LOOP Events and Industry Experience

Frank Rahn

EPRI

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EPRI

Attachment 3

Three of EPRI's Guidelines in Assessing Loss-of-all Offsite Power Experience

- Loss-of-all-offsite-power means that offsite power is not available to the minimum number of a unit's safeguard busses that are required for safe shutdown
- The duration of the loss is how long offsite power is truly unavailable, not how long the emergency diesel generators power the safeguard buses
- EPRI is not co-mingled loss-of-offsite power data and blackout data

Determining the Duration of Losses of All Offsite Power

- In times past, and occasionally even today, the duration of a LOOP is recorded as the length of time the emergency diesels power the buses
  - This is a required record and is readily known
- However, many, if not most, plants make the diesels their first line of defense, even when other sources of offsite power are available
- They switch back to offsite power only after any unstable water levels, erratic flows and deviate pressures are under control, and a convenient moment presents itself

Determining the Duration of Losses of All Offsite Power (con't)

- EPRI works with the plant on every event to analyze and determine how long offsite power is truly unavailable

- This has been a time-consuming on-going effort, but it is the key to having meaningful loss-of offsite power statistics

EPRI Believes That Loss-of-Offsite Power Statistics and Grid Blackout Statistics Should be Evaluated Separately

- The occasional loss-of-offsite-power is something very different than a grid blackout
- The occasional loss-of-offsite power usually occurs because of events such as weather, or a random isolated equipment or human failure:
  - Such failures can be minimized but never completely eliminated
  - The impact of such failures is usually limited to one plant and a loss-of-power for hours
  - In the U.S. there are typically only 1, 2,or 3 such losses of all offsite power per year

EPRI Believes That Loss-of-Offsite Power Statistics and Grid Blackout Statistics Should be Evaluated Separately (con't)

- A grid blackout is not the result of one or two random failures:
  - It indicates an overall grid weakness
  - The impact can cover a broad territory and many plants, and the loss-of-power can last from many hours to days
  - There is an intense effort to improve grid reliability
- If combined, blackout statistics would overwhelm normal loss-of-offsite power statistics and totally obscure their meaning
- For the above reasons, EPRI sees a grid blackout as something very different

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Loss-of-Offsite Power Experience Through the Years

- EPRI became interested in loss-of-offsite power in the early 1980's:
  - Statistics were showing a 10% chance of losing offsite power sometime during the year
  - However, plants were basing statistics on emergency diesel operation, not on actual losses of offsite power
  - They were also classing most partial losses of offsite power as losses of all offsite power
  - In the 1970's and 1980's the transmission grid was not as robust as it is today
  - The net of all this was an apparent poor loss experience

Loss-of-Offsite Power Experience Through the Years (con't.)

- Since then, the overall loss experience has continued to greatly improve:
  - This is to be expected
  - There are many more switchyards, including new switchyards for each new power plant
  - There are many more and heavier transmission lines
  - With more switchyards, the average length of each line is shorter, hence the exposure is less
  - There are more parallel paths from one place to another
  - Also of great significance, the occurrence of plant centered equipment failures has continued to decline

Loss-of-Offsite Power Experience Through the Years (con't)

- During the six years 1998 – 2003 there were only 9 losses of all offsite power:
  - 6 were longer than 4 hours
  - 5 were longer than 8 hours
- The more robust grids and switchyards have greatly reduced the incidents of minor, short duration losses
- What remains are the longer losses associated with weather and major failures

Loss-of-Offsite Power Experience Through the Years (con't)

- The following are the number of losses of ALL offsite power that occurred at the 103 U.S. operating nuclear plants during the most recent 6 years:

Year	Number of Events
1998	3
1999	2
2000	1
2001	1
2002	0
2003	2

The Current LOOP Statistics

	Losses Per Generating Unit Year
Year 2003	0.019
Most Recent 3 Years (2001 thru 2003)	0.010
Most Recent 10 Years (1994 thru 2003)	0.020

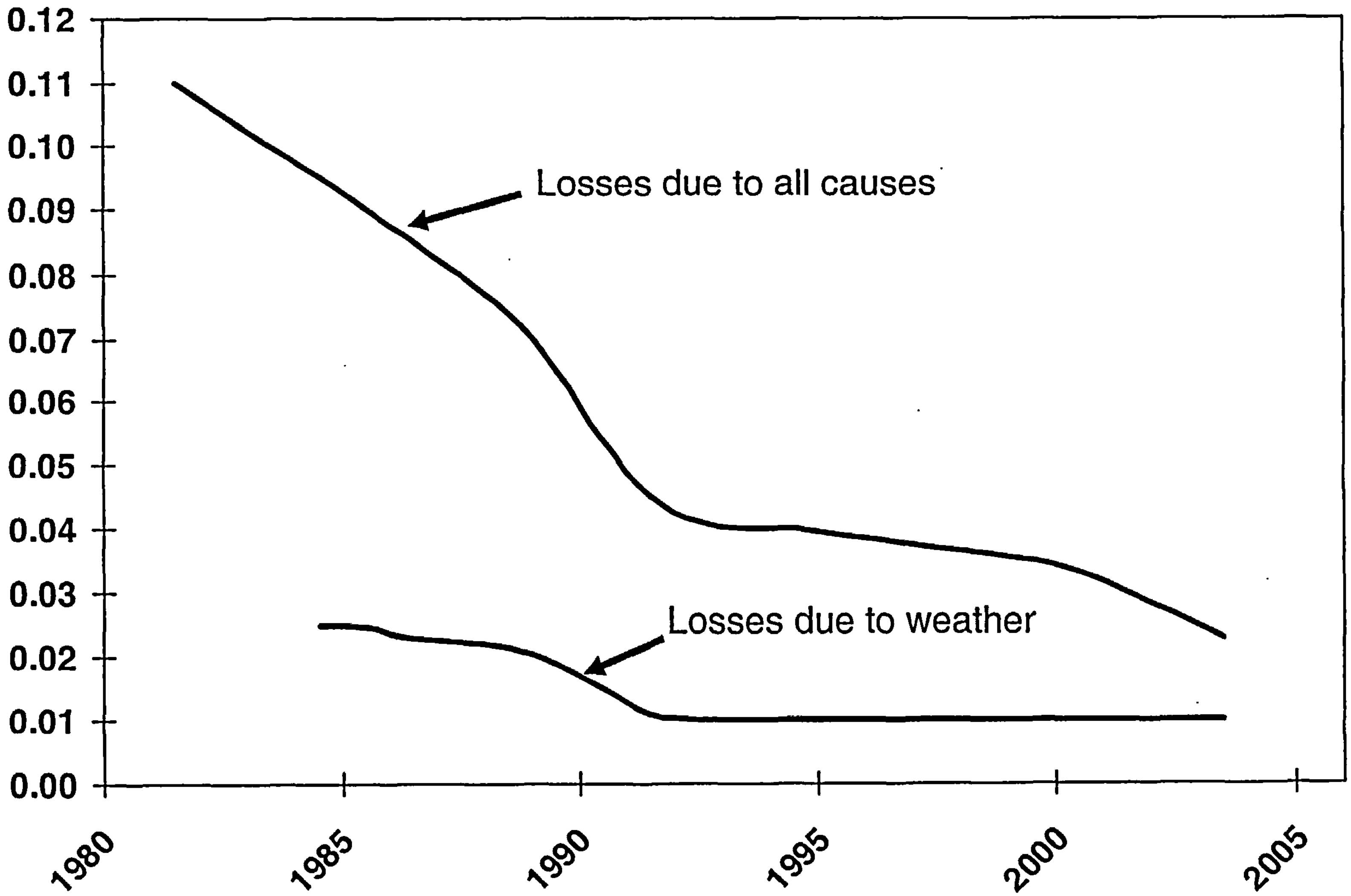
A View of the Past 10 Years

- There were 21 LOOPS at U.S. nuclear power units
- 15 LOOPS lasted longer than one hour
- 12 LOOPS lasted longer than two hours
- 10 LOOPS lasted longer than four hours
- The median duration was between 3 and 4 hours

A View of the Past 10 Year (con't)

- At present there is a 2% to 3% chance that the average U.S. nuclear plant will lose all offsite power sometime during the year:
  - There are 103 plants operating in the U.S.
  - There typically are 2 or 3 instances per year where all offsite power is lost

The Probability That A U. S. Nuclear Power Plant Would Lose All Offsite Power To Its Safeguard Buses Sometime During The Year



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Weather Caused LOOP Experience

- Of the 21 LOOPS during the past 10 years, 7 were caused by weather

- The median for weather events was about 6 hours

Weather Caused LOOP Experience (con't)

- There has not been a weather caused LOOP for 6 years
- The two most recent weather LOOPS occurred in 1998 (at Braidwood 1 and Davis Besse)
- There has been no hurricane caused LOOP during the last 10 years
- There has been only one weather caused LOOP on the Eastern seaboard during the last 10 years

The Median Duration of Losses of All Offsite Power

- Through the years the overall median duration of losses of offsite power has increased from around ½ hour to between 3 and 4 hours

- The reason is readily apparent:
  - The number of non-weather, plant centered random losses of short duration has decreased
  - The number of weather caused losses has remained relatively flat
  - Weather caused losses tend to last substantially longer than typical equipment caused LOOPS

How are Nuclear Plants Coping with Grid Related Events

- There have been several significant grid events in the last 10 years that have impacted nuclear plants
- These include:
  - Northeast Blackout August 14, 2003
    - more than 531 generating units (including 9 nuclear) were lost
    - all nuclear units performed as designed
    - they remained in a safe shutdown condition until their restart
  - WSCC Blackout August 10,1996
    - several nuclear units tripped, but no LOOP recorded, e.g. Diablo Canyon had voltage thru 230kV line from Morro Bay

How are Nuclear Plants Coping with Grid Related Events

- In addition there have been a couple of instances of a 'stressed grid,' including:
  - PJM July 6, 1999
    - No nuclear units tripped, voltage remained above 0.9 pu, frequency remained stable
  - Callaway August 12, 1999
    - Plant in shutdown mode
    - INPO SOER 99-1
  - California 2001
    - Extended period of grid concern
    - Additional transmission capacity to Path 15 is being added
    - Protocols with CAISO in place

How are Nuclear Plants Coping with an Extended Period of Grid Instability

California 2001-2

- SONGS
  - Unit 3 was out of service for an extended period following a fire
  - No known issues that would have impacted the plant response to a Unit 2 trip, transient, or accident
    - Stations did not receive any "Degraded Voltage Notifications' from load dispatcher
    - The station under-voltage protection system had been upgraded in the early '90s
    - There are ---- transmission lines into the station providing widely diverse sources of off-site power
- Diablo Canyon
  - Risk management policy for Stage 3, including
    - treating 500kV system as a trip risk
    - treating 230 kV system as a degraded trip mitigation system
    - 3 EDGs per unit were kept on high readiness
    - resulting operational decisions impacted maintenance
  - Prior preparations effectively executed
    - rolling blackouts provided sufficient reserve margin and capacity
    - CA ISO met its TCA commitments
    - Transmission lines into the station provided widely diverse sources of off-site power from both north and south, and insulated the station from 'Path 15' issues
    - Analysis confirmed appropriate performance consistent with operational risk management policies

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Maintenance Planning

- Plants are now starting to routinely evaluate grid stress when considering maintenance activities
  - Either qualitative, or semi-quantitative
  - Risk monitors (EOOS, Safety Monitor, etc.)
  - System Indicators have been developed that change color according to System Reliability Ratings and Market Conditions

System Indicator Used by Duke Power

MONDAY

OVERALL SYSTEM INDICATOR	[illegible]

SYSTEM RELIABILITY RATING			
1	Excellent (>1800mw)	10 ■	
2	Good (1200-1800mw)	8 ☐	
3	Adequate (<1200mw)	6 ☐	
4	Fair (<520mw-Can Purchase)	4 ☐	
5	Poor (<520mw-Can Not Purchase)	2 ☐	
6	Critical (Negative Reserve)	1 ☐	

MARKET CONDITION RATING			
7	Low (<$30mw/hr.)	4 ☐	3
8	Medium (>$30 mw/hr <$85 mw/hr)	3 ■	
9	High (>$85 mw/hr)	2 ☐	
10	Ex. High (>$100 mw/hr)	1 ☐	

Un-check System Reliability and Market rating first - then e
update ratings

	System	Market	Color
	L6	L17	G
#	L7	L17	G
8	L6	L18	G
6	L8	L18	O
4	L9	L18	O
2	L7	L19	O
1	L6	L20	Y
	L7	L20	O
	L10	L17	R
	L11	L17	R
	L10	L18	R
	L11	L18	R
4	L8	L19	O
3	L9	L19	O
2	L10	L19	R
1	L11	L19	R
	L8	L20	O
	L9	L20	O
	L10	L20	R

System Availability		
Generatio	Actual	Capability
Nuclear	7,184	6,996
Fossil	6,489	7,699
Hydro	2,744	2,804
CT	2,332	1,784
Firm Purch	211	841
Firm Sale	832	0
Net Capac	18,128	20,124
Expected	13,150	
Daily Oper	4,978	
*Unit Trip (	1,000	
System R	3,978	
Generation	1,996	

Nuclear Generation		
Units	MW Actual	MW Cap
CNS-1	1170	1,129
CNS-2	1169	1,129
MNS-1	1120	1,100
MNS-2	1142	1,100
ONS-1	864	846
ONS-2	864	846
ONS-3	855	846
	7,184	6,996

Enter: Mw actual for each nucl
Expected peak load
MW actual capability fc
other generation

Transmission Control Agreements (TCAs)

All, or nearly all, Nuclear Plants have agreements with their Transmission Providers

These vary according to organization, but typically include 15 elements

- Transmission Lines
- Sufficient Capacity
- Minimum Voltage
- Normal Voltage
- Maximum Voltage
- Grid Operating Conditions
- System Studies
- Stability/Availability
- LOOP Priority
- Frequency
- Reliability Criteria
- Patrols
- Inspections/Washing
- Preventive Maintenance
- UFSAR Update

Transmission Control Agreements (TCAs) example

- Contract between SCE, SDG&E, PG&E and CAISO
- San Onofre and Diablo Canyon 'grid specs' have been incorporated into the TCA
- Operation of grid according to TCA improved grid reliability and operability after deregulation
  - meets NERC, WSCC, Local Reliability Criteria (TCA) and NRC criteria
  - in event of LOOP, priority return of offsite power to nuclear plants
  - immediately communicate impaired/potentially degraded grid conditions

Summary

- LOOP experience for random events has improved since the SBO Rule
- Longer average duration for blackouts is not a result of more long events, but fewer short events
- EDGs and other emergency equipment seem to be performing as designed
- Current experience seem consistent with, and an improvement over, the original assumptions for SBO Rule
- Nuclear Units are addressing concerns about transmission grid stability:
  - TSAs
  - INPO 99-1
  - Risk Monitors that account for weather and 'grid stress'
  - System studies and further research