hours and to the second emergency bus at 0018 hours on August 15.

Analysis Results. The mean CCDP for this event is 3.4 x 10^{-5}. The complete ASP analysis can be found at ML040580598.

Nine Mile Point 2

At 1611 hours on August 14, 2003, Nine Mile Point 2 experienced a disturbance on the electrical grid and a subsequent turbine trip followed by reactor trip while operating at 100% power. Undervoltage conditions occurred on each of the three emergency buses at 1612 hours. Plant EDGs started and supplied power to safety-related plant loads until offsite power was restored. (Refs. 7 and 9).

Other conditions, failures, and unavailable equipment. No other significant conditions, failures, or unavailable equipment occurred during the event.

Recovery opportunities. Offsite power was first available at 2235 hours. Offsite power was restored to the Division 1 emergency bus at 0122 hours on August 15, to the Division 3 emergency bus at 0356 hours, and to the Division 2 emergency bus at 0708 hours.

Analysis Results. The mean CCDP for this event is 4.7 x 10^{-4}. The complete ASP analysis can be found at ML040580606.

Perry

At 1610 hours on August 14, 2003, Perry experienced a disturbance on the electrical grid and a subsequent main generator trip followed by a turbine trip and a reactor trip while operating at 100% power. Plant EDGs started and supplied power to safety-related plant loads until offsite power was restored. (Refs. 8 and 10).

Other conditions, failures, and unavailable equipment. The A train of Residual heat removal (RHR) was inoperable for approximately 6 hours because of air binding in the keep-fill system pump. The low-pressure core spray (LCS) system was also affected by the air binding in the keep-fill system, but the LCS system was recoverable from the start of the LOOP. Approximately 3 hours into the event, the reactor core isolation cooling (RCIC) turbine-driven pump was manually secured to prevent an automatic shutdown because of high steam tunnel temperature. The high steam tunnel temperature was caused by a loss of ventilation, and the RCIC system was recoverable.

The Division 1 EDG tripped on reverse power while being removed from service. This had no effect on the CCDP for this event.

Recovery opportunities. Offsite power was first available at 1737 hours when one transmission yard breaker was closed. Offsite power was restored to the Division 1 emergency bus at 1813 hours on August 14, to the Division 3 emergency bus at 1214 hours on August 15, and to the Division 2 emergency bus at 1548 hours on August 15.

Analysis Results. The mean CCDP for this event is 5.0×10^{-4}. The complete ASP analysis can be found at ML040580615.

References

1. Licensee Event Report 341/03-002, Revision 1, *Automatic Reactor Shutdown Due to Electric Grid Disturbance and Loss of Offsite Power*, event date August 14, 2003, (ADAMS Accession No. ML033570189).

2. Licensee Event Report 333/03-001, Revision 0, *Automatic Reactor Shutdown Due to Grid Instability Associated With the August 14th, 2003 Transmission Grid Blackout and Related Plant MODE Change with the A EDG Subsystem Inoperable*, event date August 14, 2003 (ADAMS Accession No. ML0329601250).

3. Licensee Event Report 244/03-002, Revision 0, *Major Power Grid Disturbance Causes Loss of Electrical Load and Reactor Trip*, event date August 14, 2003, (ADAMS Accession No. ML0328904410).

4. Licensee Event Report 247/03-005, Revision 0, *Automatic Reactor Trip due to Reactor Coolant Pump Trip on Under-Frequency Caused by a Degraded Off-Site Grid*, event date August 14, 2003 (ADAMS Accession No. ML0328902230).

5. Licensee Event Report 286/03-005, Revision 0, *Automatic Reactor Trip due to Reactor Coolant Pump Trip on Under-Frequency Caused by a Degraded Off-Site Grid*, event date August 14, 2003, (ADAMS Accession No. ML0328902210).

6. Licensee Event Report 220/03-002, Revision 0, *Reactor Scram Due to Grid Disturbance*, event date August 14, 2003 (ADAMS Accession No. ML0329701050).

7. Licensee Event Report 410/03-002, Revision 0, *Reactor Scram Due to Electric Grid Disturbance*, event date August 14, 2003 (ADAMS Accession No. ML0329701090).

8. Licensee Event Report 440/03-002, Revision 1, *Reactor Scram Due to Electric Grid Disturbance*, event date August 14, 2003 (ADAMS Accession No. ML033530117).

9. NRC Region 1 Grid Special Report, October 15, 2003, (ADAMS Accession No. ML0324102160).

10. NRC Region 3 Grid Special Report, August 28, 2003, (ADAMS Accession No. ML0324102370).

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REMARKS

TRANSMITTAL OF Preliminary ASP ANALYSES (August 14 LOOP events)

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