Pacific Southwest Blackout on September 8, 2011 at 15:27

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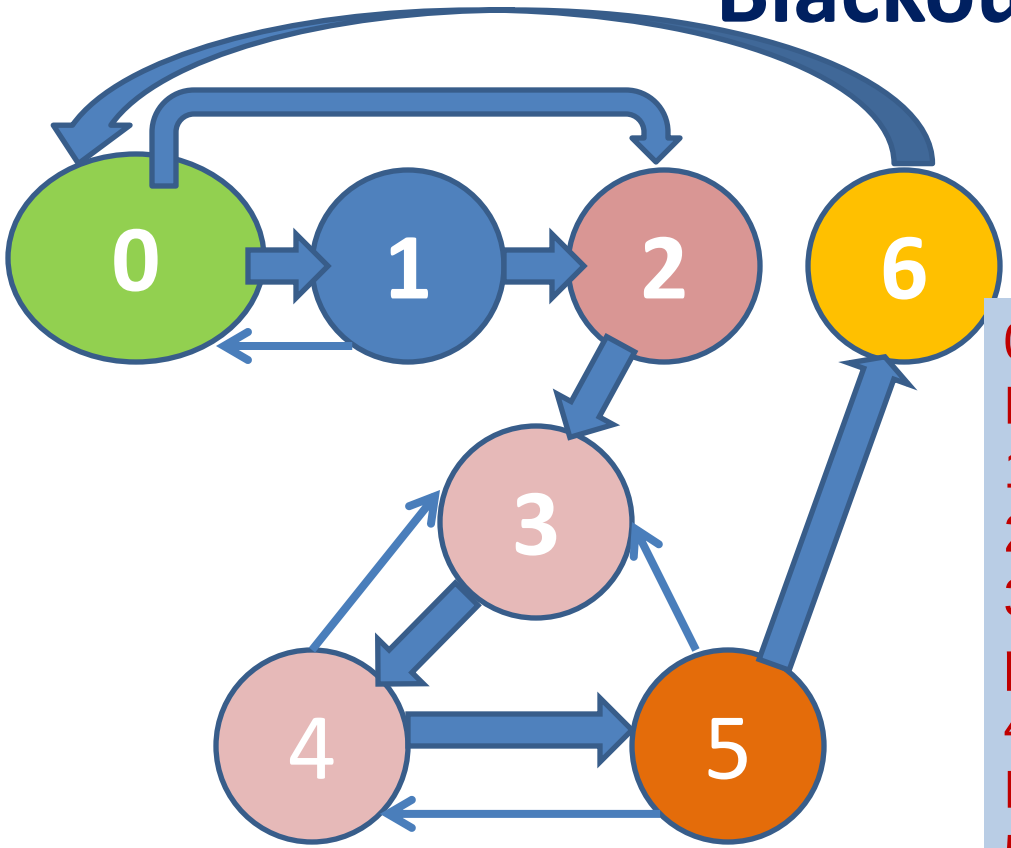
Outline

1. Generic Scenario for a Blackout Event
2. Impact of September 8th Blacout
3. History of WECC Disturbances
4. Lessons Learned

1. Generic Scenario of a Cascading Blackout



0 – System State Before Blackout
1 – Contingency Conditions
2 – Triggering Events
3 – Power Flow Surges, Voltage problems, Overloads
4 – Protection System Trips Lines, Transformers, Generators
5 – System Separation, Instability and Voltage Collapse
6 - Blackout System State

1. Cascading Event – Various Definitions

- A cascading failure is a process, in which an initiating event/failure increases the stress of other system components, resulting in their overloading above the limits for which they were designed.
- NERC definition: The uncontrolled successive loss of system elements triggered by an incident at any location. Cascading results in widespread electric service interruption that cannot be restrained from sequentially spreading beyond an area predetermined by studies.
- A cascading outage is defined as the event in which an abnormal cascading processes develop in power systems, when every disturbance triggers a next one, and so on, result in blackouts, i.e. mass-scale tripping of generating sources and disruption of electricity supply over large areas.
- CFTF definition: Cascading Failure is a Sequence of Dependent Failures of Individual Components that successively Weakness the Power System

1. Pre-Event State (state-0)

Normal (Pre-Event) Operating State

In this state the operating parameters of BES lie within acceptable limits. However noticeable deviations of parameters were observed during the blackouts

- Extreme conditions (summer & winter peak)
- Weakened topology (important equipment out of service)
- Natural Disasters and Extreme weather

Does the system operate reliable in this state?

- The term “reliable operation” means operating the elements of the bulk-power system within equipment and electric system thermal, voltage and stability limits so that instability, uncontrolled separation, or cascading failures of such system will not occur as a result of a sudden disturbance or unanticipated failure of system elements.

1. Triggering Events (state-3)

- Various N-1 (overload, protection failure, short-circuit..)
  - **Failure of Equipment**
  - **Malfunctioning of protective devices**
- N-k simultaneous outages
- Other Causes
  - **Extreme weather, Lighting**
  - **Human Error**
  - **Lack of situational awareness**
  - **Operational planning error**
  - **Control system error**

1. Cascading Event - Progression

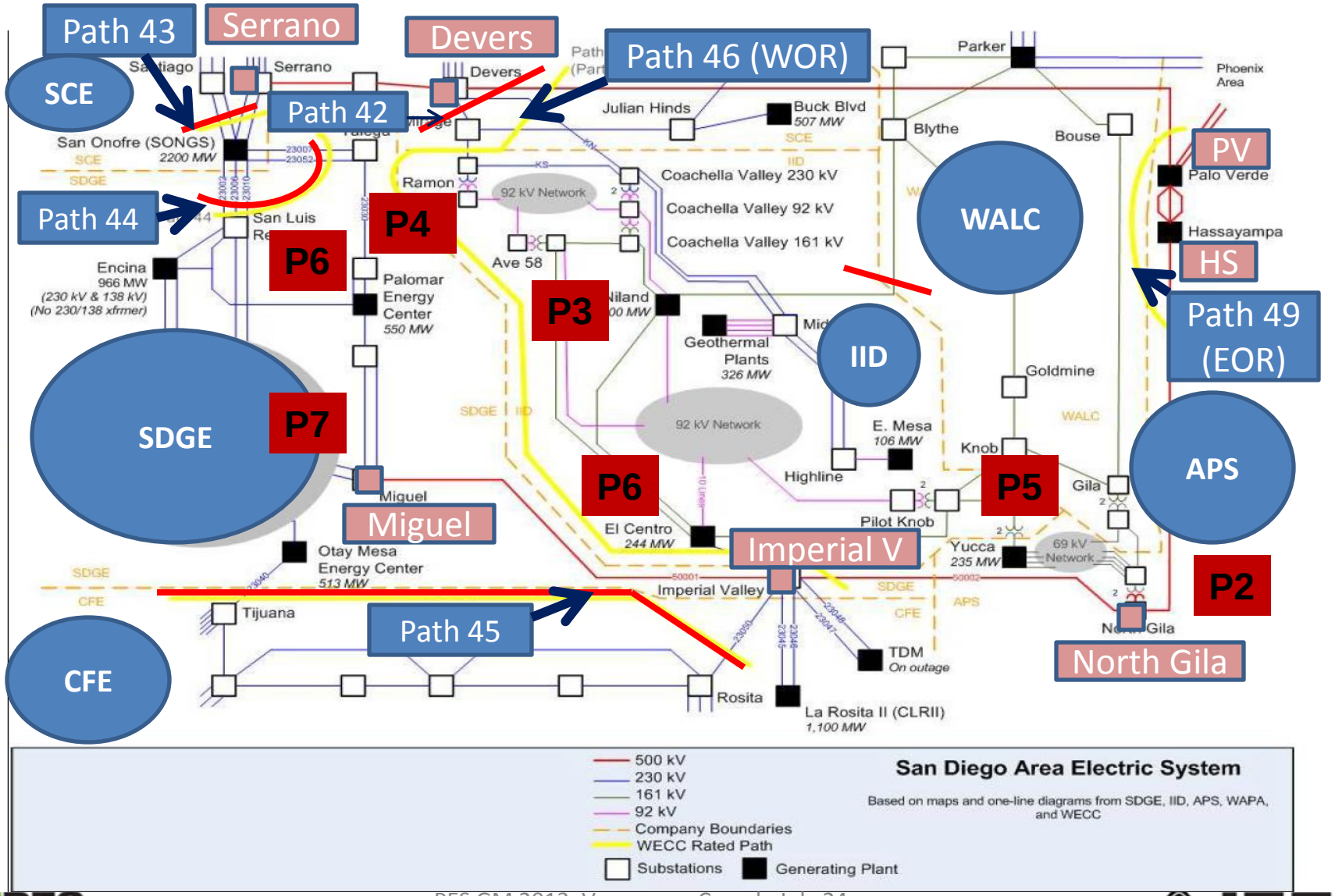
The outage of the overloaded components can progress either slowly (steady-state progression), or quickly (transient progression).

- The transient progression usually involves voltage instability, frequency instability and small signal instability (power oscillations) and its time scale is between seconds and several tens of seconds. The examples are blackouts in US-West on July 2, 1996 and the most recent one in India on August 31, 2012.
- The slow progression involves line tripping between fairly large time intervals, in order of minutes. In this case the line tripping occurs either after exceeding a short-term emergency line loading limit or the line sags and short-circuit between the line and trees takes place. The examples of the slow progressing cascading is the blackout in France on December 19, 1978, initial phase of the NE US blackout on August 14th, 2003 and blackout in Italy on September 28, 2003.

2. Impact of September 8, 2011 Blackout in AZ-CA Region

- About 2.7 million people affected.
- 7.89 GW of load interrupted
- 6 -12 hours to fully restore all loads.
- Average load interruption time: 8.1 hours.
- WECC peak load: ~130 GW.
- Affected area peak load:~17 GW.

2. Affected Area Electric System



FERC/NERC Staff Report on the September 8, 2011 Blackout

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2. Pre-Disturbance Conditions on Paths in affected area

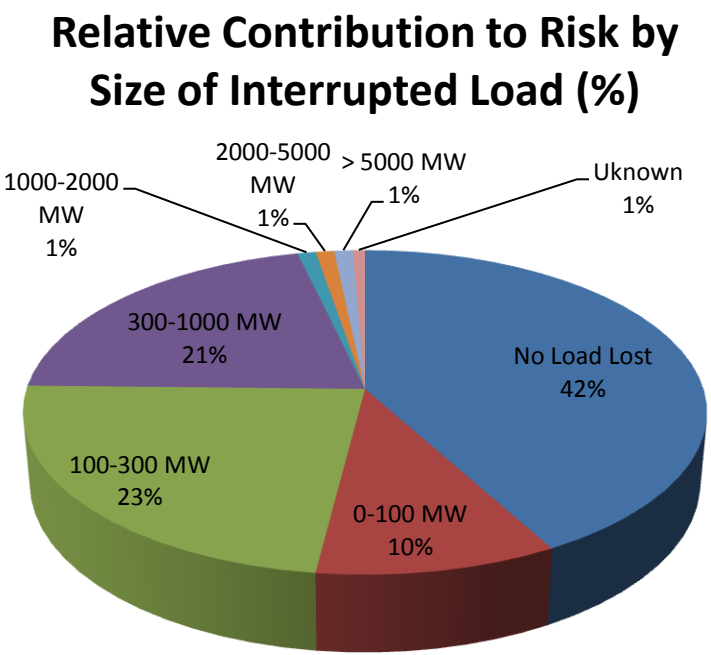
Path in Affected Area	Path rating	Path Flow & (%)
Path 44 (South of S.O.)	2,200 MW	1,302 MW (78%)
Path 45 (SDGE-CFE)	800 MW S>N, 408 MW N>S	241 MW (60%)
230 kV S Line (part of Path 46)	239 MW	90 MW (38%)
500 kV H-NG Line (part of path 49)	1,800 MW	1,397 MW (78%)
SDGE Import SOL	2,850 MW	2,539 MW (89%)
Path 42 (IID-SCE)	600 MW E>W	-40 MW

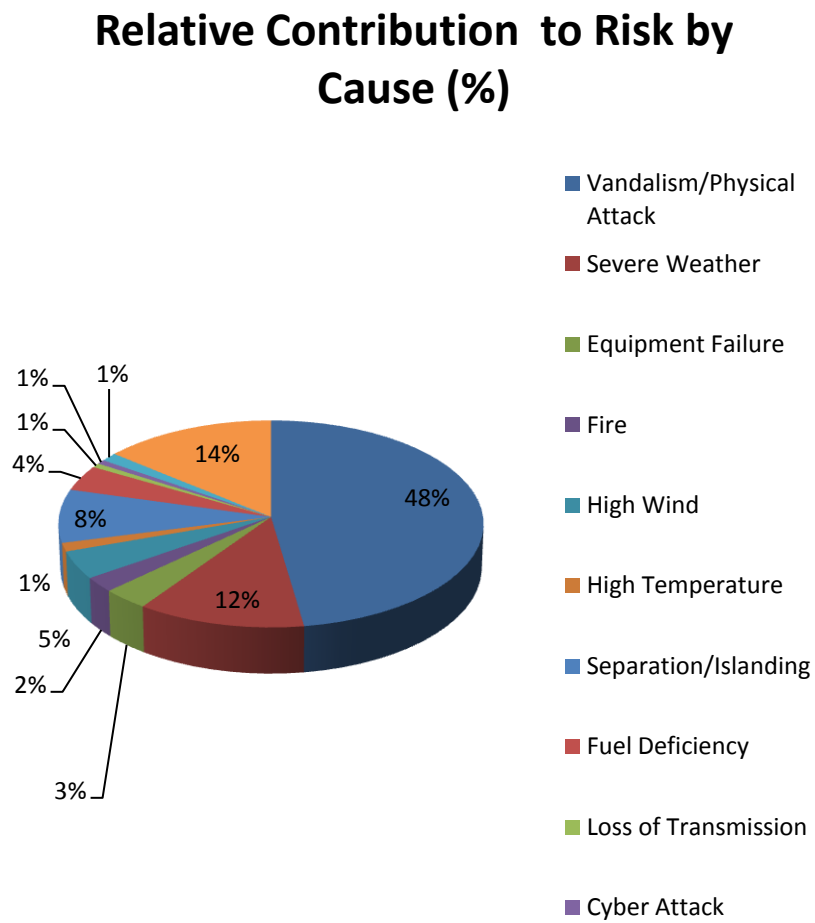
2. Main Contributing Factors to SW Outage[1]

- Impact of sub-100 kV facilities
- Not studying/coordinating effects of Protection Systems and RAS during contingency
- Not providing effective operator tools and instructions for reclosing lines with large phase angle differences
- Failure to recognize IROLs

[1]FERC/NERC Report

3. WECC Disturbances 2002-2012





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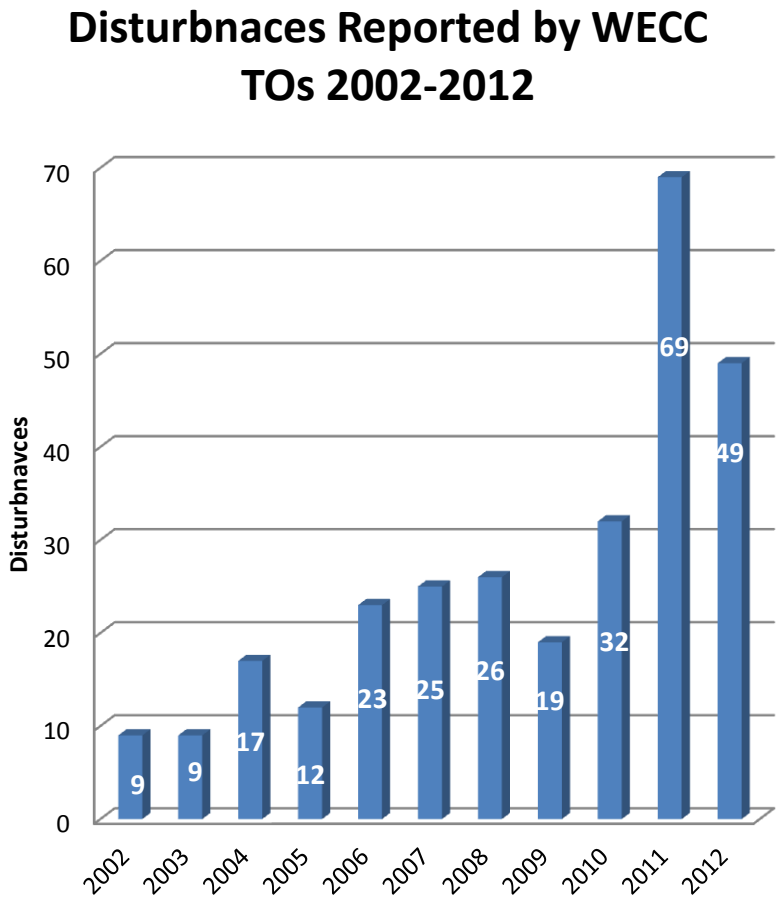
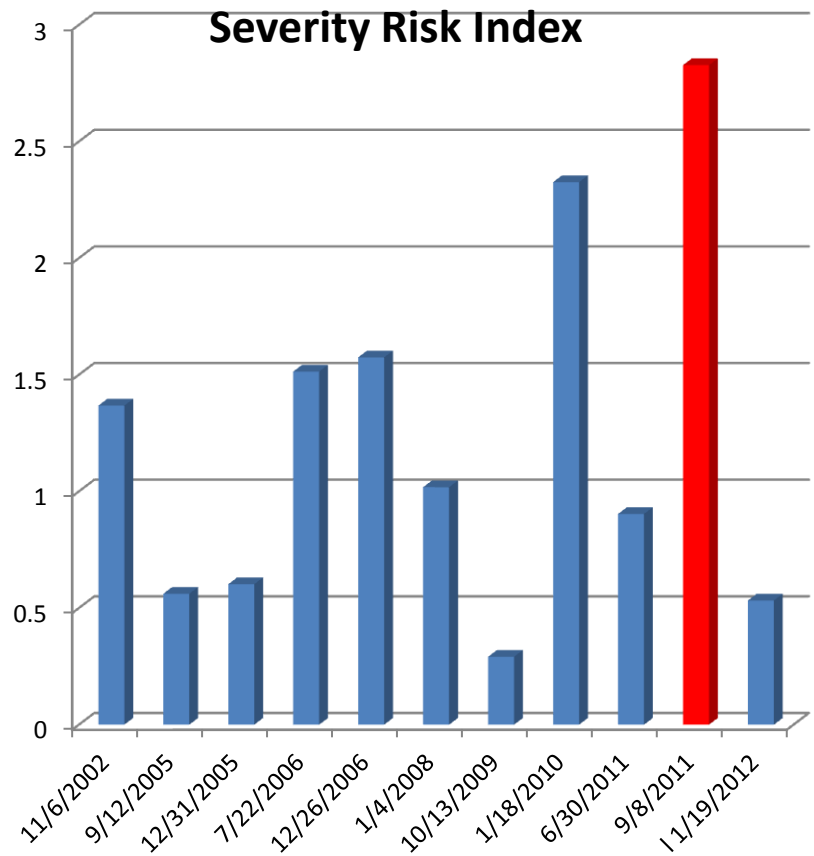
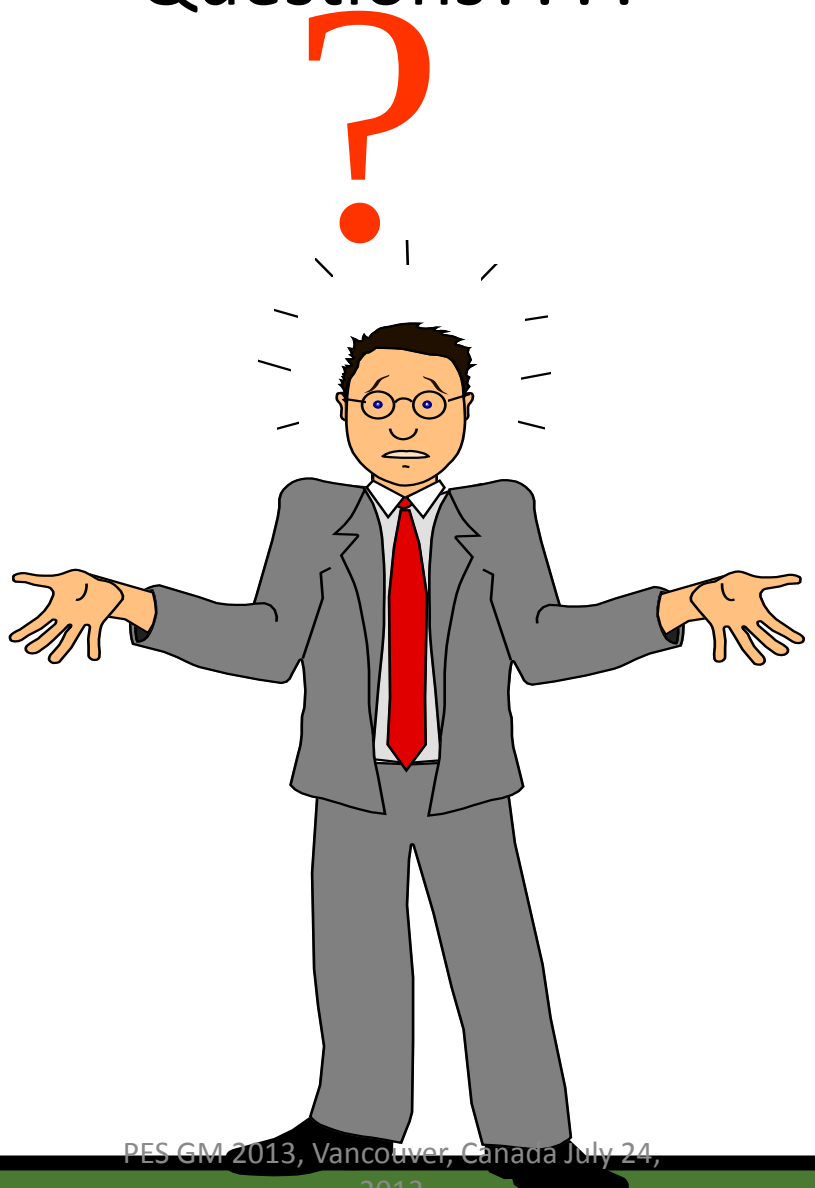




4. Lessons Learned
What did come from Blackouts?

- **1965 – Marked the beginning of fundamental change in the electric power industry. Regional reliability organizations and the NERC were formed to monitor and promote electric system reliability. The impetus for the EMS advanced applications came from this blackout.**
- **1996 – Disturbance reports propose 32 recommendations for August 10 outage and 24 recommendations for July 2 outage. As a result of these recommendations WSCC has developed:**
  - **new Voltage Stability Criteria, Undervoltage load shedding strategy, and reactive power reserve monitoring methodology.**
  - **Seasonal Studies**
  - **The impetus for the mandatory membership in reliability councils and enforced compliance with reliability criteria came from these two blackouts.**
- **2003 – Task Force Final Report proposes 14 Recommendations relating to**
  - **Strategic Initiatives (Strengthen the NERC Compliance Enforcement Program,…)**
  - **Technical Initiatives (Improve Operator and Reliability Training…)**
  - **Actions to Improve Reliability (Voltage and Reactive Management,…)**
- **2011 – The Final Joint NERC/FERC Report propose 27 Recommendations relating to**
  - **situational awareness; next-day planning; seasonal planning; near- and long-term planning;**
  - **impact of sub-100-kV facilities; Interconnection Reliability Operating Limits (IROL).**

Questions????



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