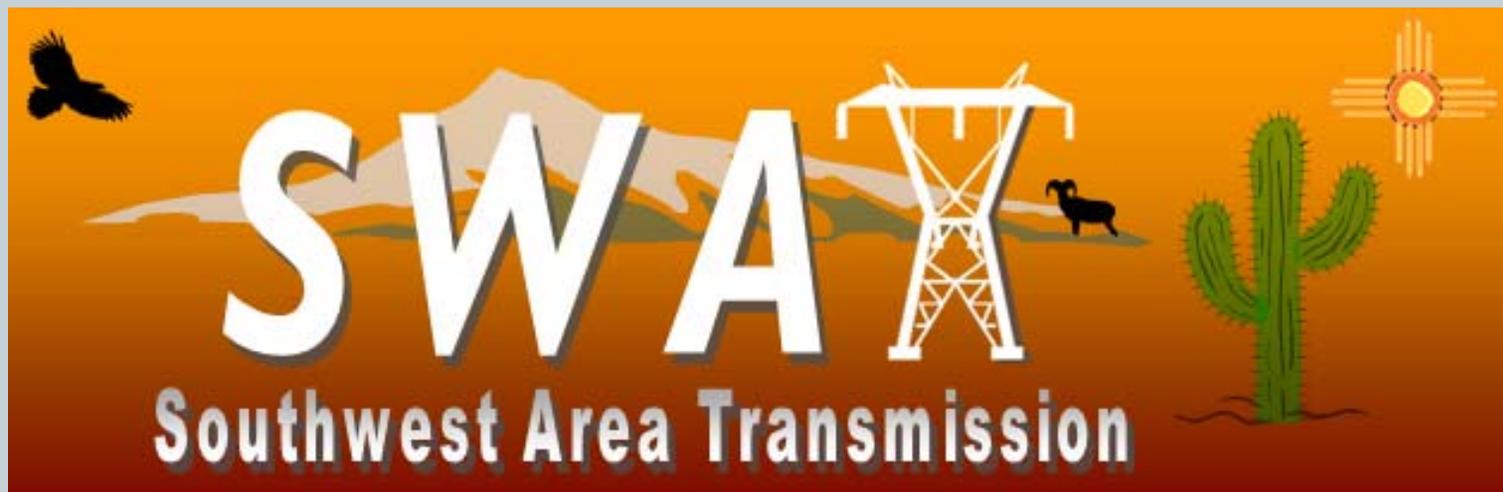


SWAT Coal Reduction Assessment Update

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PRESENTED TO THE
ARIZONA CORPORATION COMMISSION
BTA WORKSHOP 2 ON AUGUST 28, 2014



Outline

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- **Overview of Coal Plant Reduction Study Activities**
- **Study Scope**
- **Modeling & Analysis**
- **Results**
- **Issues Requiring Further Research**
- **Conclusions**
- **Recommendations**
- **Next Steps**

Overview and History

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- **Coal Reduction Assessment Task Force (CRATF) formed at Feb. 19, 2014 SWAT Oversight meeting**
 - SWAT area coal reduction of approximately 25% (of ~10 GW total) by 2019.
 - California plans to mitigate SONGS and once-through cooling retirements with preference resources
- **Concerns identified include: Dynamic stability, lack of “inertia”, WECC Path Rating Changes, etc.**
- **Study did not address more dramatic coal plant shutdowns necessary to satisfy proposed EPA Clean Power Plan (§111(d)) for Arizona**

Outreach to other Regions/Planning Groups

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- Presented at WestConnect PMC since formation
- Ongoing verbal contact with CAISO
 - Willing to work with us, but will await our response to bring this matter up internally or with other regions
 - Has had five years to address SONGS and Once-through gas generation shutdown
- Outreach to California TOs (SDG&E, SCE, LADWP, IID)
 - Representation from several CA entities on CRATF WebEx meetings
- Presented efforts to TEPPC/TAS/SPSG in April and August 2014
- Discussed with Southwest Power Pool (SPP) on July 1, 2014
 - SPP interested in reviewing results and possibly coordinating comments

Presentations to the Arizona Corporation Commission 8th BTA Workshops 1 & 2

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- **8th BTA Workshop 1 – May 15, 2014**
 - Early stage of study
 - Prior to EPA Guidelines and Implementation Plans
- **8th BTA Workshop 2 – August 28, 2014**
 - Present results of study
 - Scenarios do not reflect the level of coal plant closures needed to comply with proposed Clean Power Plan rule for Arizona
- **Propose further study to assess impact of 111(d) on Arizona**

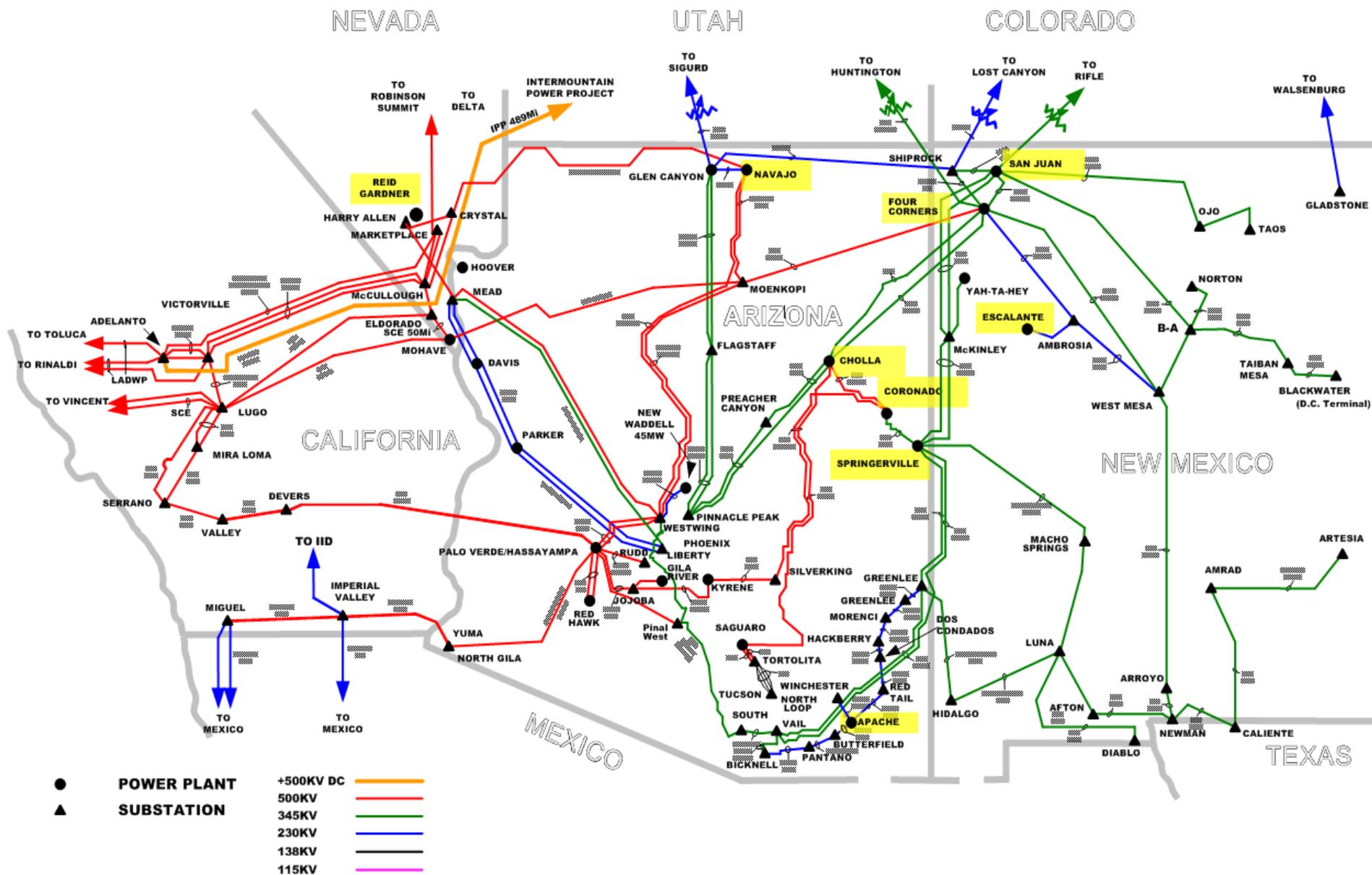
CRATF Study Objectives and Scope

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- **Phase 1:**
 - To identify possible reliability issues due to loss of inertia and/or dynamic reactive capability associated with anticipated coal plant shutdowns
 - To identify potential limit to shutdowns through sensitivity analysis

- **Phase 2:**
 - Specific objectives to be determined upon completion of Phase 1
 - Possibly Identify Path Rating issues associated with change in generation resource mix and plant locations due to anticipated coal plant shutdowns

SWAT Coal Plants



Baseline and Scenario Assumptions

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- **Baseline**
 - Reference case without coal plant shutdowns
 - 2019 HS WECC/AZ Coordinated Case
- **Two Scenarios (about 20% coal retirement)**
 - “CR Scenario” Case: Expected Coal Reduction with Planned new Gas
 - “CR Scenario Renewable” Case: Expected Coal Reduction with Planned new Gas replaced by Renewables
- **Two Sensitivities (about 50% coal retirement)**
 - CR Sensitivity High Renewable” Case: High Coal Reduction with High Renewables
 - “CR Sensitivity Gas/ Renewable” Case: High Coal Reduction with Renewables and Planned new Gas
- **Specific generating units and locations identified to replace retired units to the extent information was available**
 - Not all assumptions are perfect - needed to decrease area interchange from SWAT to California by approximately 900 MW in sensitivities.

Contingency Analysis

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- **Single and Category C multiple contingencies within the SWAT footprint.**
 - Benchmark Scenario and Sensitivity cases against Baseline with pre-coal reduction dispatch
 - 3-phase fault with normal clearing
 - 3-phase or single-line-to-ground fault with delayed clearing (breaker failure)
 - 3-phase fault with normal clearing plus loss of circuit on common tower or in common corridor.
 - Voltage, frequency and rotor angle plots are created for identified buses

Status of Technical Analysis

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- **Case Preparation**
 - Baseline Case: No coal reduction
 - Expected Coal Reduction Scenario with Planned Gas replacement
 - Expected Coal Reduction with Renewable replacement
 - High Coal Reduction with High Renewables
 - High Coal Reduction with High Renewables and Planned Gas units
- **Power Flow Analysis**
 - Analysis of all TO provided contingencies completed on all cases
 - Comparison of all cases against Baseline cases completed
- **Transient Analysis**
 - Simulations of all TO provided transient scenarios completed
 - Comparison of Baseline & CR Scenario/Sensitivity results completed

Power Flow Modeled Coal Generation Dispatch (MW)

Coal Units	Baseline No CR	"Gas " & "Renewable" CR 2k	"High Renewable" CR 5k Sensitivity	"High Renewable\Gas" CR 5k Sensitivity
Four Corners 1 – 3	0	0	0	0
Four Corners 4 & 5	1597	1597	748	748
San Juan 1	360	360	0	0
San Juan 2 & 3	894	350	0	0
San Juan 4	472	415	505	527
Navajo 1	805	0	0	0
Navajo 2 & 3	1610	1610	805	805
Apache 2& 3	389	389	195	195
Cholla 1 - 4	1119	1119	1119	1119
Coronado 1 & 2	850	850	429	429
Springerville 1 - 4	1650	1441	1391	1391
Reid Gardner 1-3	0	0	0	0
Reid Gardner 4	257	0	0	0
Total	10003	8131	5192	5214
Reduction from Baseline		1872	4811	4789

Power Flow Modeled Gas Generation (MW)

Coal Units	Baseline No Reduction	CR 2k "Gas"	CR 2k "Renewable"	"High Renewable" CR 5k Sensitivity	"High Renewable\Gas" CR 5k Sensitivity
Reid Gardner *CC Unit 1	0	180	0	0	180
Reid Gardner *CC Unit 2	0	180	0	0	180
Reid Gardner *CC Unit 3	0	230	0	0	230
Ocotillo	0	95	0	0	95
Ocotillo	0	95	0	0	95
Ocotillo	0	95	0	0	95
Ocotillo	0	55	0	0	55
Ocotillo	0	55	0	0	55
San Juan GT	0	170	0	0	170
La Luz GT	0	40	0	0	40
Total Planned Gas Units	0	1195	0	0	1195

* NVE reconsidering plan to build gas combined cycles at Reid Gardner. May add solar only.

Power Flow Modeled Incremental Renewable Power Output (MW)

New PV Units	Baseline No CR	"Gas " CR 2k	"Renewable " CR 2k	"Renewable" CR 5k	"High Renewable\Gas" CR 5k Sensitivity
Rooftop PV in Arizona	0*	0	0	1360	950
Utility-scale PV in Arizona	0	0	514	804	804
Rooftop PV in New Mexico	0	0	0	300	85
Wind unit in New Mexico (San Juan)	0	0	210	450	450
Utility-scale PV in Nevada	0	300	890	890	300
Utility-scale PV in TEP	0	60	60	112.3	112.3

* Indicates amount of renewable resources in addition to that which was already in service in the 2019 case.

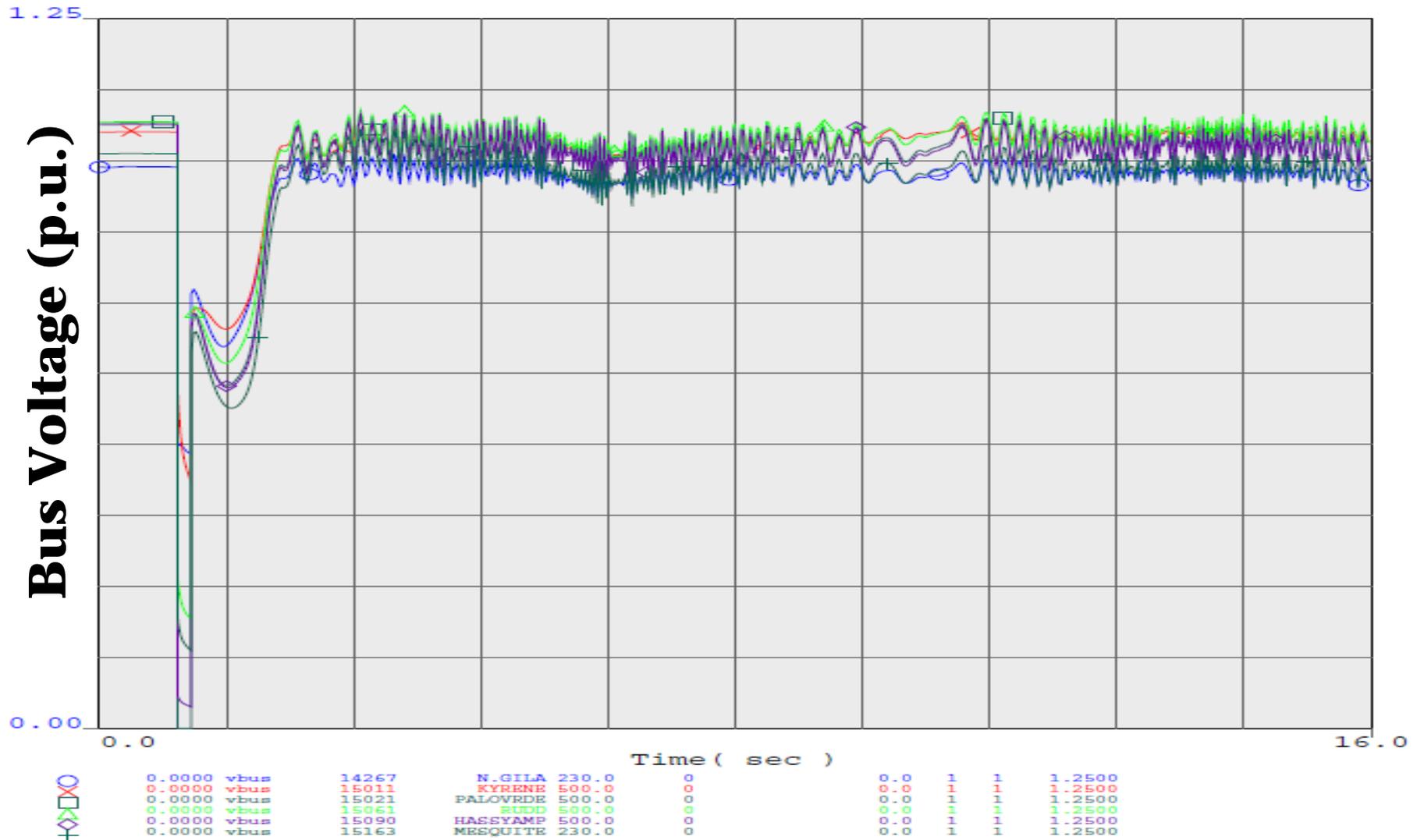
Baseline Scenario Assumptions

14

- 2019 Arizona Coordinated Heavy Summer Base Case
- No Coal Plant Retirements Assumed

Baseline

Fault at Largest Generating Unit, Loss of Unit



Coal Reduction Scenario Assumptions

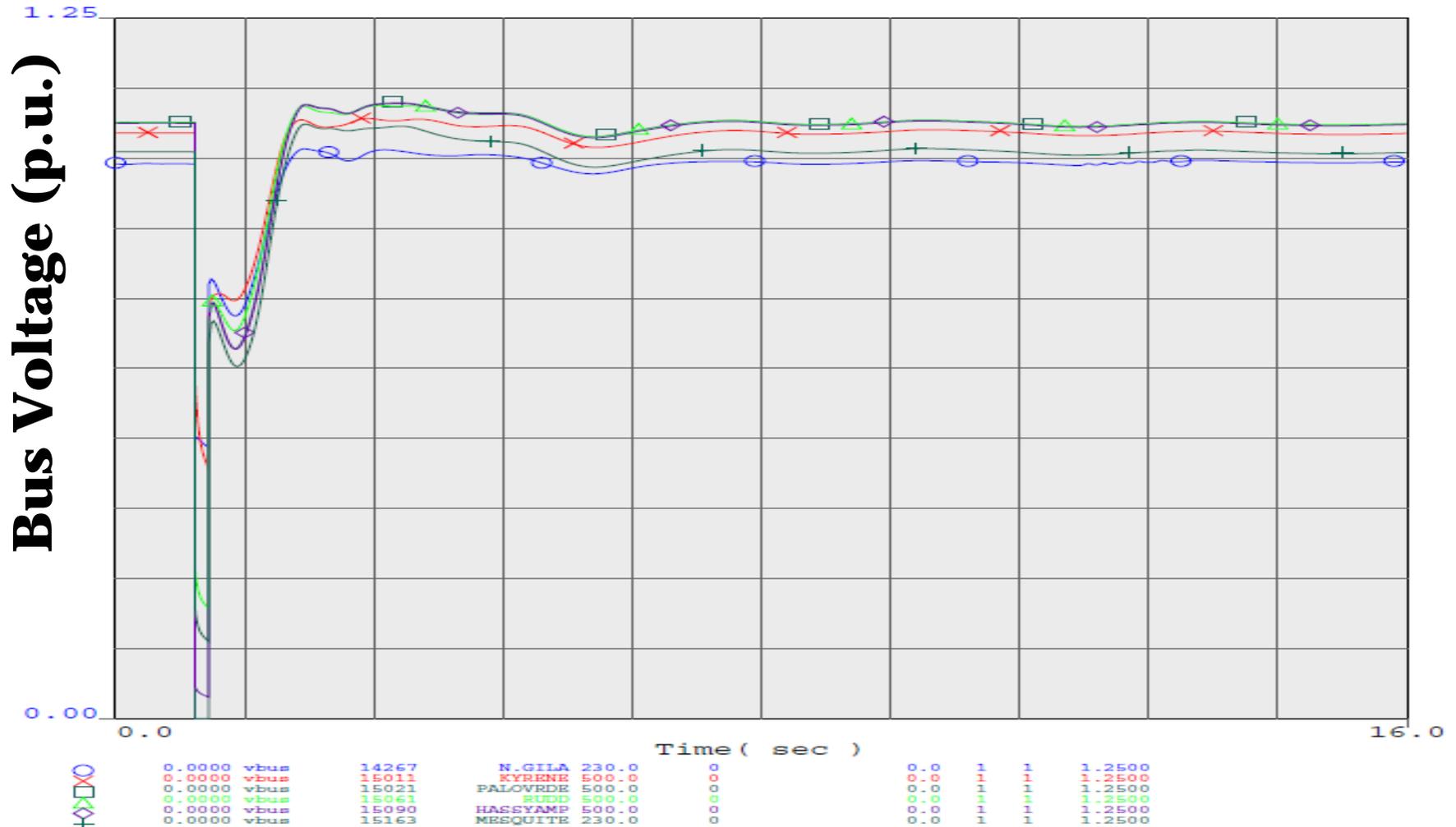
16

- 2019 Arizona Coordinated Heavy Summer Base Case
- 1872 MW Coal Plant Retirements Assumed
- 1195 MW New Gas Units Added
- 360 MW of New Renewables Added
- 317 MW balance from reduction in area interchange to California

CR Scenario

Fault at Largest Generating Unit, Loss of Unit

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Baseline versus CR Scenario Summary

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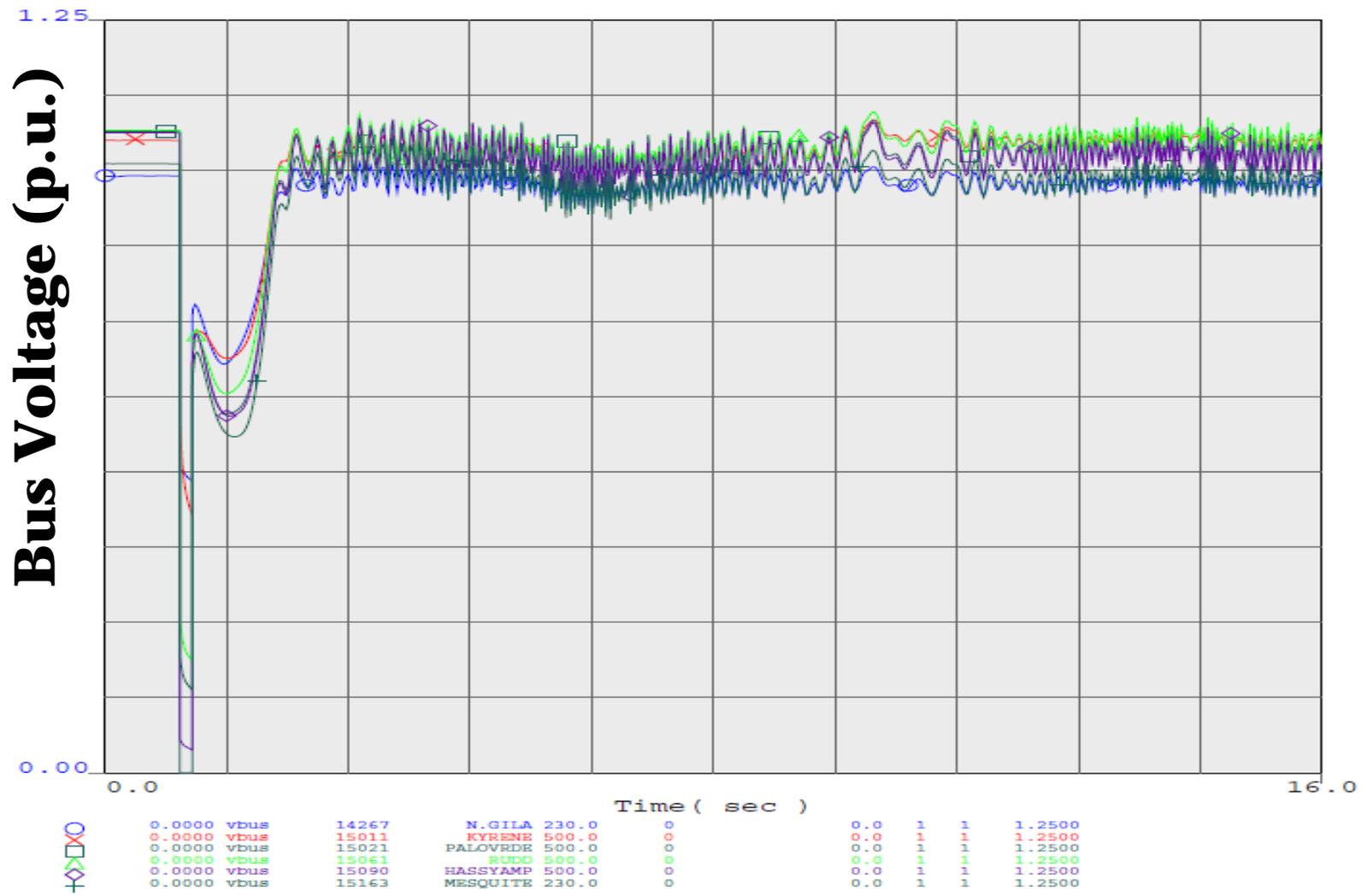
- Both are stable
- Coal reduction with gas performance is improved over Baseline
- Addition of gas units contributes to inertia and dynamic reactive capability
- Units located closer to load centers and fault locations improve performance

Coal Reduction Scenario with Renewables Added in Place of Gas Assumptions

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- **2019 Arizona Coordinated Heavy Summer Base Case**
- **1872 MW Coal Plant Retirements Assumed**
- **0 MW New Gas Units Added**
- **1674 MW of New Renewables Added**
- **315 MW balance from reduction in area interchange to California**

CR Renewable (No Incremental Gas) Scenario Fault at Largest Unit, Loss of Unit



CR Gas versus CR Renewable Scenario Summary

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- Both are stable
- Coal reduction with gas performance is better than CR renewable scenario
- Addition of gas units contributes to inertia and dynamic reactive capability
- Renewables have less reactive capability

High Coal Reduction Renewable Sensitivity Assumptions

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- 2019 Arizona Coordinated Heavy Summer Base Case
- 4811 MW Coal Plant Retirements Assumed
- 0 MW New Gas Units Added
- 3916 MW of New Renewables Added
 - Possibly higher renewables than would be available by 2019
- 895 MW balance from area interchange
 - Assumes that California will add resources

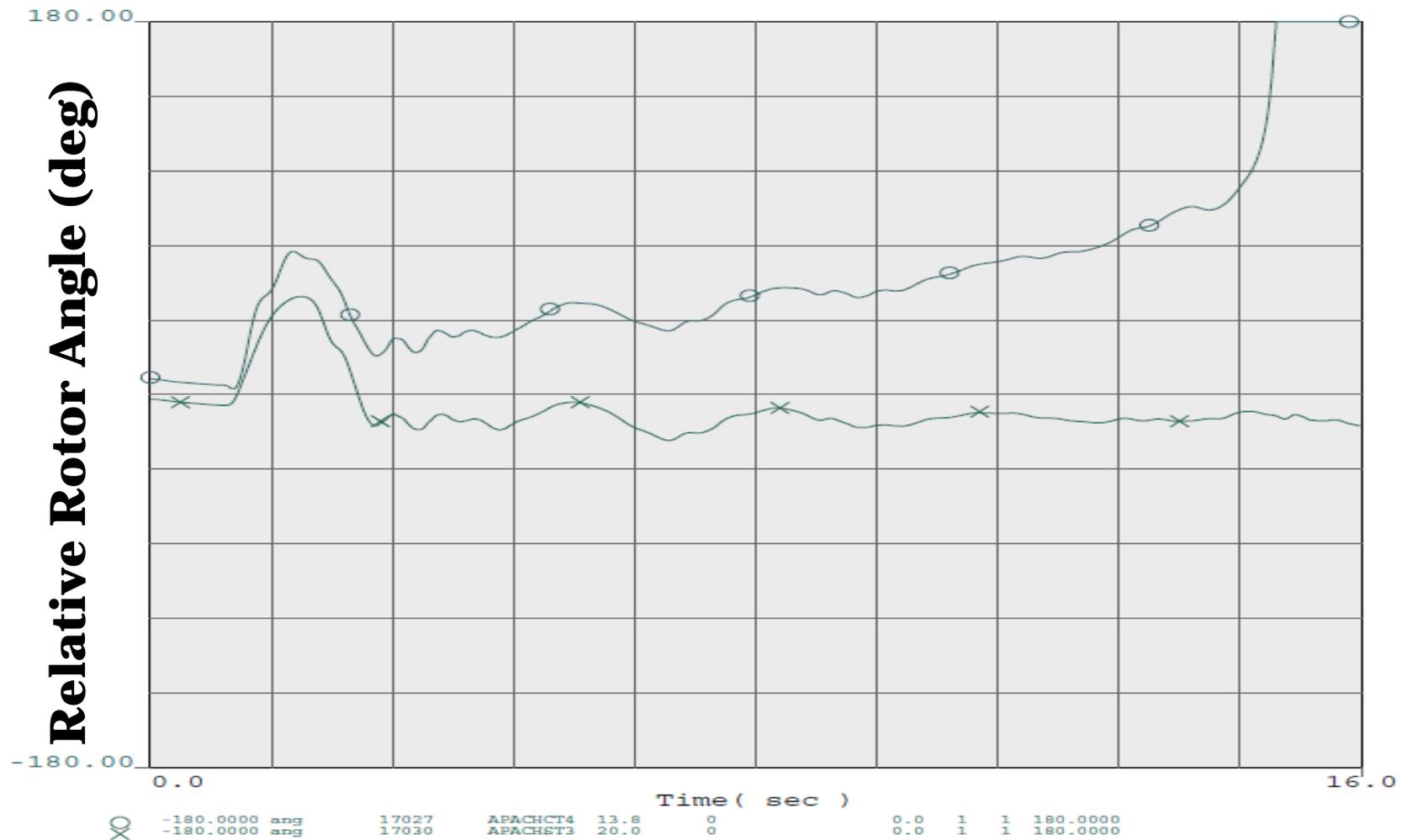
High CR & Renewable Sensitivity Summary

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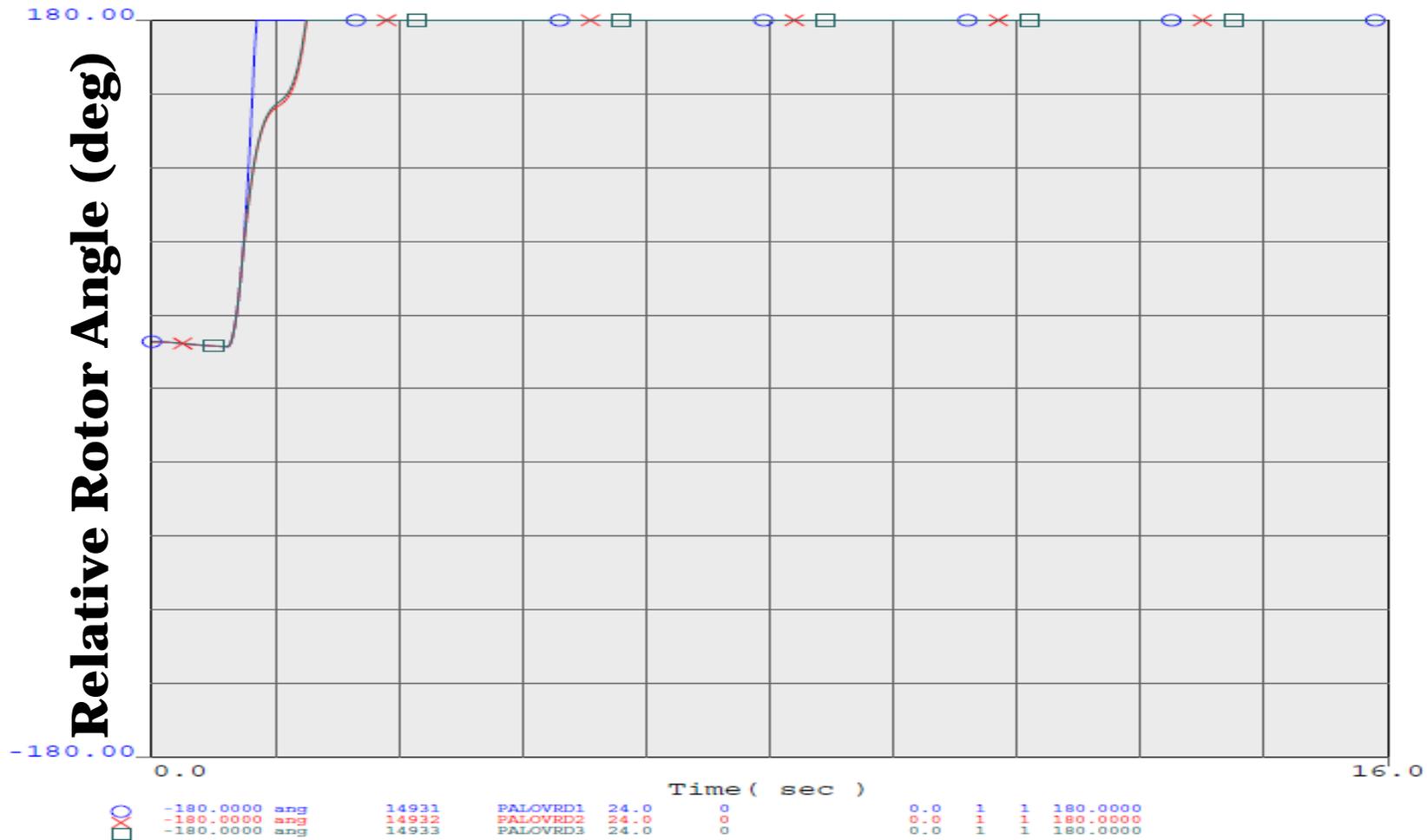
- Bus voltage unstable
- Large loss of coal plant inertia and dynamic reactive power capability
- Renewables do not add inertia and have limited reactive capability
 - Rooftop assumed to operate at unity power factor
 - Utility-scale PV systems have inverters with reactive capability
- This sensitivity case was based on assumed resources and locations

High CR & Renewable Sensitivity

Fault at Largest Generator, Loss of Unit



High CR & Renewable Sensitivity Fault at Largest Generator, Loss of Unit



CR Sensitivity - High CR & Renewable Summary

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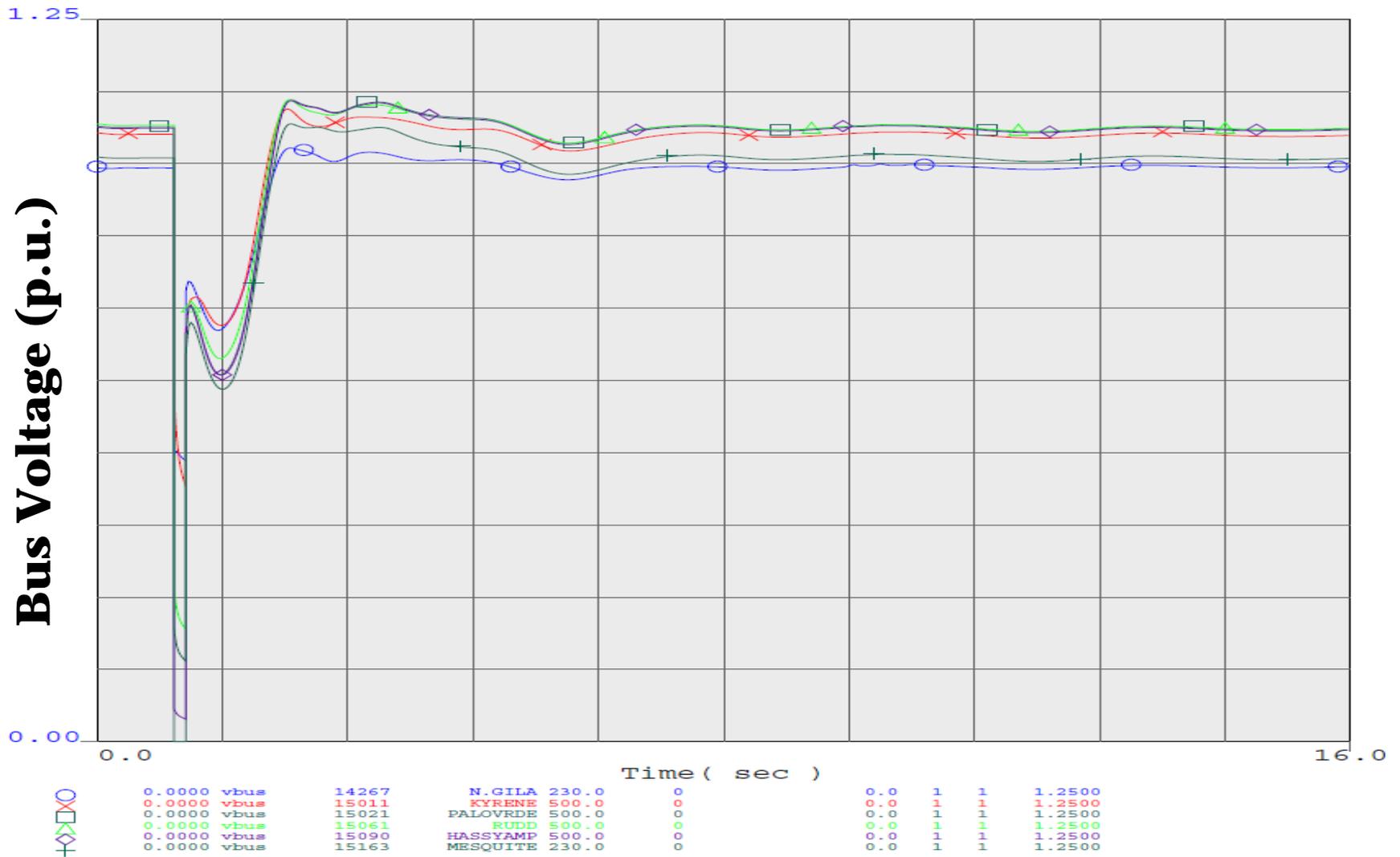
- Rotor angle oscillations are undamped
- Generators will eventually trip
- Can result in cascading failures

High Coal Reduction with Gas and Renewable Sensitivity Assumptions

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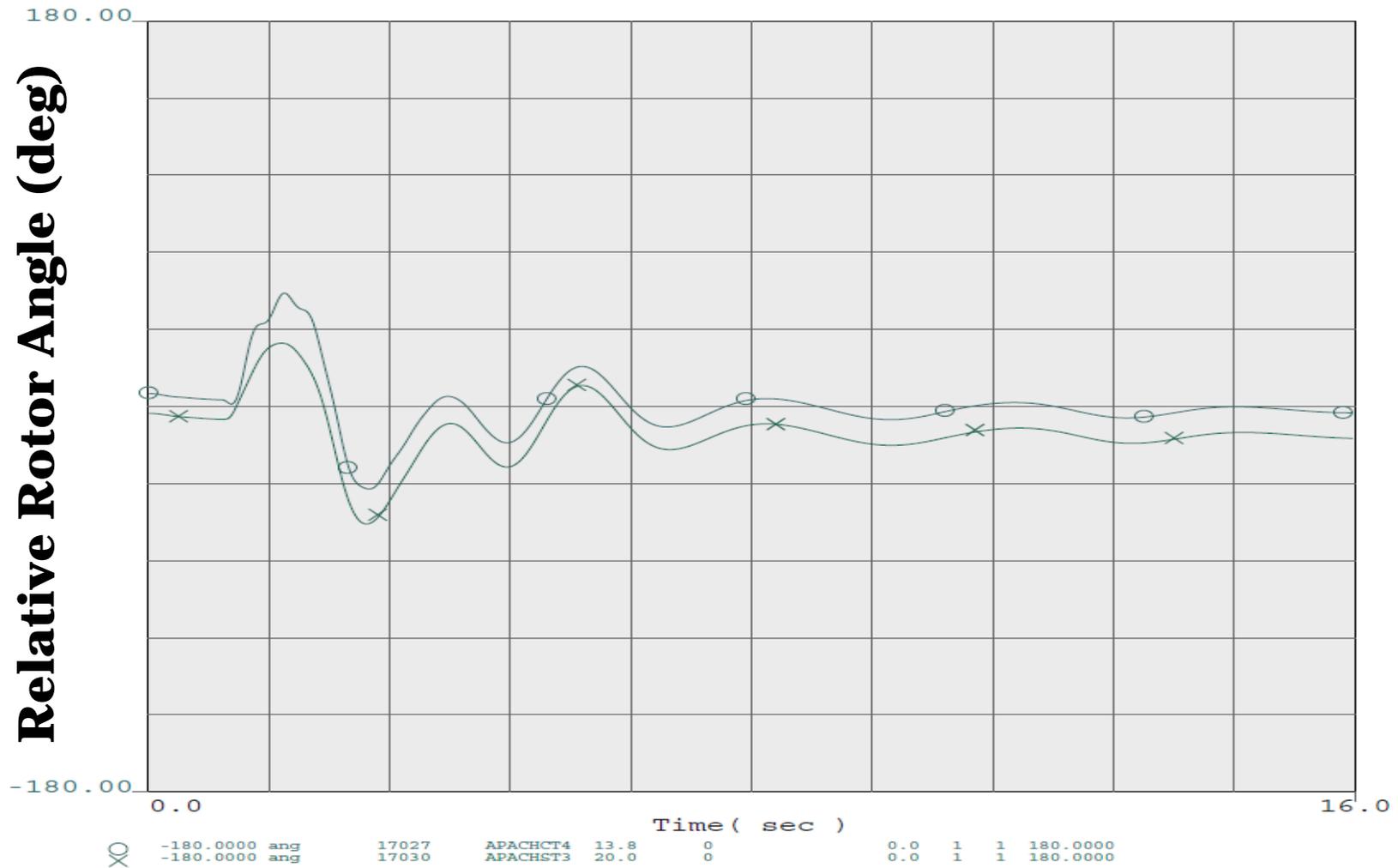
- 2019 Arizona Coordinated Heavy Summer Base Case
- 4811 MW Coal Plant Retirements Assumed
- 1195 MW New Gas Units Added
- 25 MW addition of San Juan 4
- 2701 MW of New Renewables Added
- 893 MW balance from reduction in area interchange to California
 - Assumes that California will add resources

High CR with Gas and Renewable Sensitivity Fault at Largest Single Generating Unit, Loss of Unit



High CR & Gas Renewable Sensitivity

Fault at Largest Single Generating Unit, Loss of Unit



High CR & Gas/Renewable Sensitivity

Generator Relative Rotor Angle

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- Rotor angle oscillations are damped
- Bus voltages are stable and similar to baseline scenario
- Addition of the planned gas units eliminates stability issues

Issues Requiring Further Research

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- **Inertia versus Voltage Support (added gas resources)**
 - Observed high voltage issues on 500kV system in Four Corners area
 - ✦ Possibly due to shutting down coal units resulting in reduced loading on lines (line charging) and losing voltage regulation capability
- **Impacts on Major Paths**
- **Impacts of Renewable intermittency**
- **Impacts of intraregional and Interregional power transfer**
 - Impact of transfers to California
- **Impact of current Section 111(d) on Arizona**

Conclusions

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- There is a limit to the number of coal plants that may be shut down while maintaining reliable system operation
- The limit to the amount of coal capacity that may be reduced is influenced by gas-fired replacement capacity
- The amount of renewable resources that may be integrated depends upon addition of gas-fueled generation or other resources that compensate for loss of inertia and dynamic reactive capability
- A question to consider: “Is replacing coal capacity with an appropriate ratio of gas/renewables the only solution?”
 - Decisions related to coal plant shutdowns within the five-year planning horizon could limit options for the future
 - Should we take a little more time to come up with a more comprehensive regional / interregional strategy?

Next Steps for SWAT

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- Possibly explore more scenarios to better determine where “the cliff” begins.
 - Evaluate higher flows to California consistent with that state’s plans.
- Identify specific transmission system needs by 2020 (e.g. reactive support, inertial resources, energy storage, dispatch patterns, etc.)
 - Arizona Corporation Commission draft order - Arizona TOs must produce a report to identify minimum transmission requirements and inertia levels to maintain reliability of the Arizona transmission system
- “Phase 2” work? – Look at impact on certain path ratings, bridge inertia and flexibility analysis
- Several SWAT participants interested in providing comments to EPA on its rulemaking (due October 16, 2014)

Interconnection-wide Next Steps

- WECC Planning Coordination Committee began a task force to investigate reliability impacts on an interconnection-wide basis
 - Goal is primarily to provide input to EPA rulemaking
- What is the progress of the coal retirement studies in the TEPPC 2014 Study Program?

Case ID	Case Summary	Priority	Requestor	Comment	10-Year PCM	20-Year LTPT	Reliability Study	Flexibility Assesment
Coal Retirement								
PC20	Coal Retirement A	High	CEERT, NRDC, PacifiCorp, SPSC, WIRAB, SPSG, Western Grid Group	Modest coal retirements with replacement generation from gas resources	X	X	X	X
PC21	Coal Retirement B	High		Aggressive coal retirements with incremental replacement generation from renewables	X	X	X	X

Coal Reduction Study Options

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- **States' Response to EPA Rule, Section 111(d)**
 - Arizona State study under SWAT Umbrella?
 - WECC-wide Study?
- **Possible WECC Coordinated Efforts**
 - Reliability – PCC Initiative?
 - Economic – TEPPC Study Plan?

Coal Reduction Study Recommendation

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- **SWAT CRATF should proceed with an Arizona study in Response to EPA Rule, Section 111(d)**
 - Study designed to simulate the current 111(d) scenario
 - Hypothetical assumptions
- **Will require information and participation by the Arizona utilities**
 - Identify which coal plants would need to be shutdown to comply with the current version of 111(d)
 - Identify replacement resources
- **Will require information and participation by California entities**
 - Resources to replace SONGS and Once Through Cooled gas plants
 - Planned West of River transfers
 - 2020 transmission topology

Questions and Comments

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