September 8, 2011 Pacific Southwest Blackout Causes and Recommendations

NASPI

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September 8, 2011 Event

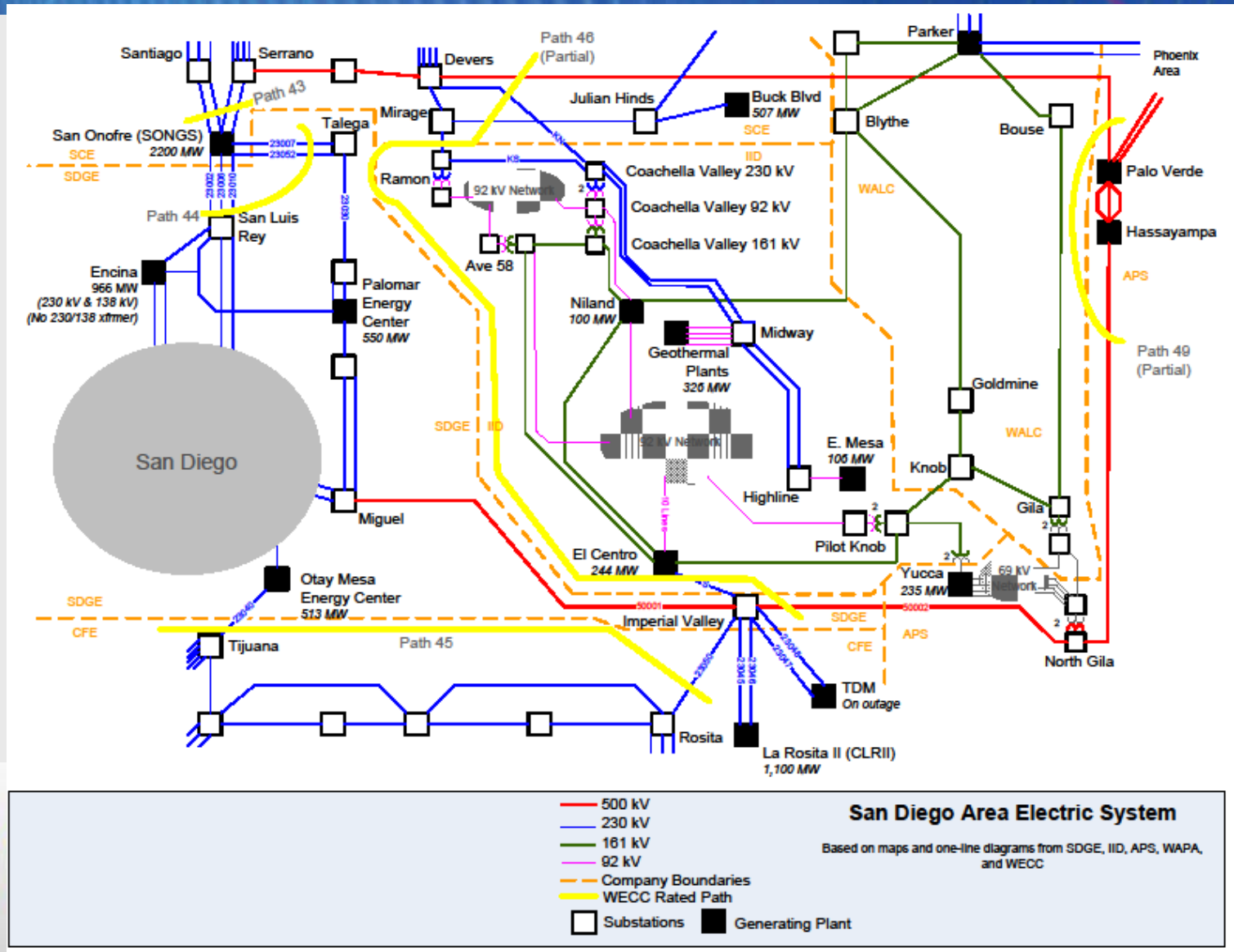
- 11 minute cascading outage in Pacific Southwest
- Initiated when single 500 kV line faulted and tripped during maintenance work
- 2.7 million customers without power in parts of Arizona, Southern California, and Baja California, Mexico, some up to 12 hours
- Power redistributed, increasing flows through underlying systems, causing voltage drops and equipment overloads
- Cascading outages led to tripping of lines and generators, automatic load shedding, and operation of a Remedial Action Scheme and an intertie separation scheme known as “Safety Net”

Customer Impacts

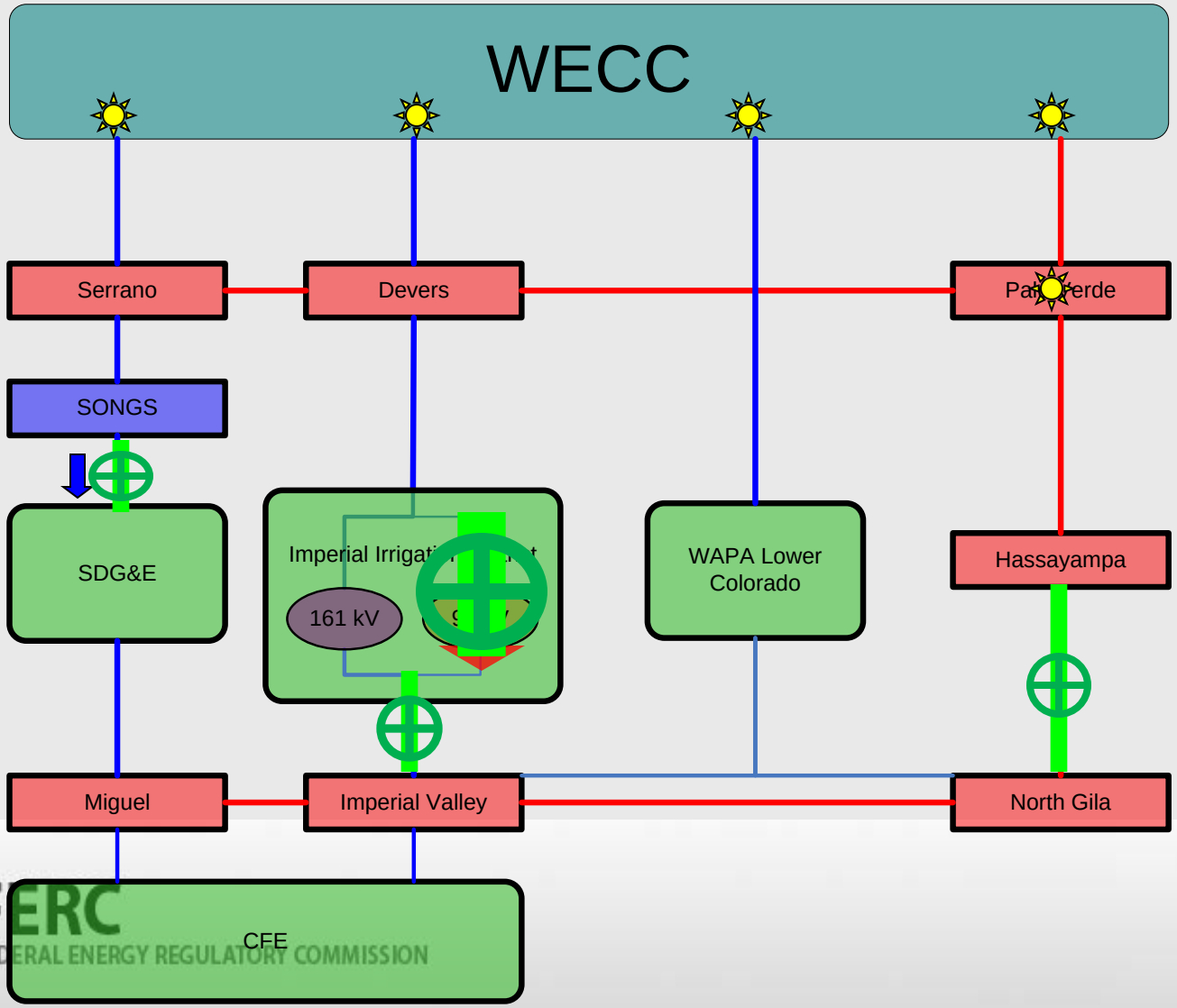
Entity	Load Lost (MW)	Customers
SDGE	4,293	1.4 million
CFE	2,150	1.1 million
IID	929	146 thousand
APS	389	70 thousand
WALC	74	Note

Note: 64 MWs of WALC's load loss affected APS's customers

Map of Affected Area



Parallel nature of the systems



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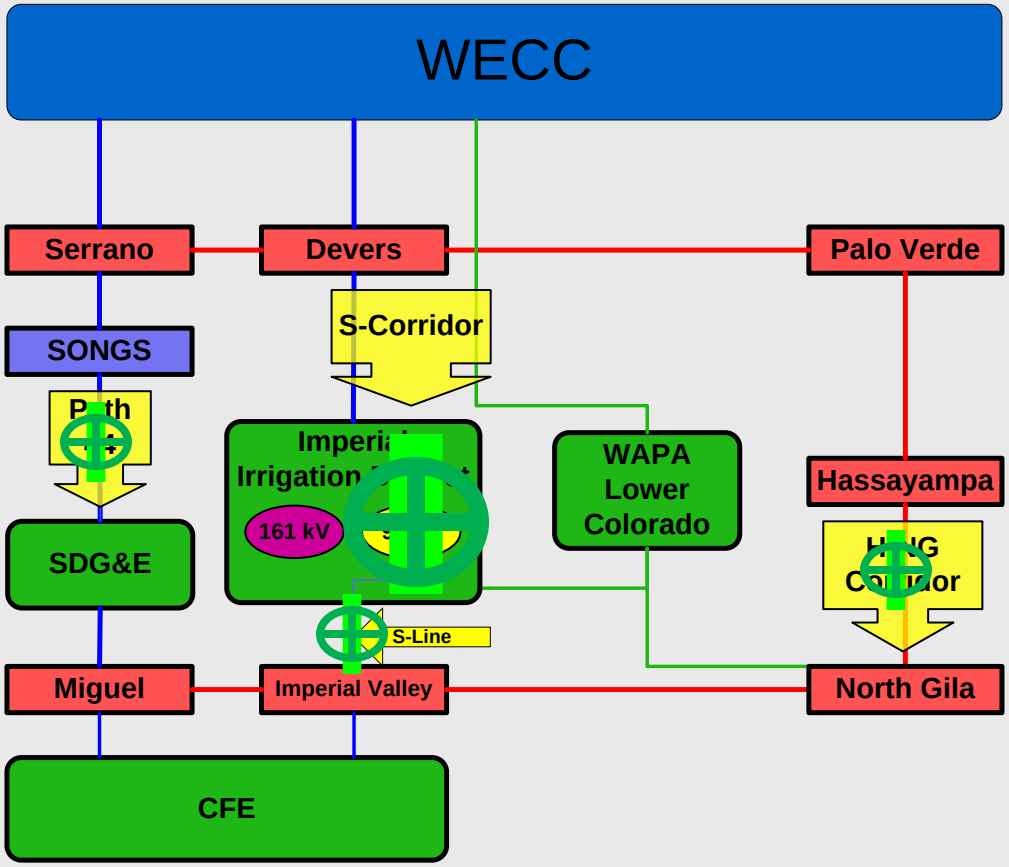
Three Parallel Corridors



Key Findings

- System was not being operated in a secure N-1 state
- *Weaknesses in two broad areas*
  - Operations planning
  - Real-time situational awareness

- *Other underlying issues that contributed to the event*
  - Not identifying and studying the impact on BPS reliability of sub-100 kV facilities in planning and operations
  - Failure to recognize IROLs in Western Interconnection
  - Not studying/coordinating effects of protection systems and RASs during plausible contingency scenarios
  - Not providing effective operator tools and instructions for reclosing lines with large phase angle differences across the reclosing breakers

Operations Planning

Failure to consider in seasonal, next-day, and real-time studies:

- Status of external generation and transmission facilities
- Impact of external contingencies
- Impacts on external systems
- Impact of sub-100 kV facilities on BPS reliability

Operations Planning

Recommended TOP/BA Improvements:

- Obtain information on neighboring BAs and TOPs, including transmission outages, generation outages and schedules, load forecasts, and scheduled interchanges

- Identify and plan for external contingencies that could impact their systems and internal contingencies that could impact neighbors' systems

- Consider facilities operated at less than 100 kV that could impact BPS reliability

- Coordinated review of planning studies to ensure operation of affected Rated Paths will not result in reliability problems

Situational Awareness

- Lack of Real-Time External Visibility
- Inadequate Real-Time Tools / alarms
- Inadequate communications among entities to help maintain situational awareness
- Reliance on Post-Contingency Mitigation Plans
- Inadequate representation of critical facilities in real-time monitoring tools (State Estimator and RTCA)

Situational Awareness

Recommended Improvements:

- Expand entities' external visibility in models through more complete data sharing
- Improve use of real-time tools to ensure constant monitoring of potential internal or external contingencies
- Improve communications among entities to help maintain situational awareness
- TOPs should review their real-time monitoring tools (State Estimator and RTCA) to ensure critical facilities are represented

Contributing Factors

- Not studying impact of sub 100 kV facilities parallel to EHV system
- Failure to recognize IROLs
- Inadequate analysis and coordination of protection systems and RASs
- Lack of Coordination of RAS
- Lack of Study/Coordination of Separation Scheme (Safety Net)
- TOPs failure to take proper pre-contingency mitigation measures considering emergency ratings and overload protection systems
- Ineffective operator tools/instructions for reclosing lines with large phase angle differences across the reclosing breakers

Contributing Factors

Recommended Improvements:

- WECC (RE) should ensure that all sub-100 kV facilities that can adversely impact BPS reliability are either designated as part of the BES or otherwise incorporated into planning and operations studies and actively monitored and alarmed in RTCA systems

- WECC-RC should study IROLs in the day-ahead timeframe and monitor potential IROL exceedances in real-time

- TOPs should have: (1) the tools necessary to determine phase angle differences across reclosing breakers following the loss of lines; and (2) mitigation and operating plans for reclosing lines with large phase angle differences

Contributing Factors

Recommended Improvements:

- TOs review transformer overload protection relay settings

- TOPs plan to take proper pre-contingency mitigation measures considering emergency ratings and overload protection systems

- All protection systems and separation schemes (Safety Nets, RAS, and SPS) studied and coordinated periodically to understand their impact on BPS reliability to ensure no unintended or undesirable effects

Role of PMUs in Event

Impacted entities access to PMU data

- SCE did not use PMU data during the event. The build out for SCE's PMUs are not complete yet. SCE doesn't have PMUs past Devers and, thus, they wouldn't have been of great use during the event.

- CAISO receives PMU data from SCE, PG&E and BPA and has access to PMU data located at SONGS and Palo Verde, and CFE, but on September 8, 2011 it was not available on the operations floor in "real time". This data was submitted to Inquiry team "after the fact" for analyzing the SOE.

- WECC RC had no PMU data at the time of September 8, 2011 disturbance

Role of PMUs in Event

Could PMUs prevent the event?

- PMUs only provide data, not solutions or outage protection
- An unsecure N-1 state cannot be detected with a PMU
- H-NG line outage was caused by a fault, not system stress
  - no precursor to trigger an alarm in PMU monitoring systems
- PMU effectiveness requires timely and appropriate action by operators trained to understand PMU data from key locations

Questions?