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ORIGINAL

BEFORE THE ARIZONA CORPORATION COMMISSION

**COMMISSIONERS**
MIKE GLEASON, Chairman
WILLIAM A. MUNDELL
JEFF HATCH-MILLER
KRISTIN K. MAYES
GARY PIERCE

| | |
|---|---|
| IN THE MATTER OF THE GENERIC DOCKET FOR THE 90-DAY PRE-APPLICATION PLANS FOR POWER PLANTS FILED PURSUANT TO A.R.S. §§ 40-360-02.B. | DOCKET NO. E-00000M-08-0170<br><br>**NOTICE OF FILING** |

Agua Caliente Solar, LLC, hereby provides notice that it is filing herewith the attached 90-day Plan for the Agua Caliente Solar Project.

RESPECTFULLY SUBMITTED this 12th day of November, 2008.

MOYES SELLERS & SIMS

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Original and Twenty-Eight (28) copies of the foregoing filed this 12 day of November 2008 with:

Docket Control
Arizona Corporation Commission
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Phoenix, Arizona 85007

Copy of the foregoing hand-delivered this 12 day of November 2008 to:

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Line Siting Committee
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# PLAN
for the
## AGUA CALIENTE SOLAR PROJECT

Submitted by Agua Caliente Solar, LLC
November 12, 2008

Pursuant to A.R.S. §40-360.02, Agua Caliente Solar, LLC ("Applicant") hereby submits its plan ("Plan") for the proposed Agua Caliente Solar Project (the "Project").

**Introduction:**

Applicant is a wholly-owned affiliate of NextLight Renewable Power, LLC. Applicant proposes to construct a nominal 280 MW concentrating solar powered electric generating facility, with associated on-site, short generation intertie transmission line and on-site switchyard. The Project is located in the eastern portion of Yuma County, approximately 10 miles north of I-8 and Dateland, Arizona.

A.R.S. §40-360.02(B) requires a party contemplating construction of an electric generating plant to file a plan with the Arizona Corporation Commission at least 90 days prior to filing an application for a Certificate of Environmental Compatibility ("CEC") for such plant. Applicant intends to file such an application for the Project early in 2009 and, therefore, files this Plan at least 90 days in advance of filing such application. This Plan covers the solar generating facility and associated generation intertie transmission line that will be constructed and owned by Applicant or its successors or assigns. In addition, this Plan also addresses a new 500kV switchyard and a short loop in-out of the existing Hassayampa - North Gila 500kV transmission line, which facilities will both be owned by Arizona Public Service Company and the other existing 500kV line joint owners (collectively, "APS") and constructed on and adjacent to the Project site in conjunction with the Project. If it is determined that the APS-owned switchyard and loop in-out facilities also require a CEC, this Plan shall also constitute the plan under A.R.S. § 40-360.02 prerequisite to a joint or separate application for a CEC covering such facilities.

**Specific Plan Information:**

The specific items of information required by A.R.S. 40-360.02(C), and the applicable responsive Plan information for the Agua Caliente Solar Project, to the extent known, are set forth below:

**With respect to the power plant:**

1. "The location of any plant proposed to be constructed":

   The Project is located in the eastern portion of Yuma County, approximately 10 miles north of I-8 and Dateland, Arizona, on a contiguous site comprising all or portions of Sections 4, 5, 9, 15, 16, 21, 22, 27, 28 and 34 of Township 5 South, Range 12 West, G&SRB&M.

2. "The purpose to be served by each proposed plant":

   The Project will supply renewable solar-powered electrical generation to load serving utilities.

3. "The estimated date by which the plant will be in operation":

   The Project is estimated to be in commercial operation by Spring of 2013.

4. "The average and maximum power output measured in megawatts of each plant to be installed":

   The Project will be designed to produce up to 280 MW of gross power output from either a single 280 MW steam turbine generator or two 140 MW steam turbine generators.

5. "The expected capacity factor for each proposed plant":

   The capacity factor of the Project will depend upon actual weather factors influencing the solar insolation and resulting operating profile, but is anticipated to be in the range of 35% to 37%, with generation produced primarily during peak load hours.

6. "The type of fuel to be used for each plant":

The Project will be fueled by solar energy captured in a heat transfer fluid using parabolic trough concentrators and converted to steam-turbine generated electricity.

7. "The plans for any new facilities shall include a power flow and stability analysis report showing the effect of the current Arizona electric transmission system. Transmission owners shall provide the technical reports, analysis or basis for projects that are included for serving customer load growth in their service territories."

Attachment A to this Plan is the System Impact Study conducted by Arizona Public Service Company showing the effect of the Project on the affected transmission systems within the western region.

**With respect to transmission lines:**

1. "The size and proposed route of any transmission lines":

The generation intertie transmission line ("Gen-Tie Line") will be a 500 kV transmission line on a single set of towers and will connect the Project generator(s) to a new 500kV switchyard to be constructed and owned by APS (the "APS Switchyard") located along the southern boundary of the Project site in Section 34, near the existing Hassayampa -North Gila 500 kV transmission line, which will be looped in-and-out of the APS Switchyard. The Gen-Tie Line route will be wholly within the Project site, a distance of approximately 1.5 miles, running from the power block area on the western edge of the Project site through Sections 28 and 34 to the APS Switchyard.

2. "The purpose to be served by each proposed transmission line":

The Gen-Tie Line will interconnect the new generator(s) to the new APS Switchyard, through which the Project will be interconnected to the electric grid via a loop in-and-out of the existing Hassayampa - North Gila 500 kV line.

3. "The estimated date by which each transmission line will be in operation":

The Gen-Tie Line, APS Switchyard and loop interconnection are anticipated to be in operation in mid-2012 to support startup and testing of the Project.

This Plan is respectfully submitted this 12th day of November, 2008.

Agua Caliente Solar, LLC

By: [signature]

Authorized Officer / Agent

Attachment A: System Impact Study

APS A subsidiary of Pinnacle West Capital Corporation

# North Gila Generation Cluster

## Final
## System Impact Study

APS Contract Nos. 52081, 52092

**By**

**Arizona Public Service Company**
**Transmission Planning**

**November 5, 2008**
**Version 1.11 - Final**

Prepared by
Utility System Efficiencies, Inc.

# SYSTEM IMPACT STUDY
# NORTH GILA CLUSTER PROPOSED GENERATION

November 5, 2008

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## LIST OF APPENDICES

## EXECUTIVE SUMMARY

This section summarizes the System Impact Study (SIS) results for a proposed generation cluster totaling 900MW in the Arizona Public Service (APS) system. Additional specific details of the proposed interconnection's impact on the surrounding transmission system can be found in the "Results and Findings" section of this report.

### Disclaimer

Nothing in this report constitutes an offer of transmission service or confers upon the Interconnection Customer, any right to receive transmission service. APS and other interconnected utilities may not have the Available Transmission Capacity to support the interconnection described in this report.

### Background:

Under provisions of the Arizona Public Service Company (APS) Open Access Transmission Tariff (OATT), APS has elected to cluster Interconnection Requests #33 and #43. Project #33 plans to interconnect to the North Gila 500kV bus as an Energy Resource, and Project #43 plans to interconnect to the Hassayampa-North Gila #1 500kV line as an Energy Resource. APS has retained Utility System Efficiencies (USE) to perform the technical analysis. Interconnection Request #33 plans to install 400MW of solar-thermal generation in 2010-2011. Interconnection Request #43 plans to install 500MW of solar-thermal generation in 2012-2013. Figure 1 below shows a sketch of the two projects. Project #33 has previously completed a Feasibility Study, whereas Project #43 has entered directly into a System Impact Study. Both projects' Applicants have signed System Impact Study (SIS) agreements, and the two projects were gathered into a common Cluster SIS which commenced on April 1, 2008.

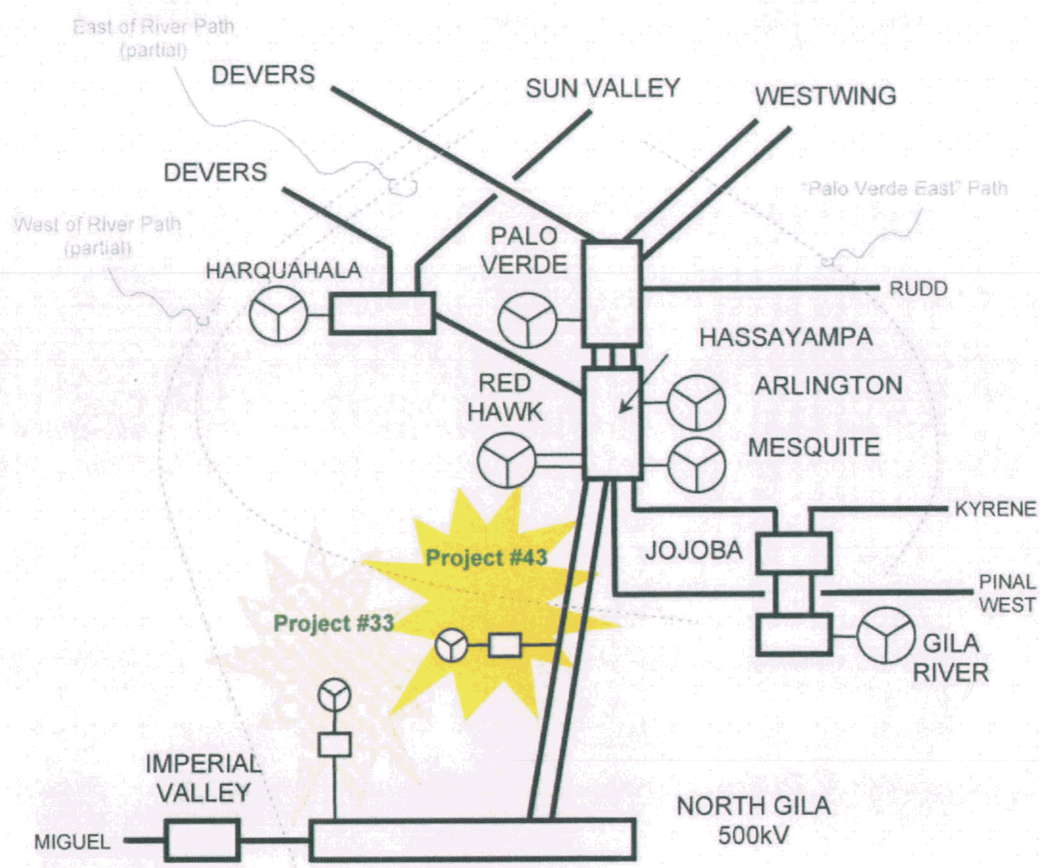



Figure 1. North Gila Cluster

**What was studied:**

This System Impact Study (SIS) examined the effects on the surrounding transmission system of interconnecting 900MW of generation in the immediate vicinity of the North Gila 500kV substation (400MW located at North Gila and 500MW located 60 miles away along the Hassayampa-North Gila #1 500kV line). This SIS used the machine parameters and characteristics provided by the Applicants. Subsequent detailed Facilities Studies may want to revisit and tune specific generator parameters.

Analyses for the proposed generator installation consisted of computer-based power flow studies, transient stability simulations, post-transient studies, and short circuit/fault duty analysis. Unless otherwise noted, this study modeled the proposed generation cluster under 2012 Summer peak load conditions (forecasted peak load of 21,909MW in AZ). Select contingencies which stressed the transmission system were simulated. Power flow, transient stability, and post-transient results were monitored for APS, SRP, IID, WAPA, SDG&E, SCE, and other neighboring systems; short circuit analyses were preformed by and coordinated between the APS and SRP Protection Departments.

**System performance criteria used in the study:**

The criteria applied in this study are consistent with NERC/WECC Reliability Criteria. For more detailed information on the criteria used for each analysis see section 1.7 "Reliability Criteria."

**Results:**

The proposed generation resulted in some new emergency thermal overloads for the APS, IID, and WALC systems under applicable (single element WECC Category B, and multiple element WECC Category C) outage conditions. In terms of voltage performance, the generation cluster had no negative effects.

Following the single element outage of the North Gila-Imperial Valley 500kV line and subsequent actions of the San Luis Rio Colorado Special Protection Scheme[1] (SLRC SPS) the North Gila generation cluster overloaded IID's two Pilot Knob 161/92kV transformers and APS's planned TS8 230/69kV transformer. These overloads were found to occur when the second Hassayampa-North Gila 500kV line is in service. Based on preliminary project timings, it is possible that phases of the generation facilities may be in service in advance of the new transmission line, which may be delayed beyond the 2012 in service date.

Under sensitivity scenarios where the new additional Hassayampa-North Gila #2 500kV line is not completed/in-place, the cluster generation was found to overload IID/WALC's Pilot Knob-Knob 161kV line and WALC's Gila 230/161kV transformer during a double element ("N-2") outage of the Palo Verde-Devers #1 and #2 500kV lines. With the Hassayampa-North Gila #2 500kV line in service, this same N-2 outage can potentially overload IID's Niland-CVSUB 161kV line when the West of River Path is heavily loaded.

Transient stability performance was monitored for APS, IID, WAPA, SDG&E, SCE, and other neighboring systems. Overall, transient stability results met or exceeded the Western Electricity Coordinating Council (WECC) criteria. No detrimental transient stability impacts were observed for neighboring systems. Several selected stability simulations revealed a slow voltage recovery phenomenon, however these issues are not associated with the new proposed generation cluster.

The cluster does not over stress any breakers in the APS or SRP systems. The coordinated study issued by SRP can be found in Appendix E "Coordinated Short Circuit Study."

**Curtailments**

Under an "Energy resource" interconnection, potential overloads may be mitigated through curtailment. Project #33 and Project #43 had elected to be studied as Energy Resources. To successfully mitigate the post-contingency overloads identified in this study, curtailment of the 900MW generation cluster would be required. Depending on the scheduling scenario, the entire cluster may be limited to

[1] For this outage, post-contingency actions of the "SLRC SPS" were simulated, opening the Gila 230/161kV transformer and tripping the SLRC generation (575MW)

90-470MW maximum output. Without the Hassayampa-North Gila #2 500kV line project in-service, the cluster may be limited to 110-210MW maximum output. Under West of River Stressed conditions, the cluster may be limited to 850MW maximum output. For a complete discussion on these generation curtailments, see section 3.5 "Generation Mitigation."

**Reinforcements**

The participants in the Cluster may elect to upgrade the transmission system rather than incurring a curtailment. Under anticipated normal operating conditions with the Hassayampa-North Gila #2 500kV line in service and the cluster generation in service, overload protection would need to be added to the new TS8 230/69kV transformer bank to automatically open the bank in the event of an overload exceeding 100% of its emergency rating. For the outage of the North Gila-Imperial Valley 500kV line, this new protection would eliminate the overload of the transformers at Pilot Knob and TS8 without creating any new overloads. Some additional communication platforms may be necessary to implement this protection, however this will be established in the Interconnection Facilities Studies.

Additional transmission upgrade projects were studied to mitigate the TS8 overload, including the addition of a second TS8 230/69kV transformer. However, adding a second TS8 230/69kV transformer did not completely eliminate the overloads. The TS8-Araby South 69kV line became overloaded due to the increase in 230kV to 69kV flow. Opening the line did not alleviate the concerns because the overload shifted to the MAB-32nd Street 69kV line. The TS8-Araby South 69kV line would need to be reconductored in addition to the transformer upgrades. Addition of an enhanced overload protection to open the TS8 bank post-contingency is the preferred solution to address the overload. This overload protection would eliminate the overload of the transformer at TS8 (as well as Pilot Knob) without creating any new overloads, and not require generation tripping or loss of load. The details and estimated cost for installation of the overload protection will need to be developed in the Interconnection Facilities Studies.

Under system conditions without the Hassayampa-North Gila #2 500kV line, the TS8 transmission facilities, and the Highline-North Gila 230kV line, no N-1 overloads were noted, including for the loss of the North Gila – Imperial Valley 500kV line. However for the N-2 double contingency outage of the Palo Verde-Devers #1 and #2 500kV lines , the Gila 230/161kV transformer overloads. The new Gila SPS that is being implemented as part of the San Luis Rio Colorado (SLRC) combined-cycle project may need to be modified to automatically open the Gila 230/161kV transformer following the double element outage of the Palo Verde-Devers #1 and #2 500kV lines to adequately mitigate the Gila 230/161kV transformer overload. Another alternative solution would be to implement a short term emergency rating for the Gila 230/161kV transformer. Since the SLRC project is in the Western Area Power Administration (Western) interconnection queue, verification with Western as to the appropriate mitigation for this N-2 condition will need to be done as part of the Interconnection Facilities Study. Western is aware of the potential overload and is engaged in establishing which option will be the proper mitigation.

With the reinforcements mentioned in this section, all WECC and NERC reliability criteria would be met without any generation curtailments.

# 1 STUDY DESCRIPTION AND ASSUMPTIONS

This section of the report provides details pertaining to the power flow case development and an overview of major study assumptions. All power flow , transient stability, and post-transient work was performed using General Electric's Positive Sequence Load Flow (GEPSLF) program, version 16.0_11.

Sensitivity cases were run to assess the impacts of relatively uncertain but significant transmission characteristics:

- **No Hassayampa-North Gila #2 500kV Line:** Identify the reliability impact upon the cluster if the Hassayampa-North Gila #2 500kV line is not completed.

- **West of the River Stressed Case:** Identify the reliability impact upon the cluster if the WOR flow is at its East-to-West rated capacity of 11,823MW.
- **Schedule cluster output to CA/Schedule cluster output to AZ for all power flow cases:** Identify the available transmission capacity for power scheduled to either California or Arizona.

A family of 12 basecases were created to properly study these sensitivities. Power flow and post-transient analysis used an APS 2012 Summer Detailed Planning basecase as a starting point. This case was developed by APS from the 2011 summer basecase jointly built by the Arizona utilities, and represents the most up-to-date transmission system topology, and includes the most recent APS load forecast for 2012. The transient stability analysis utilized the Western Electricity Coordinating Council (WECC) approved 2012 Heavy Summer basecase, version 2a and its corresponding dynamic data file (dyd). This WECC basecase was generally aligned with the major system changes observed in the APS Detailed Planning basecase, particularly the 500kV topology. The West-of-River Stressed basecase was derived from a case modeling the East-of-River Path at its anticipated future limit of 10,500MW. This EOR case was obtained from Southern California Edison, and had previously undergone review and input from APS, MWD, SCE, SRP, TEP, and WALC. **Table 1** on the following page summarizes the cases utilized in this generation cluster study.

**Table 1. Basecase Modeling Summary**

| # | Scenario Description | WOR Stressed to 11,823MW (E→W) | Hasayampa-North Gila #2 500kV line | Sink | | Starting Basecase | | |
|---|---|---|---|---|---|---|---|---|
| | | | | CA | AZ | APS Planning | WECC 12HS2a | EOR Stressed |
| Power Flow Analysis | | | | | | | | |
| 1. | Pre Project | | √ | | | √ | | |
| 2. | Post Project (CA) | | √ | √ | | √ | | |
| 3. | Post Project (AZ) | | √ | | √ | √ | | |
| 4. | Pre Project, No Hassayampa-North Gila #2 | | | | | √ | | |
| 5. | Post Project, No Hassayampa-North Gila #2 (CA) | | | √ | | √ | | |
| 6. | Post Project, No Hassayampa-North Gila #2 (AZ) | | | | √ | √ | | |
| Post Transient | | | | | | | | |
| 1. | Pre Project | | √ | | | √ | | |
| 2. | Post Project (CA) | | √ | √ | | √ | | |
| 4. | Pre Project, No Hassayampa-North Gila #2 | | | | | √ | | |
| 5. | Post Project, No Hassayampa-North Gila #2 (CA) | | | √ | | √ | | |
| 11. | Pre Project, West of River Stressed | √ | √ | | √ | | | √ |
| 12. | Post Project, West of River Stressed | √ | √ | | √ | | | √ |
| Transient Stability | | | | | | | | |
| 7. | Pre Project | | √ | | | | √ | |
| 8. | Post Project (CA) | | √ | √ | | | √ | |
| 9. | Pre Project, No Hassayampa-North Gila #2 | | | | | | √ | |
| 10. | Post Project, No Hassayampa-North Gila #2 (CA) | | | √ | | | √ | |
| 11. | Pre Project, West of River Stressed | √ | √ | | | | | √ |
| 12. | Post Project, West of River Stressed (CA) | √ | √ | √ | | | | √ |

## *1.1 Power Flow Pre-Project Case Modeling*

The Pre-Project power flow case simulated a high load, high generation condition for Summer 2012. As a starting point, the SIS utilized an APS Detailed Planning study case ("sm12#17.sav"), which includes modeling of the 69kV sub-transmission system. The additional modifications described below were implemented to create the SIS power flow cases.

**Case 1**: "2012" Pre-Project Heavy Summer High Load/High Generation ("1_PRE_12HS-AZ17.sav")

1. Study base case "sm12#17.sav" was obtained from APS Transmission Planning. This basecase includes the planned Green Path Project, Sunrise Project, Palo Verde-Devers #2 line, Hassayampa-North Gila #2 line, Sun Valley 500/230kV substation with associated transmission elements, TS8 230/69kV substation with associated transmission elements, and the San Luis Rio Colorado generation project.

***General Changes***

2. Changed all isolated/islanded busses from Type "0" to Type "-4".

***Arizona Changes***

3. As directed by APS, the Palo Verde-Devers #2 500kV model was corrected to emanate from the new Delany substation (formerly known as "Harquahala Junction").
4. As directed by APS, emergency ratings (120-125% of normal) were added for selected APS 230/69kV transformers.
5. As directed by APS, the Yarnell-Wickenburg 69kV line section was opened as part of their long term plans in the area.
6. As directed by APS, the second shunt at the Salome 69kV bus was placed in service for voltage support.
7. In the initial case, the Area 14 swing generator's output (Navajo 3) was greater than its maximum capacity. To bring Navajo 3 back within limits, output of Gila River generation was increased to a net of 2100MW, and San Luis Rio Colorado was increased to 575MW.
8. Adjustments were made to the Glen Canyon, Shiprock, Pinto, Sigurd, and San Juan phase shifting transformers, to rebalance flows and bring the Shiprock 345/230kV transformer within 100% of its normal rating.
9. As directed by APS, an emergency rating of 700MVA (117% of normal) was added to the Sun Valley 500/230kV transformer.
10. As directed by APS, the series capacitors at both ends of the Red Mesa-Four Corners 500kV line were inserted.
11. As directed by APS, Harquahala was increased 108MW to its net Pmax of 1100MW. Mesquite was reduced to balance the generation.
12. The Hassayampa-North Gila #1 and #2 500kV line ratings were corrected to 2338.2MVA normal and 2598MVA emergency for the conductor segments, and 1905.2MVA normal and 2572MVA emergency for the series capacitor segments.
13. The Mesquite Solar Project (720MW) was added to the model. Phoenix area generation KYRENE 4 & 5, DBG CT 1 & 2 and ST, AGUAFR 5 & 6, and OCOTGT2 were turned offline to accommodate this new generation.
14. TS8 topology was corrected to the most recent plan to loop into the Gila-SLRC #2 230kV line. The North Gila-TS8 230kV line was removed.
15. Yuma 69kV system changes include:
    - Laguna 69kV topology was corrected to the most recent plan to add the LAGUNATP 69kV bus and associated lines.
    - SW8 69kV substation was added. The station was looped into the SW5-SW7 69kV line and a new North Gila-SW8 69kV line was added.
    - The MAB S-ARABY S 69kV line was opened.

***WALC Changes***

16. As directed by WALC, the tap setting was corrected for WAPA's North Gila 500/230kV transformers, to avoid under-voltage conditions on the local 230kV system.

***LADWP Changes***

17. Modeling of LADWP's Green Path North Project was updated to the current expected configuration, including the DEVERSLA and HESP500 500kV busses.

***SCE Changes***

18. Modeling of the tertiary buses for the Devers 500/230kV transformers was corrected.
19. The Devers 500kV shunt capacitors "c1" and "c2" were added to the model.
20. The Devers-Valley #2 500kV line was added as part of the Palo Verde-Devers #2 500kV line project.
21. As directed by SCE, the series capacitor ratings and status were updated for the Eldorado-Lugo 500kV line and Mohave-Lugo 500kV line.

***SDG&E Changes***

22. As directed by SDG&E the following lines and transformers were added to the model:
    - DIVISION – NAVSTMTR #2 69KV LINE
    - WABASH – MAIN ST #2 69KV LINE
    - MAIN ST – NATNLCTY 69KV LINE
    - ENCNITAS – R.SNTATP 69KV LINE
    - R.SNTATP – NORTHCTY 69KV LINE
    - NORTHCTY – PENSQTOS 69KV LINE
    - PENSQTOS – ENCINA #2 230KV LINE
    - DEL MAR – PENSQTOS #2 69KV LINE
    - BATIQTOS – SHADOWR 138KV LINE
    - CHCARITA – SHADOWR 138KV LINE
    - MDWLRKTP – SHADOWR 138KV LINE (N.O.)
    - MISSION – CARLTHT2 138KV LINE
    - SYCAMORE – CARLTHT2 138KV LINE
    - CARLTNHS – CARLTHT2 138KV LINE
    - MIGUEL #2 230/138KV TRANSFORMER
23. As directed by SDG&E the following lines were removed from the model:
    - SYCAMORE – CARLTHTP 138KV LINE
    - WABASH – NATNLCTY 69KV LINE
    - LOSCOCHS – SOUTHBAY 138KV LINE
    - SHADOWR – ESCNDO50 138KV LINE
    - ESCNDO50 138/69KV LINE
24. As directed by SDG&E the following lines were opened in the model:
    - ESCNDO51 – NCMETRTP 138KV LINE
    - BATIQTOS – MDWLRKTP 138KV LINE
    - CHCARITA – MDWLRKTP 138KV LINE
    - MDWLRKTP – NCMETRTP 138KV LINE
    - NCMETER – NCMETRTP 138KV LINE
    - ENCINA – NORTHCTY 138KV LINE
    - ENCNITAS – PENSQTOS 69KV LINE
    - MISSION – CARLTNHS 138KV LINE
    - NORTHCTY – PENSQTOS 138KV LINE
    - R.SNTATP – DEL MAR 69KV LINE
    - R.SNTATP – PENSQTOS 69KV LINE
25. As directed by SDG&E the impedance of the following lines and transformers were changed in the model:
    - DIVISION – NAVSTMTR 69KV LINE
    - ENCINA – NORTHCTY 138KV LINE
    - SILVERGT – OLD TOWN 230KV LINE
    - SILVERGT – OLDTWNTP 230KV LINE
    - NORTHCTY – PENSQTOS 138KV LINE
    - WABASH – MAIN ST 69KV LINE
    - GRNT HLL – SOUTHBAY 138KV LINE

- SOUTHBAY 138/69KV TRANSFORMER

26. As directed by SDG&E the ratings of the following lines and transformers were changed in the model:
    - DIVISION – NAVSTMTR 69KV LINE
    - ENCINA – NORTHCTY 138KV LINE
    - ENCNITAS – PENSQTOS 69KV LINE
    - NORTHCTY – PENSQTOS 138KV LINE
    - R.SNTATP – PENSQTOS 69KV LINE
    - WABASH – MAIN ST 69KV LINE
    - GRNT HLL – SOUTHBAY 138KV LINE
    - SOUTHBAY 138/69KV TRANSFORMER
27. As directed by SDG&E the taps of the following transformers were changed in the model:
    - MISSION #1 230/138 TRANSFORMER
    - MISSION #2 230/138 TRANSFORMER
    - OLD TOWN #1 230/69KV TRANSFORMER
    - OLD TOWN #2 230/69KV TRANSFORMER

***IID Changes***

28. The IID model was replaced with the most recent planed configuration provided by IID. The model includes the planned 230kV line from Highline to North Gila.
29. The area interchange export schedule for IID was reduced by 600MW.

A summary of the Pre-Project power flow case attributes are listed in **Table 2**. Power flow diagrams of the transmission system for the Pre-Project, normal/"all lines in service" condition are provided in **Appendix A**.

## *1.2 Power Flow Post Project Case Modeling*

The modeling for the new generation in the vicinity of North Gila utilized machine characteristics provided by the Applicants. Subsequent detailed Facilities Studies may want to revisit and tune specific generator parameters. The arrangement of the North Gila Cluster is depicted in **Figure 2**.

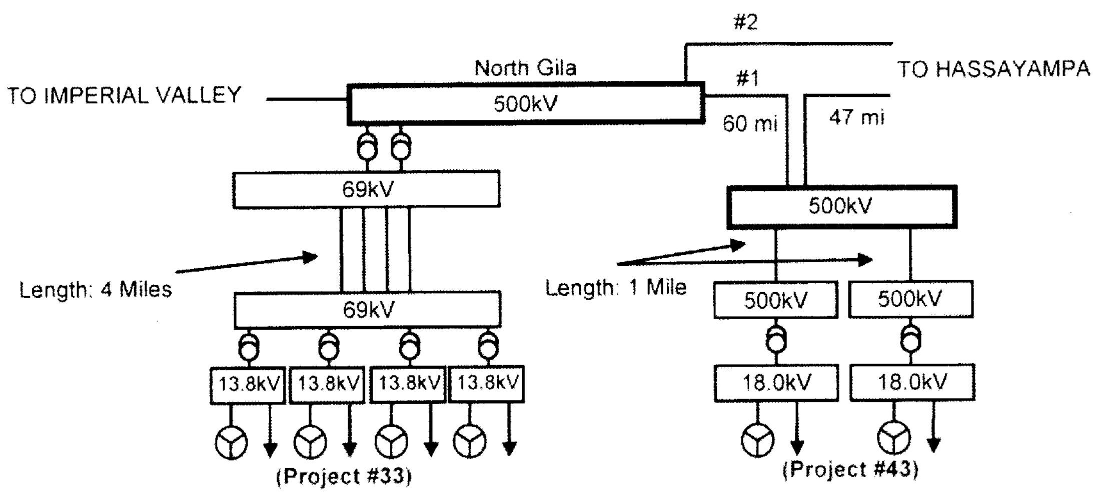



Figure 2. Cluster Arrangement at North Gila

As previously indicated in **Table 1,** when modeling the North Gila generation cluster two scheduling sensitivities were modeled. One case considered all 900MW scheduled to CA, and the other case considered all 900MW scheduled to AZ.

The Post-Project case with power scheduled to CA was modeled as follows:

**Case 2**: "2012" Post-Project Heavy Summer, Power Scheduled to CA ("2_PST_12HS-AZ17_CA.sav")

- Project #33 was modeled as four generators with a Base of 116 MVA, a Pmax of 115.6MW, and Qmax/Qmin capabilities of 60/-25MVAR. An auxiliary load of 3MW was modeled. Each generator was dispatched at 103MW such that the net output was 100MW each (net total of 400MW). The auxiliary load and generator were connected to a 13.8kV bus then stepped up to a common 69kV bus through a Generator Step Up (GSU) transformer for each unit. Four parallel 4 mile 69kV lines delivered power to the North Gila substation where it was further stepped-up to 500kV through two 500/69kV transformers.
- Project #43 was modeled as two generators each with a Base of 275 MVA, a Pmax of 275MW, and Qmax/Qmin capabilities of 60/-25MVAR. An auxiliary load of 25MW and 10 MVAR was modeled for each unit. The generators were dispatched at 275MW such that the net total output was 500MW. The units were connected to dedicated 18.0kV buses then stepped up to 500kV through dedicated Generator Step Up transformers. Two one-mile 954 ACSR 500kV lines were modeled from the high-side of each GSU to the 500kV bus that tapped into the Hassayampa-North Gila 500kV line.
- The power scheduled to CA was distributed equally between PG&E, SCE, and SDG&E. To accommodate the new generation, local generation in each of those areas was reduced. In PG&E, MOSSLND6 and MOSSLND7 were each reduced from 700MW to 550MW. In SCE, REDON8 G was reduced from 470MW to 370MW, TOT037C1 and TOT037C2 were each reduced from 405MW to 305MW. In SDG&E, ENCINA 5 was reduced from 320MW to 170MW, PEN_ST was reduced from 200MW to 125MW, and OTAYMST1 was reduced from 210MW to 135MW.

Power flow plots of the transmission system along with the new generation cluster under normal/"all-lines-in-service" conditions are provided in **Appendix A**. **Table 2** summarizes the Post-Project power flow case attributes.

The Post-Project case with power scheduled to AZ was modeled as follows:

**Case 3**: "2012" Post-Project Heavy Summer, Power Scheduled to AZ ("3_PST_12HS-AZ17_AZ.sav")

- This case is generally the same as Case 2; however, the generation cluster's power is scheduled to AZ (instead of CA). To accommodate the new generation, local generation in the Palo Verde Hub was reduced. MES-CT1, MES-CT2, MES-CT3, MES-CT1 were each reduced from 172MW to 45MW, MES-ST1 was reduced from 282MW to 85MW, and MES-ST2 was reduced from 291MW to 95MW.

Power flow plots of the transmission system along with the new generation cluster under normal/"all-lines-in-service" conditions are provided in **Appendix A**. **Table 2** summarizes the Post-Project power flow case attributes.

## 1.3 Power Flow Sensitivity Case Modeling

For Power Flow, sensitivities with the Hassayampa-North Gila #2 500kV line out of service was studied in addition to the scheduling sensitivity. Cases 4 through 6 were created to properly study the variations which included pre and post project models.

**Case 4**: "2012" Pre-Project Heavy Summer, Hassayampa-North Gila #2 Out of Service ("4_PRE_12HS-AZ17_HNG2-OUT.sav")

- Started with Case 1.
- Removed the Hassayampa-North Gila #2 500kV line between "HASSYAMP 500" and "N.GILA 500".
- As directed by APS, removed the TS8 Project by opening the 230/69kV transformer.
- As directed by IID, removed the Highland-North Gila 230kV line.

**Case 5**: "2012" Post-Project Heavy Summer, Hassayampa-North Gila #2 Out of Service, Power Scheduled to CA ("5_PST_12HS-AZ17_CA_HNG2-OUT.sav")

- Started with Case 2.
- Removed the Hassayampa-North Gila #2 500kV line between "HASSYAMP 500" and "N.GILA 500".
- As directed by APS, removed the TS8 Project by opening the 230/69kV transformer.
- As directed by IID, removed the Highland-North Gila 230kV line.

**Case 6**: "2012" Post-Project Heavy Summer, Hassayampa-North Gila #2 Out of Service, Power Scheduled to AZ ("6_PST_12HS-AZ17_AZ_HNG2-OUT.sav")

- Started with Case 3.
- Removed the Hassayampa-North Gila #2 500kV line between "HASSYAMP 500" and "N.GILA 500".
- As directed by APS, removed the TS8 Project by opening the 230/69kV transformer.
- As directed by IID, removed the Highland-North Gila 230kV line.

Power flow plots of the transmission system along with the new generation cluster under each condition is provided in **Appendix A**. **Table 2** summarizes the Post-Project power flow case attributes.

**Table 2. Pre-Project and Post-Project Power Flow Case Attributes**

| | All Planned Projects In Service | | | No Hassayampa-North Gila #2 500kV Line | | |
|---|---|---|---|---|---|---|
| | Pre-Project | Post - Project CA | Post - Project AZ | Pre-Project | Post – Project CA | Post – Project AZ |
| **Major Path/Branch Flows:** | | | | | | |
| Path 46 – West of the River | 6,842 | 7,662 | 6,838 | 6,883 | 7,730 | 6,885 |
| Path 49 – East of the River | 5,515 | 5,480 | 4,626 | 5,499 | 5,458 | 4,610 |
| Palo Verde East Path | 5,285 | 5,539 | 5,308 | 5,363 | 5,610 | 5,369 |
| Palo Verde-Devers #1 500kV Line | 1,079 | 1,221 | 1,070 | 1,128 | 1,270 | 1,110 |
| Hassayampa-Delany 500kV Line | 691 | 852 | 688 | 746 | 907 | 733 |
| Delany-Devers 500kV Line | 1,108 | 1,246 | 1,098 | 1,156 | 1,294 | 1,137 |
| Delany-Sun Valley 500kV Line | 681 | 705 | 689 | 689 | 711 | 694 |
| N.Gila-Imperial Valley 500kV Line | 1,309 | 1,548 | 1,361 | 1,236 | 1,507 | 1,335 |
| Hassayampa-N.Gila #1 500kV Line (measured at Hass.) | 643 | 207 | 96 | 1089 | 501 | 313 |
| Hassayampa-N.Gila #2 500kV Line (measured at Hass.) | 643 | 482 | 372 | n/a | n/a | n/a |
| **Arizona Area 14 (incl. WALC)** | | | | | | |
| Load[2] | 21,993 | 22,055 | 22,055 | 21,993 | 22,055 | 22,055 |
| Losses | 827 | 827 | 826 | 832 | 829 | 827 |
| Generation | 30,898 | 31,859 | 30,959 | 30,903 | 31,862 | 30,960 |
| Interchange (exports) | 8,031 | 8,929 | 8,030 | 8,030 | 8,930 | 8,030 |
| **IID Area 8** | | | | | | |
| Generation | 884 | 888 | 886 | 881 | 883 | 882 |
| Interchange (imports) | 450 | 450 | 450 | 450 | 450 | 450 |
| **SDG&E Area 22** | | | | | | |
| Generation | 2,870 | 2,581 | 2,873 | 2,869 | 2,580 | 2,872 |
| Interchange (imports) | 2,256 | 2,556 | 2,255 | 2,256 | 2,556 | 2,257 |
| **SCE Area 24** | | | | | | |
| Generation | 14,762 | 14,483 | 14,758 | 14,769 | 14,490 | 14,764 |
| Interchange (imports) | 7,490 | 7,789 | 7,490 | 7,490 | 7,789 | 7,490 |
| **PG&E Area 30** | | | | | | |
| Generation | 26,612 | 26,313 | 26,613 | 26,615 | 26,313 | 26,615 |
| Interchange (imports) | 1,319 | 1,619 | 1,318 | 1,317 | 1,618 | 1,316 |
| Case | 1 | 2 | 3 | 4 | 5 | 6 |

[2] For the Post-Project scenarios, Area 14's Load increases 62MW due to modeling of new cluster generation's auxiliary loads.

## 1.4 Post-Transient and Transient Stability Pre and Post Project Case Modeling

The Post-Transient simulations were performed using the previously-described Pre- and Post-Project APS Detailed Planning power flow cases. Specifically, cases 1 (Pre), 2 (Post CA), 4 (Pre-HNG2 Out), and 5 (Post-HNG2 Out CA).

Additionally, two cases were studied which modeled the West of River Path stressed to 11,823MW. Transient stability and post-transient analyses were applied to these cases. These basecases were obtained from Southern California Edison (SCE), and were originally tuned as East of River stressed cases. Transmission topology changes (particularly 500kV projects) were added to reflect a 2012 condition, and generation was tuned to stress the WOR Path to a flow of 11,823MW.

**Case 11**: "2012" Pre-Project Heavy Autumn, WOR at 11,823MW
("11_PRE_WOR.sav")

1. Study base case "11HA_EOR_PRE.sav" was obtained from SCE Transmission Planning.

***General Changes***

2. Changed all isolated/islanded busses from Type "0" to Type "-4".
3. All generation with Pgen greater than their governor's "mwcap" parameter were reduced to appropriate levels.
4. In order to stress the WOR Path, Nevada exports and area generation were increased by 800MW, SDG&E exports and area generation were increased by 1000MW, SCE exports and area generation were reduced by 1200MW, PG&E exports and area generation were reduced by 400MW, and LADWP exports and area generation were reduced 200MW.

***Arizona Changes***

5. Modeling of the Palo Verde-Devers #2 500kV line was adjusted to match the most recent plans. These plans include termination of the line at Delany rather than at Harquahala.
6. The Jojoba 500kV bus was re-numbered from 14008 to 15089.
7. The Sun Valley (a.k.a. "TS5")-Raceway (a.k.a. "TS9") 500kV line was added to the model.
8. The second Sun Valley 500/230kV transformer was removed.
9. The Hassayampa-North Gila #2 500kV line was added, including series compensation and line shunts.
10. Normal and/or Emergency ratings were corrected on the following elements:
    - HASSYAMP – REDHAWK 500 #1 line
    - HASSYAMP – REDHAWK 500 #2 line
    - HASSYAMP – DELANY (HARQ JCT) 500 line
    - HASSYAMP – ARLINTON 500 #1 line
    - HASSYAMP – MESQUITE 500 #1 line
    - HASSYAMP – JOJOBA 500 #1 line
    - JOJOBA – GILA RIVER 500 #1 line
    - JOJOBA – GILA RIVER 500 #2 line
    - JOJOBA – KYRENE 500 #1 line
    - PALOVRDE – RUDD 500 #1 line
    - MEAD – MARKETPL 500 #1 line
    - NAVAJO – CRYSTAL 500 #1 line
    - CTRYCLUB – LINCSTRT 230 #1 line
    - CTRYCLUB – GLENDALE 230 #1 line
    - SUNVLY 500 – SUNVLY 230 #1 transformer
11. Gila River GSU taps were adjusted as instructed by APS.
12. Adjustments were made to the Glen Canyon, Shiprock, Pinto, Sigurd, and San Juan phase shifting transformers, to rebalance flows and bring the Shiprock 345/230kV transformer within 100% of its normal rating.
13. A second 500/345kV transformer was added at Four Corners as part of the Navajo Transmission Project.

14. The Imperial Valley-North Gila 500kV line ratings series compensation were set to 1905MVA normal, and 2572MVA emergency.
15. The Four Corners-Moenkopi 500kV Series capacitors were placed in service (matching the status of the Four Corners-Red Mesa 500kV series capacitors).
16. The Navajo-Westwing 500kV line was removed.
17. The Navajo-Moenkopi 500kV line was opened.
18. Output of Gila River generation was reduced to a net of 2100MW from 2300MW, and San Luis Rio Colorado was set to 575MW.
19. Harquahala generation was set to its Pmax of 1140MW.
20. Line impedance and ratings were corrected on the LINCSTRT–WPHXAPSN 230 and ORME–RUDD 230 lines
21. Second ORME-RUDD 230kV and ORME-ANDERSON 230kV lines were added.
22. The LIBERTY-RUDD 230kV line was added.
23. The LIBERTY-ORME 230kV line was opened.
24. The Mesquite Solar Project (720MW) was added to the model. Phoenix Area generation KYRENE 2, and DBG CT 1 & 2 and ST were turned offline to accommodate the new generation.
25. The modeling around the HASSYTAP 230kV bus was corrected.
26. The PARKER – HARCVAR 230kV line ratings were corrected.
27. The LIBERTY – HASSYTAP 230kV line ratings were corrected.
28. TS8 Substation and associated Yuma Area 230kV and 69kV transmission additions were made. TS8 was modeled as being looped into the Gila-SLRC #2 230kV line.

***WALC Changes***

29. San Luis Rio Colorado (SLRC) generation (WAPA) and associated transmission was added to the model. The transmission included:
    - Two North Gila 500/230kV transformers
    - Two 230kV lines from North Gila to Gila
    - One Gila 230/161kV transformer
    - Two 230kV lines from Gila to SLRC
    - Three 230/18kV Generator Step Up transformers

***LADWP Changes***

30. The fourth 500/230kV transformer at McCullough was removed.
31. Green Path North was added.

***SCE Changes***

32. A second 500kV SVC was added at Devers.
33. The Lugo 500kV SVC was removed.
34. The second Merchant-Eldorado 230kV line was removed.
35. Both Devers 500kV shunt capacitors were switched into service.
36. As directed by SCE, RANCHVST and PADUA stations and associated equipment were placed into service. ORMOND1G was increased 434MW to offset the increase in load at PADUA.
37. As directed by SCE, the series capacitor ratings and status were updated for the Eldorado-Lugo 500kV line and Mohave-Lugo 500kV line.

***SDG&E Changes***

38. The Sunrise Project was added.
39. Grant Hill substation and associated elements were added to the model.
40. The Miguel 230/138kV Transformer Project was represented in the case.
41. As directed by SDG&E the following lines and transformers were added to the model:
    - DIVISION – NAVSTMTR 69KV LINE
    - WABASH – MAIN ST 69KV LINE
    - MAIN ST – NATNLCTY 69KV LINE
    - EPP – ENCINATP 230KV LINE
    - EPP – ESCNDIDO 230KV LINE
    - SYCAMORE – PENSQTOS 230KV LINE
    - R.SNTAFE – R.SNTATP 69KV LINE
    - ENCNITAS – R.SNTATP 69KV LINE
    - PENSQTOS – ENCINA 230KV LINE

- DEL MAR – PENSQTOS 69KV LINE
- BATIQTOS – SHADOWR 138KV LINE
- CHCARITA – SHADOWR 138KV LINE
- SYCAMORE – CHCARITA 138KV LINE
- SYCAMORE – CARLTHTP 138KV LINE
- MISSION – CARLTHT2 138KV LINE
- SYCAMORE – CARLTHT2 138KV LINE
- CARLTNHS – CARLTHT2 138KV LINE
- R.SNTATP – NORTHCTY 69KV LINE
- NORTHCTY – PENSQTOS 69KV LINE
- SANLUSRY 230/69KV TRANSFORMER
- SYCAMORE 230/138KV TRANSFORMER

42. As directed by SDG&E the following lines were removed from the model:
    - ENCINA – NORTHCTY 138KV LINE
    - CHCARITA – CARLTHTP 138KV LINE
    - ENCNITAS – PENSQTOS 69KV LINE
    - ESCNDIDO – ENCINATP 230KV LINE
    - MISSION – CARLTNHS 138KV LINE
    - NATNLCTY – SAMPSON 69KV LINE
    - NATNLCTY – WABASH 69KV LINE
    - NCMETER – NCMETRTP 138KV LINE
    - NORTHCTY – PENSQTOS 138KV LINE
    - R.SNTATP – DEL MAR 69KV LINE
    - R.SNTATP – PENSQTOS 69KV LINE
    - SYCAMORE – ESCNDIDO 230KV LINE
    - TALEGA – S.ONOFRE 230KV LINE
    - TALEGA – S.ONOFRE 230KV LINE
    - WABASH – SAMPSON 69KV LINE
    - MISSION-SOUTHBAY 138KV LINE
    - LOSCOCHS – SOUTHBAY 138KV LINE
    - SHADOWR – ESCNDO50 138KV LINE
    - ESCNDO50 138/69KV TRANSFORMER
43. As directed by SDG&E the impedance of the following lines and transformers were changed in the model:
    - SILVERGT – OLD TOWN 230KV LINE
    - SILVERGT – OLDTWNTP 230KV LINE
    - SYCAMORE – ELLIOTT 69KV LINE
    - GRNT HLL – SOUTHBAY 138KV LINE
    - SOUTHBAY 138/69KV TRANSFORMER
44. As directed by SDG&E numerous line ratings were updated.
45. As directed by SDG&E the taps of the following transformers were changed in the model:
    - SILVERGT #1 230/69KV TRANSFORMER
    - SILVERGT #2 230/69KV TRANSFORMER
    - OLD TOWN #1 230/69KV TRASNSFORMER
    - OLD TOWN #2 230/69KV TRASNSFORMER

***IID Changes***

46. The IID model was replaced with the most recent planned configuration provided by IID. The model includes Green Path South and the planned 230kV line from Highline to North Gila.
47. The IID area interchange export schedule was reduced by 181MW.

**Case 12**: "2012" Post-Project Heavy Autumn, WOR at 11,823MW ("12_PST_WOR.sav")

- Project #33 was modeled as four generators with a Base of 116 MVA, a Pmax of 115.6MW, and Qmax/Qmin capabilities of 60/-25MVAR. An auxiliary load of 3MW was modeled. Each generator was dispatched at 103MW such that the net output was 100MW each (net total of 400MW). The auxiliary load and generator were connected to a 13.8kV bus then stepped up to a common 69kV bus through a Generator Step Up (GSU) transformer for each unit. Four parallel 4 mile 69kV lines delivered power to the North Gila substation where it was further stepped-up to 500kV through two 500/69kV transformers.
- Project #43 was modeled as two generators each with a Base of 275 MVA, a Pmax of 275MW, and Qmax/Qmin capabilities of 60/-25MVAR. An auxiliary load of 25MW and 10 MVAR was modeled for each unit. The generators were dispatched at 275MW such that the net total output was 500MW. The units were connected to dedicated 18.0kV buses then stepped up to 500kV through dedicated Generator Step Up transformers. Two one-mile 954 ACSR 500kV lines were modeled from the high-side of each GSU to a 500kV bus that tapped into the Hassayampa-North Gila 500kV line.
- The power was scheduled to AZ to maintain WOR at 11,823MW. AZ generation was decreased at Mesquite and Arlington (both located at the Palo Verde Hub). MES-CT1 through CT4 were reduced from 170MW to 70MW each, MES-ST1 and ST2 were reduced from 300MW to 100MW, ARL-CT1 and CT2 were reduced from 183MW to 163MW, and ARL-ST1 was reduced from 297MW to 267MW.

Power flow plots of the transmission system along with the new generation cluster under each condition is provided in **Appendix A**. **Table 3** summarizes the power flow case attributes.

**Table 3. Pre-Project and Post-Project West of River Stressed Case Attributes**

| | All Planned Projects In Service | |
|---|---|---|
| | **Pre-Project** | **Post - Project** |
| **Major Path/Branch Flows:** | | |
| Path 46 – West of the River | 11,824 | 11,809 |
| Path 49 – East of the River | 10,241 | 9,340 |
| Palo Verde East Path | 4,054 | 4,032 |
| Palo Verde-Devers #1 500kV Line | 1,828 | 1,819 |
| Hassayampa-Delany 500kV Line | 1,242 | 1,232 |
| Delany-Devers 500kV Line | 1,879 | 1,869 |
| Delany-Sun Valley 500kV Line | 466 | 465 |
| N.Gila-Imperial Valley 500kV Line | 1,822 | 1,869 |
| Hassayampa-N.Gila #1 500kV Line (measured at Hass.) | 935 | 387 |
| Hassayampa-N.Gila #2 500kV Line (measured at Hass.) | 935 | 658 |
| **IID Area 8** | | |
| Generation | 882 | 884 |
| Interchange (exports) | 65 | 65 |
| **Arizona Area 14 (incl. WALC)** | | |
| Load[3] | 13,204 | 13,266 |
| Losses | 318 | 322 |
| Generation | 23,197 | 23,240 |
| Interchange (exports) | 9,745 | 9,722 |
| **SDG&E Area 22** | | |
| Generation | 2,522 | 2,541 |
| Interchange (imports) | 1,761 | 1,737 |
| **SCE Area 24** | | |
| Generation | 5,426 | 5,422 |
| Interchange (imports) | 10,223 | 10,223 |
| **PG&E Area 30** | | |
| Generation | 15,113 | 15,109 |
| Interchange (imports) | 3,253 | 3,257 |
| Case | 11 | 12 |

[3] For the Post-Project scenarios, Area 14's Load increases 62MW due to modeling of Cluster auxiliary loads.

## *1.5 Transient Stability Power Flow Cases*

Transient stability simulations were performed using the WECC approved 2012 Heavy Summer (12hs2a.sav) basecase as the starting point. This case does not match the APS Detailed Planning basecase, but has a corresponding dynamic data file (dyd). The WECC basecase will be aligned as closely as is feasible with the APS Detailed Planning basecase. The changes to the WECC basecase primarily focused on the 500kV topology. In addition to the WECC approved basecase, the previously described WOR stressed basecases were also used.

Prior to the finalization of the power flow and dynamics data sets, a flat-run and "bump test" were simulated to ensure true power system behavior was not masked by any remote dynamic modeling anomalies. The following changes were made to the 2012 Heavy Summer power flow cases and corresponding dynamic data files for the Pre-Project case:

**Case 7**: "2012" Pre-Project Heavy Summer High Load/High Generation ("7_PRE_12HS-WECC.sav")

1. Study base case "12hs2a.sav" was obtained from APS Transmission Planning.

***General Changes***

2. Changed all isolated/islanded busses from Type "0" to Type "-4".
3. All generation with Pgen greater than their governor's "mwcap" parameter were reduced to appropriate levels.

***PG&E Changes***

4. The OLINDA SVD was changed to a Shunt Capacitor, and the Grizzly-Malin 500kV sections 1 through 7 were changed from Circuit "2" to "1" in preparation for FACRI simulation.

***Arizona Changes***

5. The Area 14 (AZ) swing bus was changed to NAVAJO 3
6. As directed by APS, emergency ratings (120-125% of normal) were added for selected APS 230/69kV transformers.
7. Modeling of the Palo Verde-Devers #2 500kV line was adjusted to the most recent plans. These plans include termination of the line at Delany rather than at Harquahala.
8. Modeling of the Sun Valley (a.k.a TS5) 500kV connections were also adjusted to the most recent plans. The ARLINTON – TS5 500kV line and the second 500/230kV transformer were removed.
9. The Hassayampa-North Gila #2 500kV line was added including the series compensation and line shunts.
10. The Cholla-Coronado 500kV line was opened.
11. The series capacitors were bypassed on the Four Corners-Moenkopi 500kV line to match the status of the Four Corners-Red Mesa 500kV line, per APS Planning.
12. The Navajo South 500kV network was overhauled.
    - The Yavapai-VV1 line was converted to the Yavapai-Moenkopi
    - The Westwing-VV1 was converted to the Yavapai-Westwing
    - The Yavapai 500/230kV transformers that were connected to VV1 were moved to the Yavapai 500kV bus
    - The Navajo-Westwing 500kV line was removed.
13. Output of Gila River generation was increased to a net of 2100MW, and San Luis Rio Colorado was set to 575MW.
14. As directed by APS, an emergency rating of 700MVA (117% of normal) was added to the Sun Valley 500/230kV transformer.
15. Bus Shunts at KYRENE 230kV, OCOTILLO 230kV, and PNPKAPS 230kV were placed in service to boost the area voltage.
16. The CORONAD1 and CORONAD2 bus voltage schedules were increased from 0.94 to 0.982 to boost the area voltage.
17. Harquahala Generation was reduced 37MW to 1100MW (net).

18. The Mesquite Solar Project (720MW) was added to the model. Basin generation KYRENE 4-6, and DBG CT 1 & 2 and ST1, and AGUAFR 6 were turned offline to accommodate the new generation.
19. The modeling around the HASSYTAP 230kV bus was corrected.
20. The PARKER – HARCVAR 230kV line ratings were corrected.
21. The LIBERTY – HASSYTAP 230kV line ratings were corrected.
22. TS8 Substation and associated Yuma Area 230kV and 69kV transmission changes were made.

***WALC Changes***

23. San Luis Rio Colorado (SLRC) generation (WAPA) and associated transmission was added to the model. The transmission included:
    - Two North Gila 500/230kV transformers
    - Two 230kV lines from North Gila to Gila
    - One Gila 230/161kV transformer
    - Two 230kV lines from Gila to SLRC
    - Three 230/18kV Generator Step Up transformers

***LADWP Changes***

24. McCullough-Victorville #1 and #2 500kV line shunts were removed to increase area voltages.

***SCE Changes***

25. As directed by SCE, the series capacitor ratings and status were updated for the Eldorado-Lugo 500kV line and Mohave-Lugo 500kV line.

***SDG&E Changes***

26. As directed by SDG&E numerous line ratings were adjusted.
27. The taps on the OLD TOWN 230/69KV transformers were adjusts to 1.0 pu.

***IID Changes***

28. The IID model was replaced with the most recent planed configuration provided by IID. The model includes Green Path South and the planned 230kV line from Highline to North Gila.
29. The Interchange export schedule was reduced 243 MW for IID.

**Case 8**: "2012" Post-Project, Heavy Summer WECC basecase, Power Scheduled to CA ("8_PST_12HS-WECC_CA.sav")

- Project #33 was modeled as four generators with a Base of 116 MVA, a Pmax of 115.6MW, and Qmax/Qmin capabilities of 60/-25MVAR. An auxiliary load of 3MW was modeled. Each generator was dispatched at 103MW such that the net output was 100MW each. The auxiliary load and generator were connected to a 13.8kV bus then stepped up to a common 69kV bus through a Generator Step Up (GSU) transformer for each unit. Four parallel 4 mile 69kV lines deliver power to the North Gila substation and stepped up again to 500kV through two 500/69kV transformers.
- Project #43 was modeled as two generators each with a Base of 275 MVA, a Pmax of 275MW, and Qmax/Qmin capabilities of 60/-25MVAR. An auxiliary load of 25MW and 10 MVAR was modeled for each unit. The generators were dispatched at 275MW such that the net output was 500MW. The units were connected to dedicated 18.0kV buses then stepped up to 500kV through dedicated Generator Step Up transformers. two one-mile 954 ACSR 500kV lines were modeled from the high side of each GSU to a 500kV bus that tapped into the Hassayampa-North Gila 500kV line.
- The power scheduled to CA was distributed equally between PG&E, SCE, and SDG&E. To accommodate the new generation, local generation was reduced. In PG&E, MOSSLND6 and MOSSLND7 were each reduced from 700MW to 550MW. In SCE, REDON8 G was reduced from 460MW to 350MW, IEEC-G1 and IEEC-G2 were each reduced from 405MW to 310MW. In SDG&E, ENCINA 5 was reduced from 325MW to 205MW, PEN_ST was reduced from 210MW to 120MW, and OTAYMST1 was reduced from 210MW to 120MW.

**Case 9**: "2012" Pre-Project, Heavy Summer WECC Basecase, No Hassayampa-North Gila #2 500kV line ("9_PRE_12HS-WECC_HNG2-OUT.sav")

- Started with Case 7.
- Removed the Hassayampa-North Gila #2 500kV line between "HASSYAMP 500" and "N.GILA 500".
- As directed by APS, removed the TS8 Project by opening the 230/69kV transformer at TS8.
- As directed by IID, removed the Highland-North Gila 230kV line.

**Case 10**: "2012" Post-Project, Heavy Summer WECC Basecase, Power Scheduled to CA, No Hassayama-North Gila #2 500kV line ("10_PST_12HS-WECC_CA_HNG2-OUT.sav")

- Started with Case 8.
- Removed the Hassayampa-North Gila #2 500kV line between "HASSYAMP 500" and "N.GILA 500".
- As directed by APS, removed the TS8 Project by opening the 230/69kV transformer at TS8.
- As directed by IID, removed the Highland-North Gila 230kV line.

Power flow plots of the transmission system along with the new generation cluster under normal/"all-lines-in-service" conditions are provided in **Appendix A**. **Table 4** summarizes the Pre and Post-Project power flow case attributes.

## 1.6 Dynamic Data

**Appendix C** provides the transient stability models used in this study, and details of these assumptions. Modeling for the new generation utilized typical machine characteristics provided by the Applicant. A stability plot of the flat run and bump test simulation is also provided in **Appendix C**.

**Models Used for each unit.**

| Project #33 | Project #43 |
|---|---|
| Machine Model – genrou | Machine Model – genrou |
| Prime Mover Model – ieeeg1* | Prime Mover Model – ieeeg1* |
| Excitation Model – esac2a | Excitation Model – exst1 |
| Power System Stabilizer Model – pss2a | Power System Stabilizer Model – pss2a |
| Auxiliary Load Model – blwscc | Auxiliary Load Model – blwscc |

*Note: Assumed high pressure single-shaft operation. The low pressure shaft logic was not used.

**Pre-Project Dynamic Data File**: "2012" Pre-Project ("12hs21_PRE.dyd"), for cases 7 & 9

1. Dynamic data file "12hs21.dyd" (developed for use with the 2012 HS2-SA WECC base case) was obtained from APS Transmission Planning.
2. Representation of San Luis Rio Colorado units located in the nearby WALC system were added to the model.
3. Representation of the Mesquite Solar units were added.
4. Model for IID area 8 was added. The model was copied from the "11HA_FIN.dyd" file that accompanied the EOR basecase. This model generally aligned with the transmission network model provided by IID. An issue with the dynamic data file was discovered, and the "ieeeg1" model was commented out for IID's ORM units due to a conflict with the "motor1" model also present for these units.
5. New "motorw" models were created and added to the file.

**Post-Project Dynamic Data File**: "2012" Post-Project ("12hs21_PST.dyd"), for cases 8 & 10

1. Added representation for Project #33's four units and Project #43's two units to the accompanying dynamic data file, using parameters supplied by the Applicants.

**Pre-Project Dynamic Data File**: "2011" Pre-Project ("11HA_EOR_PRE.dyd"), for case 11

1. Dynamic data file "11HA_FIN.dyd" (developed for use with the 2011 HA WECC base case) was obtained from SCE Transmission Planning designed to accompany the East of River stressed basecase they provided.
2. Representation of San Luis Rio Colorado units located in the nearby WALC system were added to the model.
3. Representation of the Mesquite Solar units were added.
4. Missing models for the Springerville 3, Springerville 4, and the Valley CC repowering project were added to the file.
5. Data references to the EPP generators and the TALEGA generator were corrected.
6. The "ieeeg1" model was commented out for IID's ORM units due to a conflict with the "motor1" model also present for these units.
7. New "motorw" models were created and added to the file.

**Post-Project Dynamic Data File**: "2011" Post-Project ("11HA_EOR_PST.dyd"), for case 12

1. Added representation for Project #33's four units and Project #43's two units to the accompanying dynamic data file, using parameters supplied by the Applicants.

**Table 4. Pre-Project and Post-Project Transient Stability Case Attributes**

| | All Planned Projects In Service | | No Hassayampa-North Gila #2 500kV Line | |
|---|---|---|---|---|
| | Pre-Project | Post-Project *CA* | Pre-Project | Post-Project *CA* |
| **Major Path/Branch Flows:** | | | | |
| Path 46 – West of the River | 6,517 | 7,321 | 6,560 | 7,374 |
| Path 49 – East of the River | 5,476 | 5,422 | 5,456 | 5,401 |
| Palo Verde East Path | 5,377 | 5,617 | 5,453 | 5,688 |
| Palo Verde-Devers #1 500kV Line | 1,095 | 1,223 | 1,141 | 1,268 |
| Hassayampa-Delany 500kV Line | 656 | 807 | 710 | 858 |
| Delany-Devers 500kV Line | 1,127 | 1,251 | 1,172 | 1,295 |
| Delany-Sun Valley 500kV Line | 636 | 662 | 645 | 670 |
| N.Gila-Imperial Valley 500kV Line | 1,118 | 1,409 | 1,063 | 1,386 |
| Hassayampa-N.Gila #1 500kV Line (measured at Hass.) | 542 | 128 | 896 | 353 |
| Hassayampa-N.Gila #2 500kV Line (measured at Hass.) | 542 | 402 | n/a | n/a |
| **IID Area 8** | | | | |
| Generation | 890 | 894 | 886 | 889 |
| Interchange (imports) | 450 | 450 | 450 | 450 |
| **Arizona Area 14 (incl. WALC)** | | | | |
| Load[4] | 22,254 | 22,316 | 22,254 | 22,316 |
| Losses | 709 | 713 | 716 | 715 |
| Generation | 30,809 | 31,775 | 30,815 | 31,777 |
| Interchange (exports) | 7,846 | 8,746 | 7,846 | 8,746 |
| **SDG&E Area 22** | | | | |
| Generation | 3,592 | 3,302 | 3,587 | 3,300 |
| Interchange (imports) | 1,401 | 1,701 | 1,402 | 1,701 |
| **SCE Area 24** | | | | |
| Generation | 16,858 | 16,573 | 16,864 | 16,577 |
| Interchange (imports) | 9,354 | 9,653 | 9,354 | 9,654 |
| **PG&E Area 30** | | | | |
| Generation | 28,625 | 28,328 | 28,628 | 28,328 |
| Interchange (imports) | 486 | 786 | 485 | 787 |
| Case | 7 | 8 | 9 | 10 |

[4] For the Post-Project scenarios, Area 14's Load increases 62MW due to modeling of Cluster auxiliary loads.

## *1.7 Reliability Criteria*

In general, an evaluation of system reliability investigates the system's thermal loading capability, voltage performance (not too high or low), and transient stability (the system should not oscillate excessively and generators should remain synchronized). The evaluation of these criteria must be conducted for credible 'emergency' conditions, such as loss of a single or double circuit line, a transformer, or a generator. Performance of the transmission system and neighboring Control Areas were measured against the Western Electricity Coordinating Council (WECC) Reliability Criteria, and the North American Electric Reliability Council (NERC) Planning Standards, described in the following subsections. The criteria for Category A (normal, "all lines in service") and Category B (single element outage) conditions were explicitly applied, both internally (within the APS system) and to external Control Areas. Similarly, this System Impact Study analyzed (more severe, multiple element) Category C outages, and monitored performance of both the internal and external systems.

### 1.7.1 (Steady-State) Power Flow Criteria

Normal Conditions

- All line loadings must be less than 100% of their continuous (normal) thermal ratings.
- All transformer loadings must be less than 100% of their continuous (normal) ratings.
- Under normal conditions, transmission bus voltages must be maintained between 0.95 per unit and 1.05 per unit.

Contingency Conditions

- For a single (N-1) contingency, no transmission element will be loaded above its emergency rating.
- Established loading limits and voltage performance for other neighboring utilities will be monitored.
- Under contingency conditions, transmission bus voltages must be maintained between 0.90 per unit and 1.10 per unit. In addition, voltage deviations at any bus for N-1 contingencies must be no more than 5% and voltage deviations for any N-2 contingencies must be no more than 10%.

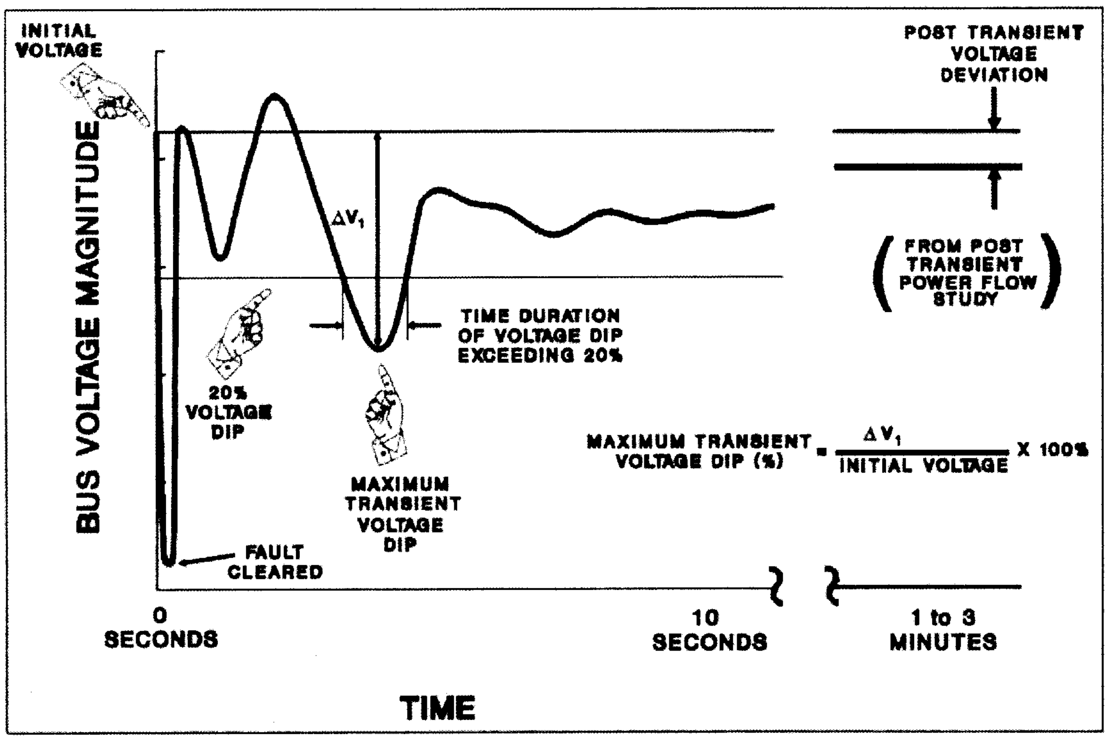
### 1.7.2 Transient Stability Criteria

With respect to the transient stability assessment of the system, this SIS applied the reliability criteria contained within the WECC disturbance-performance table of allowable effects on *other* systems. **Table 3** and **Figure 3** (following page) are excerpts from the WECC Reliability Criteria.

### Table 3. WECC Disturbance-Performance Table of Allowable Effects on Other Systems

| NERC and WECC Categories | Outage Frequency Associated with the Performance Category (outage/year) | Transient Voltage Dip Standard | Minimum Transient Frequency Standard | Post Transient Voltage Deviation Standard |
|---|---|---|---|---|
| A<br>System normal | Not Applicable | Nothing in addition to NERC | | |
| B<br>One element out-of-service | ≥ 0.33 | Not to exceed 25% at load buses or 30% at non-load buses.<br>Not to exceed 20% for more than 20 cycles at load buses. | Not below 59.6Hz for 6 cycles or more at a load bus. | Not to exceed 5% at any bus. |
| C<br>Two or more elements out-of-service | 0.033 – 0.33 | Not to exceed 30% at any bus.<br>Not to exceed 20% for more than 40 cycles at load buses. | Not below 59.0Hz for 6 cycles or more at a load bus. | Not to exceed 10% at any bus. |
| D<br>Extreme multiple-element outages | < 0.033 | Nothing in addition to NERC | | |

### Figure 3. NERC/WECC Voltage Performance Parameters



# 2 STUDY METHODOLOGY

This section summarizes the methods used to derive the power flow and transient stability results.

## 2.1 Power Flow

Power flow analysis considers a snapshot in time where transformer tap changers and SVD's have had time to adjust, the phase-shifters have not adjusted, and the system swing bus balances the system during each contingency scenario. All power flow analysis was conducted with version 16.0_11 of General Electric's PSLF/PSDS/SCSC software. Power flow results were monitored and reported for APS and other neighboring systems, including (but not limited to) IID, WAPA, SRP, SCE/CAISO, and SDG&E/CAISO.

Traditional power flow analysis was used to evaluate thermal and voltage performance of the system under emergency N-1 (single contingency) conditions. Thermal loadings were reported when a modeled transmission component was loaded over 98% of its appropriate emergency MVA rating (as entered in the power flow database), <u>and</u> the incremental change in component loading, between Pre-Project and Post-Project, exceeded 1%.

Transmission voltage violations for normal N-0 (no contingency) conditions were reported where per unit voltages were less than 0.95 or greater than 1.05. Emergency (N-1, single contingency) voltage violations were reported when per unit voltage was less than 0.90 or greater than 1.10. In addition, voltage deviations between the pre- and post-contingency conditions were recorded whenever these deviations were greater than 5%, <u>and</u> when the voltage deviation exhibited an increase greater than or equal to 1% between the Pre- and Post-Project power flow cases.

## 2.2 Post Transient

Post-transient analysis determines if the voltage deviations at critical buses meet the maximum allowable voltage dip criteria, and if any transmission elements exceed their maximum rating for selected N-1 and N-2 disturbances. This snapshot focuses on the first few minutes following an outage where the transformer taps changers have adjusted, the phase-shifters and SVDs have not adjusted, and all of the system generation reacts by governor control to balance the system during each contingency scenario. Loads will be modeled as constant power during this timeframe. All voltages at distribution substations will be restored to their normal values by the transformer tap changers and other voltage control devices. Generator VAR limits will be modeled as a constant single value for each generator since the reactive power capability curve will not be modeled in the power flow program. Alpha min and Gamma min of the PDCI and IPPDC will be adjusted to 5 degrees and 13 degrees, respectively. Shunt capacitors (132 MVAR) at Adelanto and Marketplace will be used if the post-transient voltage deviation exceeds 5% at those buses.

## 2.3 Transient Stability

Transient stability analysis is a time-based simulation that assesses the performance of the power system during (and shortly following) a contingency. Transient stability studies were performed to verify the system's stability following a critical fault on the system. Prior to finalization of the power flow and dynamics data set, a flat-run and bump test were run to ensure true power system behavior was not masked by any remote dynamic modeling anomalies.

Transient stability analysis was performed based on WECC Disturbance-Performance Criteria for selected system contingencies. Initial transient stability contingencies were simulated out to 10 seconds. (Extended simulation runs out to 20 seconds were not required to confidently assess a damped system performance.) All simulated faults were assumed to be three-phase. For 500kV faults, 4 cycle breaker clearing times were assumed for the near-end and far-end breakers

All transient stability simulations were conducted using version 16.0_11 of General Electric's PSLF/PSDS/SCSC software.

The Worst Condition Analysis (WCA) tool, available in the PSDS software package, tracks and records the transient stability behavior of all output channels contained within the binary output file of a transient stability simulation. The monitoring of channel output was initiated two cycles after fault clearing, to ensure that all post-fault stability behavior would be captured. System damping was assessed visually with the aid of stability plots.

**Parameters Monitored to Evaluate System Stability Performance:**

**Rotor Angle**

Rotor angle plots provide a measure for determining how the proposed generation unit would swing with respect to other generation units in the area. This information is used to determine if a machine would remain in synchronism or go out-of-step from the rest of the system following a disturbance.

**Bus Voltage**

Bus voltage plots, in conjunction with the relative rotor angle plots, provide a means of detecting out-of-step conditions. The bus voltage plots are useful in assessing the magnitude and duration of post disturbance voltage dips and peak-to-peak voltage oscillations. Bus voltage plots also give an indication of system damping and the level to which voltages are expected to recover in steady state conditions.

**Bus Frequency**

Bus frequency plots provide information on magnitude and duration of post-fault frequency swings with the new Project(s) in service. These plots indicate the extent of possible over-frequency or under-frequency, which can occur due to an area's imbalance between load and generation.

**Other Plotted Parameters**

- Generator Terminal Voltage
- Generator Rotor Speed
- Bus Angle

## 3 RESULTS & FINDINGS

This section provides the results obtained by applying the previous assumptions and methodology. It illustrates all findings associated with the power flow, post transient, and transient stability analyses.

### *3.1 Power Flow Analysis*

The power flow analysis focused on high load, high generation conditions for Summer 2012. The Pre-Project case was used as a baseline to measure the impact of the new generation proposals and planned transmission upgrades. Two Post-Project cases were created, one that scheduled the cluster generation output to AZ, and another that modeled the output to CA (33% to PG&E/SCE/SDG&E each).

A similar set of cases were created for the sensitivity of no Hassayampa-North Gila #2 500kV line. Two transmission projects are dependent upon completion of the Hassayampa-North Gila #2 500kV line and are subsequently not modeled. These projects are the TS8 transmission facilities, and IID's Highline-North Gila 230kV line. Six cases were required to adequately model the "All Planned Projects In Service" and the sensitivity conditions. The details about these cases are discussed in sections 1.1 through 1.3.

Contingencies were then applied to the power flow cases. The list of contingencies simulated is provided in **Appendix B**. Selected power flow plots from the Pre-Project case under normal and emergency system conditions are included in **Appendix A**.

### 3.1.1 Power Flow Results

**Table 4** tabulates post-contingency thermal overloads for the various case scenarios. The Table identifies that the Cluster's 900MW of new generation could contribute to (and result in) potential emergency overloads.

<u>Category A (N-0) Thermal Loading Concerns, Normal Conditions</u>
No normal overloads were observed for the addition of the two projects.

<u>Category B (N-1) Thermal Loading Concerns</u>

An overload of the Pilot Knob 161/92kV transformers was observed following the loss of the North Gila-Imperial Valley 500kV line. This overload had previously been identified during WALC's System Impact Study for the San Luis Rio Colorado Project ("SLRC", a 575MW generator connecting to the North Gila 500kV bus). As a result of the SLRC interconnection study, a Special Protection Scheme (SPS) was proposed to mitigate the post-contingency overload of the Pilot Knob 161/92kV transformers (SPS to open the Gila 230/161kV transformer and drop the SLRC plant). The power flow simulation appears to confirm the effectiveness of mitigating the transformer overload (98.3% loaded) under Pre-Project conditions. However, with the addition of the North Gila Cluster generation, this issue re-emerges. Following a contingency of the North Gila-Imperial Valley 500kV line and subsequent SLRC SPS actions, the Pilot Knob transformers are potentially overloaded by 112.4% if power is scheduled to CA, and 101.4% if power is scheduled to AZ. The potential post-contingency loading of the Pilot Knob transformers decrease to 86.3% when the Hassayampa-North Gila #2 line project is not modeled. IID has indicated that a short term emergency rating for these transformers is not feasible due to their age.

**Table 4. Power Flow Results – Thermal Loading**

| WECC Category | CONTINGENCY / AFFECTED ELEMENTS | Normal/ Emerg. Rating (MVA) | All Planned Projects In Service: Pre-Project (%) | All Planned Projects In Service: Post-Project Loading (%) CA | All Planned Projects In Service: Post-Project Loading (%) AZ | No Hassayampa-North Gila #2 500kV Line: Pre-Project (%) | No Hassayampa-North Gila #2 500kV Line: Post-Project Loading (%) CA | No Hassayampa-North Gila #2 500kV Line: Post-Project Loading (%) AZ |
|---|---|---|---|---|---|---|---|---|
| "B" | **N-1 N.Gila-Imperial Valley 500kV Line 1 (No SLRC SPS Action)** Blythe SPS triggered on overload of the Blythe-Niland 161kV line, dropping Blythe Unit 1 (144 MW) for cases 1-6 | | | | | | | |
| | Gila-Knob 161kV line (WALC) | 169/186 | 92.4% | 110.8% | 97.1% | 107.3% | 131.6% | 117.1% |
| | Gila 230/161kV Xfmr. (WALC) | 300/300 | 105.1% | 117.1% | 108.9% | 136.7% | 155.0% | 145.4% |
| | El Centro-Pilot Knob 161kV line (IID) | 165/165 | 96.6% | 114.7% | 99.9% | 90.2% | 111.8% | 97.1% |
| | El Centro 161/92kV Xfmr. (IID) | 125/125 | 91.4% | 105.8% | 92.2% | 89.0% | 104.4% | 90.8% |
| | Coachella 230/92kV Xfmrs. (IID) | 150/165 | 99.6% | 102.4% | 99.0% | 98.5% | 100.1% | 97.0% |
| | Pilot Knob 161/92kV Xfmrs. (IID) | 37/37 | 130.6% | 152.1% | 133.9% | 122.6% | 148.2% | 130.1% |
| | Pilot Knob-Knob 161kV line (IID/WALC) | 165/165 | 114.9% | 129.8% | 116.7% | 137.0% | 155.7% | 141.5% |
| | TS8 230/69kV Xfmr. (APS) | 187/233 | 89.4% | 94.4% | 90.8% | *Not Applicable* | | |
| | **N-1 N.Gila-Imperial Valley 500kV Line 1 (+ SLRC SPS to trip Gila 230/161kV Xfmr. and drop the SLRC units)** Blythe SPS triggered on overload of the Blythe-Niland 161kV line, dropping Blythe Unit 1 (144 MW) for cases 2,5 only | | | | | | | |
| | Coachella 230/92kV Xfmrs. (IID) | 150/165 | 101.8% | 108.6% | 101.4% | 104.0% | 110.4% | 103.1& |
| | Pilot Knob 161/92kV Xfmrs. (IID) | 37/37 | 98.3% | 112.4% | 100.8% | 73.5% | 86.3% | 77.8% |
| | TS8 230/69kV Xfmr. (APS) | 187/233 | 98.8% | 112.6% | 101.3% | *Not Applicable* | | |
| "C" | **N-2 Palo Verde-Devers #1 and #2** | | | | | | | |
| | Gila 230/161kV Xfmr (WALC) | 300/300 | < 80.0% | 85.4% | < 80.0% | 98.4% | 109.8% | 104.3% |
| | Pilot Knob-Knob 161kV line (IID/WALC) | 165/165 | < 80.0% | 83.6% | < 80.0% | 97.0% | 104.5% | 97.0% |
| | | Case | 1 | 2 | 3 | 4 | 5 | 6 |

Also for the outage of the North Gila-Imperial Valley 500kV line, the post-contingency overload of the Coachella 230/92kV transformers has been identified by IID as a pre-existing issue. IID is currently working with the CAISO and SDG&E toward a long term solution. The SLRC SPS appears to increase the potential overload of these transformer banks. In the Pre-Project condition the emergency loading of the Coachella transformers increases from 99.6% to 101.8% when the SLRC SPS actions are accounted for. The addition of the North Gila Cluster generation increases this potential overload to 108.6% if the power is scheduled to CA, but has a minimal effect on the overload if the power is scheduled to AZ.

Another concern triggered by the contingency of the North Gila-Imperial Valley 500kV line and SLRC SPS action is the potential overload of the TS8 230/69kV transformer. The SLRC SPS is a determining factor for this overload. If the cluster generation is scheduled to CA, the potential loading of the TS8 transformer without the SLRC SPS is 94.4%, but increases to 112.6% when the SPS actions are included. Similarly, if the cluster is scheduled to AZ, the potential loading without the SPS is 90.8% and increases to 101.3% when the SPS actions are included.

The addition of the generation cluster appears to increase the dependence upon the existing Blythe SPS that drops one Blythe unit if the Blythe-Niland 161kV is overloaded in association with the N.Gila-Imperial Valley 500kV single contingency. The Blythe SPS is triggered when power is scheduled to CA in the post-project cases with or without the Hassayampa-North Gila #2 500kV line.

*Category C (N-2) Thermal Loading Concerns*

Under conditions without the Hassayampa-North Gila #2 500kV line, the N-2 loss of the Palo Verde-Devers #1 and #2 500kV lines potentially overloads WALC's Gila 230/161kV transformer. If the 900MW cluster generation is scheduled to CA the potential overload is 109.8%, and if the power is scheduled to AZ the potential overload is slightly lower at 104.3%. The Gila transformer does not have a short term (higher) emergency rating, so the overload is based upon the continuous rating of 300MVA.

Under the same conditions described above, the Pilot Knob-Knob 161kV line potentially overloads to 104.5%, but only when the cluster generation is scheduled to CA. The line loading is virtually unaffected when the cluster generation is scheduled to AZ. As with the Gila transformer, this line does not have a short term emergency rating, so the overload is based upon the continuous rating of 165MVA.

*Category A, B, and C Voltage Concerns*

No voltage violations or concerns were observed in the power flow study.

## 3.2 *Post Transient Results*

Post-Transient simulations were performed on six (6) selected cases covering the normal condition, the sensitivity with no Hassayampa-North Gila #2, and the sensitivity with West of River Stressed under both Pre-Project and Post-Project conditions. Twenty (26) selected contingencies were simulated to determine if the generation addition would create any voltage deviation violations or thermal overloads. A complete list of the applied outages are listed in **Appendix B**, "List of Contingencies".

### 3.2.1 Post Transient Results

Results of the Post Transient Analysis show some post-contingency thermal overloads under the Post-Project conditions. The results indicate an increased dependence upon operation of both the SLRC SPS and the Blythe SPS, following the loss of the North Gila-Imperial Valley 500kV line. The SLRC SPS is identified and proposed in the System Impact Study for the San Luis Rio Colorado (SLRC) performed by the Western Area Power Administration Lower Colorado Region (WALC). The scheme is designed to open the Gila 230/161kV transformer and drop the SLRC generation. The Blythe SPS (an existing scheme, also managed by WALC) trips one Blythe unit for overload of the Blythe-Niland 161kV line.

*Category B (N-1) Thermal Loading Concerns*

Following the contingency of the North Gila-Imperial Valley 500kV line and subsequent SLRC SPS and Blythe SPS actions the Pilot Knob transformer potentially overloads to 113% (same as the power flow simulation) under Post-Project conditions, increased from 98% in the Pre-Project case. As with the power flow simulation, when the Hassayampa-North Gila #2 500kV line is not modeled the overload does not occur.

For this same contingency and SPS actions, the Coachella transformers are overloaded for both the Pre-Project (101%) and Post-Project (108%) conditions. As previously noted in the power flow discussion, this reliability concern has been identified by IID as a pre-existing issue.

The TS8 230/69kV transformer is also potentially overloaded following the contingency of the North Gila-Imperial Valley 500kV line with the same SPS actions. Post-transient results showed a potential Post-Project overload of the TS8 transformer is 113% under summer peak conditions (similar to 112.6% in the power flow simulation). The West of River stressed cases indicate the overload exists in the Pre-Project as well as the Post-Project condition. The overload is not observed in the "No Hassayampa-North Gila #2" sensitivity because the TS8 transformer (as well as the Highline-North Gila 230kV line) are not modeled for the absence of the Hassayampa-North Gila #2 500kV line.

*Category C (N-2) Thermal Loading Concerns*

With the addition of the cluster generation, the double contingency of the Palo Verde-Devers #1 and #2 500kV lines and subsequent SPS action dropping 1159MW of load in SCE, the Niland-CVSUB 161kV line can potentially reach 100% of its emergency rating. This overload only appears in the WOR Stressed case sensitivity, and appears to be related to high West of River flows. The Pre-Project loading is a notable 98%. For the same contingency and SPS action, the North Gila-Imperial Valley 500kV line is loaded to 97% Pre-Project and 98% Post-Project; the series compensation for the North Gila-Imperial Valley line is modeled in service, resulting in a circuit rating of 1905MVA normal and 2572MVA emergency.

*Category A, B, and C Voltage Concerns*

Results of the Post Transient Analysis show no voltage deviation violations under the Pre-Project or Post-Project conditions.

**Table 5. Post Transient Results – Thermal Loading**

| WECC Category | CONTINGENCY / AFFECTED ELEMENTS | Normal/ Emerg. Rating (MVA) | All Planned Projects In Service | | No Hassaympa-North Gila #2 500kV Line | | West of River Stressed | |
|---|---|---|---|---|---|---|---|---|
| | | | Pre-Project (%) | Post-Project (%) | Pre-Project (%) | Post-Project (%) | Pre-Project (%) | Post-Project (%) |
| "B" | **N-1 N.Gila-Imperial Valley 500kV Line 1 (No SLRC SPS Action)** Blythe SPS triggered on overload of the Blythe-Niland 161kV line, dropping Blythe Unit 1 (144 MW) for cases 1, 2, 3, 4, 5 only | | | | | | | |
| "B" | Gila-Knob 161kV line | 169/186 | 93% | 111% | 108% | 133% | 105% | 109% |
| "B" | Gila 230/161kV Xfmr. | 300/300 | 105% | 117% | 137% | 156% | 112% | 116% |
| "B" | El Centro-Pilot Knob 161kV line | 165/165 | 97% | 115% | 91% | 113% | 109% | 112% |
| "B" | El Centro 161/92kV Xfmr. | 125/125 | 91% | 106% | < 90% | 105% | < 90% | < 90% |
| "B" | Coachella 230/92kV Xfmrs. | 150/165 | 99% | 102% | 98% | 100% | < 90% | < 90% |
| "B" | Pilot Knob 161/92kV Xfmr. | 37/37 | 131% | 152% | 123% | 148% | 130% | 134% |
| "B" | Pilot Knob-Knob 161kV line | 165/165 | 115% | 130% | 138% | 157% | 121% | 122% |
| "B" | TS8 230/69kV Xfmr. | 187/233 | < 90% | 94% | *Not Applicable* | | 92% | 94% |
| "B" | **N-1 N.Gila-Imperial Valley 500kV Line 1 (with SLRC SPS to trip Gila 230/161kV Xfmr and SLRC units)** Blythe SPS triggered on overload of the Blythe-Niland 161kV line, dropping Blythe Unit 1 (144 MW) for cases 2, 5 only | | | | | | | |
| "B" | Coachella 230/92kV Xfmrs. | 150/165 | 101% | 108% | 103% | 110% | < 90% | < 90% |
| "B" | Pilot Knob 161/92kV Xfmr. | 37/37 | 98% | 113% | < 90% | < 90% | 91% | 93% |
| "B" | TS8 230/69kV Xfmr. | 187/233 | 99% | 113% | *Not Applicable* | | 105% | 108% |
| "C" | **N-2 Palo Verde-Devers #1 and #2 (No SPS Action)** | | | | | | | |
| "C" | IV-N.Gila 500kV line | 1905/2572 | < 90% | < 90% | < 90% | < 90% | 104% | 105% |
| "C" | Ramon-Mirage 230kV line | 389/389 | < 90% | < 90% | < 90% | < 90% | 113% | 114% |
| "C" | Niland-CVSUB 161kV line | 165/181 | < 90% | < 90% | < 90% | < 90% | 116% | 118% |
| "C" | El Centro-AV58TP1 161kV line | 165/165 | < 90% | < 90% | < 90% | < 90% | 106% | 108% |
| "C" | AVE52-Thermal 92kV line | 132/132 | < 90% | < 90% | < 90% | < 90% | 99% | 102% |
| "C" | Thermal-KTP2 92kV line | 132/132 | < 90% | < 90% | < 90% | < 90% | 104% | 106% |
| "C" | CVSUB 161/92kV Xfmr. | 125/137 | < 90% | < 90% | < 90% | < 90% | 100% | 102% |
| "C" | **N-2 Palo Verde-Devers #1 and #2 (with SPS Action to drop SCE load)** 1159 MW dropped for cases 11, 12 only | | | | | | | |
| "C" | IV-N.Gila 500kV line | 1905/2572 | < 90% | < 90% | < 90% | < 90% | 97% | 98% |
| "C" | Niland-CVSUB 161kV line | 165/181 | < 90% | < 90% | < 90% | < 90% | 98% | 100% |
| | | **Case** | **1** | **2** | **4** | **5** | **11** | **12** |

## 3.3 *Transient Stability Analysis*

Transient stability simulations were performed on six (6) selected cases covering both the Pre-Project and Post-Project conditions. Twenty (20) selected contingencies were simulated for the transient stability analysis, to determine whether the North Gila Cluster generation addition would create any system instability. The outages applied for transient stability are listed in **Appendix B**, "List of Contingencies".

All transient stability simulations were run for a period of 10 seconds. Line faults were simulated as three phase faults with zero fault impedance placed at the substation bus, unless otherwise noted as a single line to ground fault. Loss of any element was assumed to occur when the fault was cleared, indicating a circuit breaker operation. Normal clearing for all 500kV elements was assumed to be four cycles.

### 3.3.1 Transient Stability Results

Twenty-four (24) transient stability outages were simulated. Many of these transient stability simulations met Western Electricity Coordinating Council (WECC) Disturbance Performance Criteria. As referenced in the Reliability Criteria section of this report, the system should meet the following transient stability performance criteria for a NERC/WECC Category 'B' disturbance (N-1):

- Transient voltage dip should not be below 25% at any load busses or 30% at any non-load busses at any time.
- The duration of a transient voltage dip greater than 20% should not exceed 20 cycles at load busses.
- The minimum transient frequency should not fall below 59.6 Hz for more than 6 cycles at load busses.

Appendix D[5] contains transient stability plots of selected contingencies that provide a representative illustration of the transmission system's Pre-Project and Post-Project voltage response. Voltage and frequency dips were observed during the transient simulations. In many instances the voltage and frequency dips occurred in the Pre-Project simulations, indicating a pre-existing issue.

Upon closer inspection of the voltage dips, it can be seen that the voltage "dips" are not the result of post-fault oscillations, but rather simply a phenomenon of slow voltage recovery (SVR) at these lower voltage busses, due to the induction motors modeled at each load bus[6]. Secondly, these voltage deviations do not affect neighboring systems. As such, these issues do not represent actual WECC criteria violations. Thirdly, these voltage deviations primarily occurred in the Pre-Project cases indicating they are not caused by the addition of the generation cluster. Multiple different contingencies trigger the same phenomena. Subsequent generator interconnection studies should continue to monitor these outages and ensure that transient stability performance is acceptable. The list below summarizes the busses that exhibited this slow voltage recovery (SVR) trait in the WECC cases (7-10).

14241 ALEXNDR 230
14400 AGUAFAPS 69
15050 BROWNING 69
15606 ALEXANDR 69
15607 ANDERSRS 69
15608 SCHRADER 69
15609 BRANDOW 69
15610 CORBELRS 69
15611 ORME RS 69
15612 PAPAGOBT 69
15613 ROGERS 69
15614 THUNDRST 69
15615 WARD 69
15616 WHITETNK 69
15617 KNOX 69
15630 DINOSAUR 69
16610 LACANADA 13.8
16639 RANVIST2 13.8
14202 CACTUS 230

The list below summarizes the busses that exhibited this slow voltage recovery (SVR) trait in the WOR cases (11 & 12).

16707 SONOITA1 13.2
16708 SONOITA2 13.2
16710 VALNCIA2 13.2
16706 CANEZ 13.2

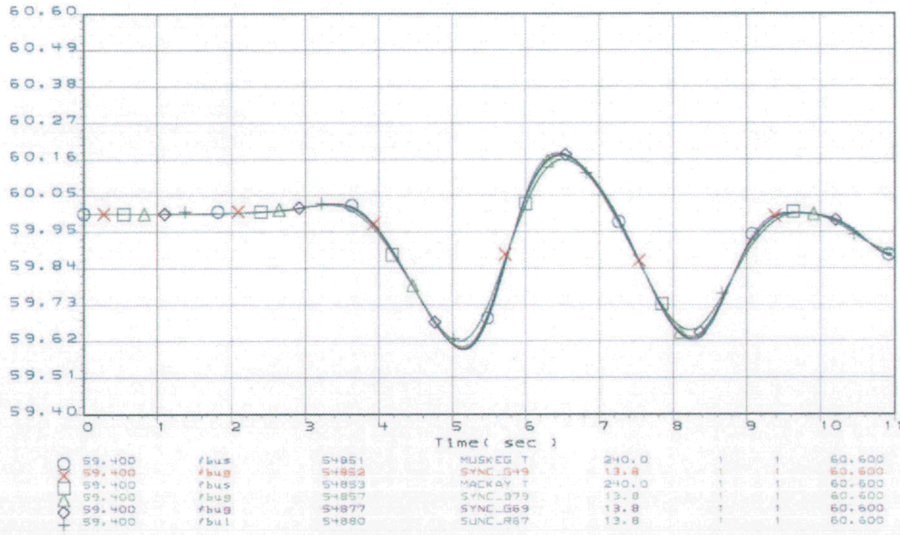
The frequency dips were observed in the Pre-Project WOR case only, for the G-1 loss of one Palo Verde Unit. The list below summarizes the busses that exhibited these dips and **Figure 4** illustrates the observed behavior. (Additional plots of this transient stability simulation are provided in **Appendix D**.)

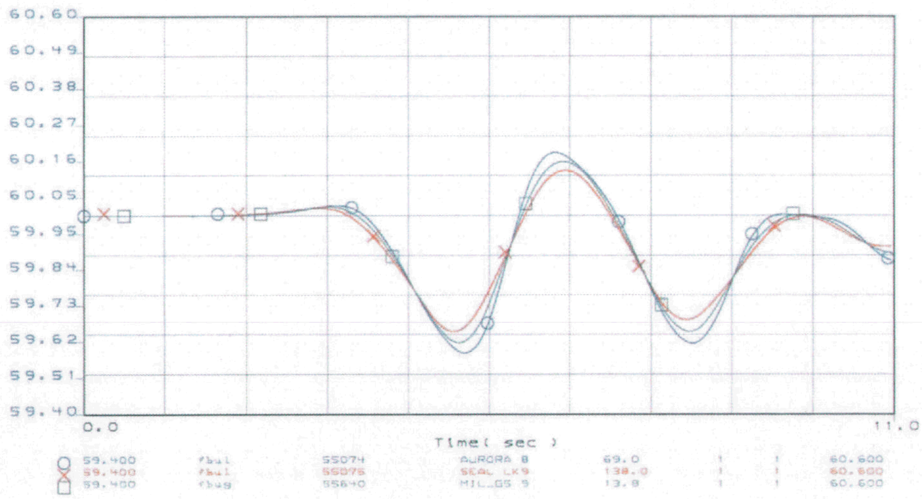
54850 SYNC_G59 13.8
54851 MUSKEG T 240
54852 SYNC_G49 13.8
54856 SYNC_G39 13.8
54876 SYNC_G19 13.8
54877 SYNC_G69 13.8
55072 SYNC_D04 240
55073 AURORA 4 240
55074 AURORA 8 69
55639 AUR_GTG1 13.8

5 Selected transient stability plots are provided in Appendix D; additional transient stability plots are available upon request.

6 During the fault, the rotor speed of the induction motors decreases (due to the load on the motor and the reduced electrical power input to the motor). When the fault is cleared, the induction motors try to accelerate back to near-synchronous speed. During this acceleration, a large amount of reactive power is drawn in to the induction motor; this large reactive demand reduces bus voltages near the motors, and slows the post-fault recovery of the system voltages.

## Figure 4. Pre-Project Frequency Dip Observation



## 3.4 *Short Circuit / Fault Duty Analysis*

Short circuit analysis of the cluster was performed by the APS Protection Department, using the CAPE program and parameters supplied by the applicants. Fault duties were calculated for both single-phase-to-ground and three-phase faults at substation busses in the immediate surrounding area before and after the cluster projects. The results presented here assume a "worst-case" scenario, with all of the project's generating units assumed on-line.

A second study was coordinated between the APS and SRP Protection Departments. This study was conducted by SRP, and modeled the multiple interconnection requests in and around the Palo Verde Hub. The study included:

- Gila Bend Cluster
  - Q44 – 280MW
- North Gila Cluster
  - Q33 – 400MW
  - Q41 – 250MW
  - Q43 – 500MW
- Harquahala Junction Cluster
  - Q38 – 400MW
  - Q39 – 800MW
  - Q42 – 500MW
- Moenkopi Cluster
  - Q36 – 1000MW

The report issued by SRP can be found in Appendix E "Coordinated Short Circuit Study."

**Table 6** provides a comparison of fault duties calculated by the APS Protection Department at several local busses for both the pre-project and both post-project conditions. The interconnection of the cluster does not appear to overstress any existing circuit breakers. The station with the least margin is Westwing where the post-project fault duty is within 2.67kA of the minimum breaker rating. The pre-project fault duty was also high (within 2.8kA). The project adds 130A to the three-phase fault current.

**Table 6. Fault Duty Results**

| Station | Pre-Project | | | | Post-Project | | | | Min. Brkr. Rating(kA) |
|---|---|---|---|---|---|---|---|---|---|
| | 3 Ph. (kA) | X/R | Ph-G (kA) | X/R | 3 Ph. (kA) | X/R | Ph-G (kA) | X/R | |
| Hassayampa 525kV (SRP) | *See Appendix E "Coordinated Short Circuit Study"* | | | | | | | | |
| North Gila 525kV | 20.03 | 19.1 | 15.54 | 25.7 | 21.6 | 18.6 | 17.7 | 23.8 | 40 |
| Palo Verde 525kV (SRP) | *See Appendix E "Coordinated Short Circuit Study"* | | | | | | | | |
| Devers 525kV (SCE) | 20.06 | 24.4 | 18.08 | 24.4 | 20.08 | 24.4 | 18.09 | 24.4 | 63 |
| Rudd 525kV | 21.2 | 24.7 | 16.4 | 19.7 | 21.3 | 24.6 | 16.4 | 19.6 | 50 |
| Westwing 525kV | 37.2 | 21.6 | 31.35 | 24.1 | 37.33 | 21.5 | 31.45 | 24.1 | 40 |
| Imperial Valley 525kV (SDG&E) | 15.43 | 52.2 | 11.52 | 28.3 | 15.9 | 51.03 | 11.7 | 27.9 | |

## 3.5 *Generation Mitigation*

This section discusses the possible generation mitigation measures required for the cluster. The measures focus on the curtailments required to mitigate the overloads for each study sensitivity.

*Mitigation Measures*

**Table 7** summarizes the potential criteria violations noted in the power flow and post-transient simulations resulting from the North Gila cluster generation addition. **Table 8** summarizes levels of curtailed output for the North Gila cluster generation which mitigates these thermal loading concerns.

**Table 7. Findings Summary**

| CONTINGENCY / AFFECTED ELEMENTS | Normal/ Emerg. Rating (MVA) | Power Flow Simulation | | | | Post Transient Simulation | | |
|---|---|---|---|---|---|---|---|---|
| | | All Planned Projects In Service | | No Hass-N. Gila #2 500kV | | All Planned Projects In Service | No Hass-N. Gila #2 500kV | WOR Sressed |
| | | *CA* | *AZ* | *CA* | *AZ* | | | |
| **N-1 N.Gila-Imperial Valley 500kV Line 1 (+ SLRC SPS to trip Gila 230/161kV Xfmr and SLRC units)**<br>Blythe SPS triggered on overload of the Blythe-Niland 161kV line, dropping Blythe Unit 1 (144 MW) for cases 2, 5 only | | | | | | | | |
| Pilot Knob 161/92kV Xfmr. (IID) | 37/37 | 112.4% | 101.4% | 86.3% | 77.8% | 113% | < 90% | 93% |
| TS8 230/69kV Xfmr. (APS) | 187/233 | 112.6% | 101.3% | *Not Applicable* | | 113% | n/a | 108%[1] |
| **N-2 Palo Verde-Devers #1 and #2**<br>1159 MW dropped for case 12 only | | | | | | | | |
| Gila 230/161kV Xfmr (WALC) | 300/300 | 85.4% | < 80.0% | 109.8% | 104.3% | < 90% | < 90% | < 90% |
| Pilot Knob-Knob 161kV line (IID/WALC) | 165/165 | 83.6% | < 80.0% | 104.5% | 97.0% | < 90% | < 90% | < 90% |
| Niland-CVSUB 161kV line | 165/181 | < 80.0% | < 80.0% | < 80.0% | < 80.0% | < 90% | < 90% | 100% |
| | **Case** | **2** | **3** | **5** | **6** | **2** | **5** | **12** |

Note 1: Also overloaded in the Pre-Project case.

*Generation Mitigation #1: Pilot Knob 161/92kV Transformer.*
*Condition: Hassayampa-North Gila #2 500kV line in service, power scheduled to CA or AZ*

IID's Pilot Knob substation features two parallel 161/92kV transformers; the values in the table represent the worst loading of the two. This emergency overload occurs in the All Planned Projects In Service model which models the planned Hassayampa-North Gila #2 500kV line. When this planned transmission line and the dependent projects of the Highline-North Gila 230kV line and the TS8 230/69kV substation are not modeled, this overload concern no longer arises. Since the overload exists regardless of where the power is scheduled, the North Gila generation cluster must either reduce its output or upgrade the system to mitigate this overload concern.

*Generation Mitigation #2: TS8 230/69kV Transformer.*
*Condition: Hassayampa-North Gila #2 500kV line in service, power scheduled to CA or AZ*

APS's TS8 230/69kV transformer is part of a planned system addition scheduled to be complete in 2012. The project is dependent upon completion of the Hassayampa-North Gila #2 500kV line project. The transformer can potentially exceed its short term emergency rating by 13%. The emergency overload occurs in the All Planned Projects In Service model and the West of River Stressed model. (For the sensitivity scenarios without the Hassayampa-North Gila #2 line, the TS8 transformer is removed from service.) One important note is that this transformer is also overloaded in the WOR Pre-Project cases, indicating a possible pre-existing issue. As with the Pilot Knob transformer, since the overload exists in the All Planned Projects In Service model regardless of where the power is scheduled, the cluster must reduce its output or upgrade the system to mitigate the overload if the new lines in this case are completed as assumed and the solution that is implemented to mitigate the transformer overload in the WOR Pre-Project cases does not also completely mitigate the overload in the post-project cases.

*Generation Mitigation #3: Gila 230/161kV Transformer.*
*Condition: No Hassayampa-North Gila #2 500kV line, power scheduled to CA or AZ*

WALC's Gila 230/161kV transformer was observed to potentially overload, but only in the sensitivity case where Hassayampa-North Gila #2 500kV line project is not in service. The two dependent projects, Highline-North Gila 230kV and the TS8 station, have a significant impact on the loading of the transformer. Both of these projects are parallel paths to the load (IID and Yuma) that is partially fed by the Gila transformer. The absence of these parallel paths contributes more flow to the Gila transformer. One option to mitigate this overload is for WALC to add a short term emergency rating to the transformer. This would remove the need for pre-contingency mitigation, but require swift curtailments by the cluster generation if the contingency should occur. If an emergency rating is not feasible, the cluster must reduce its output or upgrade the system to mitigate the overload.

*Generation Mitigation #4: Pilot Knob-Knob 161kV Line*
*Condition: No Hassayampa-North Gila #2 500kV line, power scheduled to CA*

The Pilot Knob-Knob 161kV line is a tie line between IID and WALC; IID maintains control of this line. A potential overload of this circuit exists for the sensitivity condition where the Hassayampa-North Gila #2 500kV line project is not complete and all of the cluster generation is scheduled to CA. The line does not have and emergency rating, so one mitigation option is to request IID to add a short term emergency rating to the line. If this overload concern persists and an emergency rating cannot be assigned, the generation cluster must limit the schedules to CA.

*Generation Mitigation #5: Niland-CVSUB 161kV line*
*Condition: Hassayampa-North Gila #2 500kV line in service, West of River stressed*

IID's Niland-Coachella 161kV line is limiting under high WOR flow only. The maximum potential loading is 100% of its emergency rating of 181MVA. Due to the short term nature of the rating, the cluster will require a swift reduction should the contingency occur. IID has indicated they are in the process of evaluating their system under high EOR/WOR flow conditions. It is likely that any upgrades that stem from that effort will help to mitigate the loading of this line. Regardless, generation cluster curtailments may still be required to help mitigate this overload.

**Table 8. Cluster Curtailment Levels to Mitigate Thermal Loading Concerns**

| Cluster Total | Scheduling Breakdown CA | AZ | Limiting Contingency | Limiting Element | Type[1] |
|---|---|---|---|---|---|
| **All Planned Projects In Service** | | | | | |
| **470** | 0 | 470 | N-1 N.Gila-Imperial Valley 500kV line w SLRC SPS | TS8 230/69kV Xfmr. | PF |
| **295** | 45 | 250 | N-1 N.Gila-Imperial Valley 500kV line w SLRC SPS | Pilot Knob 161/92kV Xfmr. | PT |
| **90** | 90 | 0 | N-1 N.Gila-Imperial Valley 500kV line w SLRC SPS | Pilot Knob 161/92kV Xfmr. | PT |
| **No Hassayampa-North Gila #2 500kV line** | | | | | |
| **210** | 0 | 210 | N-2 Palo Verde-Devers #1 & #2 500kV lines | Gila 230/161kV Xfmr. | PF |
| **160** | 60 | 100 | N-2 Palo Verde-Devers #1 & #2 500kV lines | Gila 230/161kV Xfmr. | PF |
| **110** | 110 | 0 | N-2 Palo Verde-Devers #1 & #2 500kV lines | Gila 230/161kV Xfmr. | PF |
| **West of River Stressed** | | | | | |
| **850** | 0 | 850 | N-2 Palo Verde-Devers #1 & #2 500kV lines | Niland-CVSUB 161kV line | PT |

Note 1: Limiting simulation is PT = Post-Transient, PF = Power Flow

If the North Gila Cluster Applicants elect to upgrade the transmission to allow for more generation output, it is recommended that both IID's Pilot Knob and APS's TS8 transformers should be upgraded. **Table 8** lists the most limiting transformer; however the two transformers are typically loaded to within a percentage point of each other.

The capacities in **Table 8** are calculated by reducing the units in the cluster proportionally. For example, if the allowable generation level is 300MW, Request #33 is dispatched at 133MW and Request #43 is dispatched at 167MW. This methodology assumes that each participant in the cluster has the same impact on the constraint. However, for this cluster, the requests do not have identical points of interconnection resulting in slightly different magnitudes of effect on the constraint. The effect of each participant under each sensitivity case was calculated for each constraint. The resulting distribution factors are listed in **Table 9**. A distribution factor can be described as the anticipated MW increase for a 100MW increase in generation.

**Table 9. Distribution Factors of Cluster Participants**

| Constraint | CA | | AZ | |
|---|---|---|---|---|
| | Q #33 | Q #43 | Q #33 | Q #43 |
| **All Planned Projects In Service** | | | | |
| N-1 N.Gila-Imperial Valley 500kV line with SLRC SPS O/L Pilot Knob 161/92kV Xfmr. | 0.3 | 0.2 | 0 | 0 |
| N-1 N.Gila-Imperial Valley 500kV line with SLRC SPS O/L TS8 230/69kV Xfmr. | 1.7 | 1.2 | 0 | 0 |
| **No Hassayampa-North Gila #2 500kV** | | | | |
| N-2 Palo Verde-Devers #1 and #2 500kV lines O/L Gila 230/161kV Xfmr. | 4.0 | 2.4 | 0.9 | 0 |
| N-2 Palo Verde-Devers #1 and #2 500kV lines O/L Pilot Knob-Knob 161kV line | 0.3 | 0.3 | 0 | 0 |
| **West of River Stressed** | | | | |
| N-2 Palo Verde-Devers #1 and #2 500kV lines O/L Niland-CVSUB 161kV line | n/a | n/a | 0.2 | 0.1 |

Therefore, due to the proximity of Request #33 to the TS8 substation, a reduction of this generation would be more effective in reducing the loading of TS8 transformer than Request #43 for the North Gila – Imperial Valley 500kV line outage.

## 3.6 *Transmission Mitigation*

This section discusses the potential transmission upgrade projects needed to mitigate the overloads caused by the Cluster. This section will discuss the benefit each project has on the required cluster curtailments. Each upgrade project will include a preliminary cost estimate.

*Transmission Mitigation #1: TS8 Transformer Protection*
*Condition: Hassayampa-North Gila #2 500kV line in service, power scheduled to CA or AZ*

The TS8 and Pilot Knob transformer overloads of 113% can occur following the contingency of the North Gila-Imperial Valley 500kV line and subsequent SLRC and Blythe SPS actions. The overloads are observed in the All Planned Projects In Service and WOR stressed initial condition cases. For the sensitivity scenarios without the Hassayampa-North Gila #2 line, the TS8 transformer is also removed from service and therefore there are no overloads.

Transmission upgrade projects were studied. Adding a second TS8 230/69kV transformer and replacing the Pilot Knob 161/92kV transformers with a larger single unit did not completely eliminate the overloads. The TS8-Araby South 69kV line became overloaded due to the increase in 230kV to 69kV flow. Opening the line did not alleviate the concerns because the overload shifted to the MAB-32$^{nd}$ Street 69kV line. The TS8-Araby South 69kV line would need to be reconductored in addition to the transformer upgrades.

For the outage of the North Gila-Imperial Valley 500kV line, new protective relaying would eliminate the overload of the transformers at Pilot Knob and TS8 without creating any new overloads or interrupting any load or generation. Some additional communication requirements may be necessary, however, this will be detailed and additional costs identified as part of the Interconnection Facilities Study.

It should be noted that under the system conditions without the Hassayampa-North Gila #2 500kV line and the TS8 transmission facilities, no N-1 overloads were noted for the loss of the North Gila – Imperial Valley 500kV line.

*Transmission Mitigation #2: Gila SPS or Gila 230/161kV Xfmr. Short Term Emergency Rating*
*Condition: No Hassayampa-North Gila #2 500kV line, power scheduled to CA or AZ*

Under sensitivity conditions without the Hassayampa-North Gila #2 500kV line, following a double-element outage of the Palo Verde-Devers #1 and #2 500kV lines, the Gila 230/161kV transformer may overload by as much as 109.8%. This transformer does not have a short term emergency rating, so the overload is of the normal continuous rating (300MVA). Under conditions where power is scheduled to CA only, the Pilot Knob-Knob 161kV line overloaded in addition to the Gila transformer.

The first mitigation option is to request WALC to develop a short term (i.e. 30 minute or 1 hour) rating for the Gila 230/161kV transformer, and request IID to develop a short term rating for the Pilot Knob-Knob 161kV line. In the event that either short term rating cannot be established, modification to the planned SPS to automatically trip the Gila transformer following loss of the Palo Verde-Devers #1 and #2 500kV lines will successfully mitigate the overload. The planned SLRC SPS currently trips the transformer for loss of the North Gila-Imperial Valley 500kV line, so a slight augmentation of the scheme may be all that is required. The details and estimated cost for the SPS implementation will need to be developed in the Interconnection Facilities Study and in coordination with Western.

It should be noted that this condition is due to a double-element outage of both Palo Verde-Devers 500kV lines. At the time of this report there is no certainty whether the second Palo Verde-Devers 500kV line will be constructed, what routing it will have, or what the final plan of service will be for the project.

*Transmission Mitigation #3:Niland-Coachella Valley 161kV line upgrade or post contingency reduction*
*Condition: West of River Stressed*

Under sensitivity conditions when West of River is stressed, following a double-element outage of the Palo Verde-Devers #1 and #2 500kV lines, the Niland-Coachella Valley 161kV line may load to 100% of its emergency rating. This line may require an upgrade or slight reduction in cluster output (50MW) to reduce the loading to 99%. This line has a 181MVA (110%) 30-minute rating, which will require quick operator action to reduce the loading of the line to within its continuous rating of 165MVA should the contingency occur. These operator actions will likely include increasing and decreasing generation according to effectiveness. This may include the units in this Cluster.

It should be noted that this condition is due to a double-element outage of both Palo Verde-Devers 500kV lines. At the time of this report there is no certainty whether the second Palo Verde-Devers 500kV line will be constructed, what routing it will have, or what the final plan of service will be for the project.

**Table 10. Upgrade Requirements for MW Injection Levels**

| Schedule to CA | Schedule to AZ | Recommended Upgrade Requirement |
|---|---|---|
| ***All Planned Projects in Service*** | | |
| < 90 | < 470 | No Projects Required |
| 90 - 900 | 470 - 900 | TS8 230/69kV Transformer Overload Protection |
| ***No Hassayampa-North Gila #2*** | | |
| < 110 | < 210 | No Projects Required |
| 110 - 900 | 210 - 900 | Modify the planned Gila SPS or Gila 230/161kV Short Term Emergency Rating |
| ***West of River Stressed*** | | |
| n/a | < 850 | No Projects Required |
| n/a | 850-900 | Upgrade the Niland-CVSUB 161kV line |

**Table 10** identifies the upgrade projects necessary to achieve the range of Cluster outputs up to its maximum of 900MW. For example, under "All Planned Projects in Service" conditions with the output scheduled to CA, the Cluster can produce up to 90MW without any upgrade projects. The Cluster can exceed 90MW and produce up to its maximum output of 900MW by implementing the TS8 230/69kV Transformer Overload Protection upgrade project.

## 3.7 Cost Estimate

Project Q43 will interconnect into one of the Hassayampa – North Gila 500kV lines. The interconnection costs will be nearly identical for interconnection into either line. Interconnection facilities will consists of a new four breaker 500 kV ring bus at the point of interconnection. The costs are listed below (the cost do not include land required for the substation and assume the new ring bus will be adjacent to the transmission line corridor). The estimated time to put the Q43 interconnection into service would be approximately 39 months.

**Table 11. Project Q43 Cost Estimates**

| ***Project Q43 Interconnection Facilities*** | |
|---|---|
| | **Cost** |
| Engineering and Design | $300,000 |
| Control & Communications | $900,000 |
| Construction Labor (Steel, Equipment & Control) | $3,100,000 |
| Steel Structures | $1,500,000 |
| Electrical Equipment | $4,200,000 |
| Below Grade | $11,500,000 |
| Contingency | $4,400,000 |
| **Total** | **$25,900,000** |

Project Q33 will interconnect into the North Gila 500kV substation with two terminations. Interconnection facilities will consists of a three new 500 kV breakers (bay 12, 14, 15), cost responsibility for half of an existing breaker (bay 11), expanding the bus, land grading, and control & communications work. Three-and-a-half breakers are required for Project Q33, however half of a breaker (bay 14) may be reimbursed to the Project in the future when another interconnection comes into the North Gila substation. Also, the costs for the bus expansion and land grading are the Projects share (2/7) of common costs that will be shared by multiple interconnection customers. Being common costs, some of those costs may be recovered in the future if there are additional interconnection customers at North Gila 500 kV that will need to share in the common facilities costs. The estimated construction and permitting time to put the Q33 interconnection into service would be approximately 28 months.

**Table 12. Project Q33 Cost Estimates**

| ***Project Q33 Interconnection Facilities*** | |
|---|---|
| | **Cost** |
| Engineering and Design | $220,000 |
| Control & Communications | $56,000 |
| Construction Labor (Steel, Equipment & Control) | $1,300,000 |
| Steel Structures | $800,000 |
| Electrical Equipment | $2,600,000 |
| Below Grade | $2,900,000 |
| Contingency | $1,600,000 |
| **Total** | **$9,500,000** |

# Appendix
# A

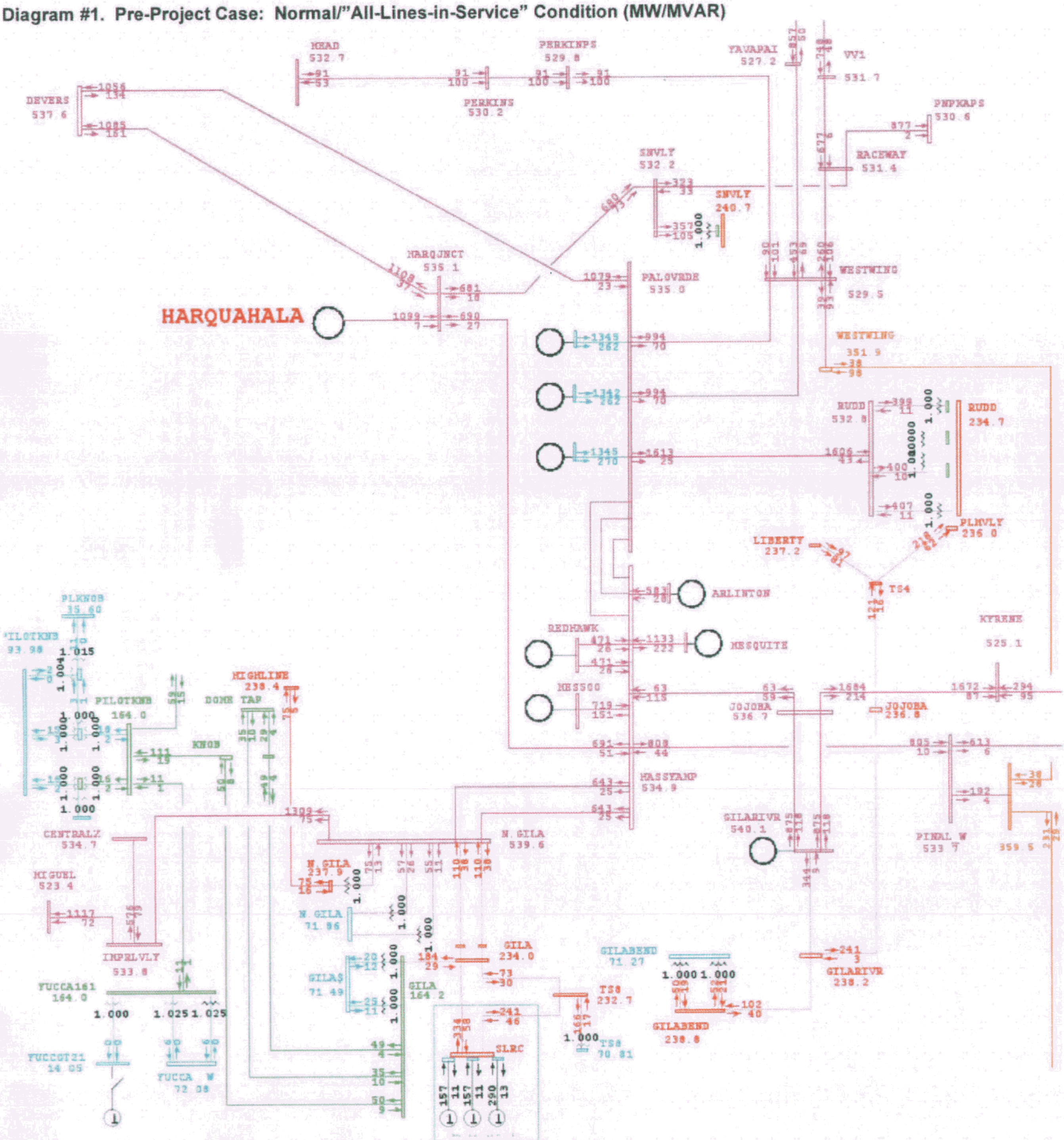
# Appendix A

## Power Flow Diagrams

# Power Flow Diagrams: North Gila Cluster System Impact Study

| Diagram | Case | Description |
|---|---|---|
| | | **Power Flow Basecase (Derived from APS Detailed Planning Case)** |
| Diagram #1 | 1 | Pre-Project Case: Normal/"All-Lines-in-Service" Condition (MW/MVAR) |
| Diagram #2 | 2 | Post-Project Case: Normal Condition, Power Scheduled to CA (MW/MVAR) |
| Diagram #3 | 3 | Post-Project Case: Normal Condition, Power Scheduled to AZ (MW/MVAR) |
| Diagram #4 | 4 | Pre-Project Case: No Hassayampa-North Gila #2 Condition (MW/MVAR) |
| Diagram #5 | 5 | Post-Project Case: No Hassayampa-North Gila #2 Condition, Power Scheduled to CA (MW/MVAR) |
| Diagram #6 | 6 | Post-Project Case: No Hassayampa-North Gila #2 Condition, Power Scheduled to AZ (MW/MVAR) |
| | | **Transient Stability Basecase (Derived from WECC "12hs2a" Case)** |
| Diagram #7 | 7 | Pre-Project Case: Normal/"All-Lines-in-Service" Condition (MW/MVAR) |
| Diagram #8 | 8 | Post-Project Case: Normal Condition, Power Scheduled to CA (MW/MVAR) |
| Diagram #9 | 9 | Pre-Project Case: No Hassayampa-North Gila #2 Condition (MW/MVAR) |
| Diagram #10 | 10 | Post-Project Case: No Hassayampa-North Gila #2 Condition, Power Scheduled to CA (MW/MVAR) |
| | | **Stressed West of River Basecase** |
| Diagram #11 | 11 | Pre-Project Case: West of River Stressed to 11,823MW (MW/MVAR) |
| Diagram #12 | 12 | Post-Project Case: West of River Stressed to 11,823MW (MW/MVAR) |
| | | **Mitigation Cases** |
| Diagram #13 | | Mitigation Case: N-1 North Gila-Imperial Valley 500kV line wSPS, Cluster Curtailed to 620MW |
| Diagram #14 | | Mitigation Case: N-2 Palo Verde-Devers #1 and #2 500kV line, Cluster Curtailed to 300MW |

Diagram #1. Pre-Project Case: Normal/"All-Lines-in-Service" Condition (MW/MVAR)



## Diagram #2. Post-Project Case: Normal Condition, Power Scheduled to CA (MW/MVAR)

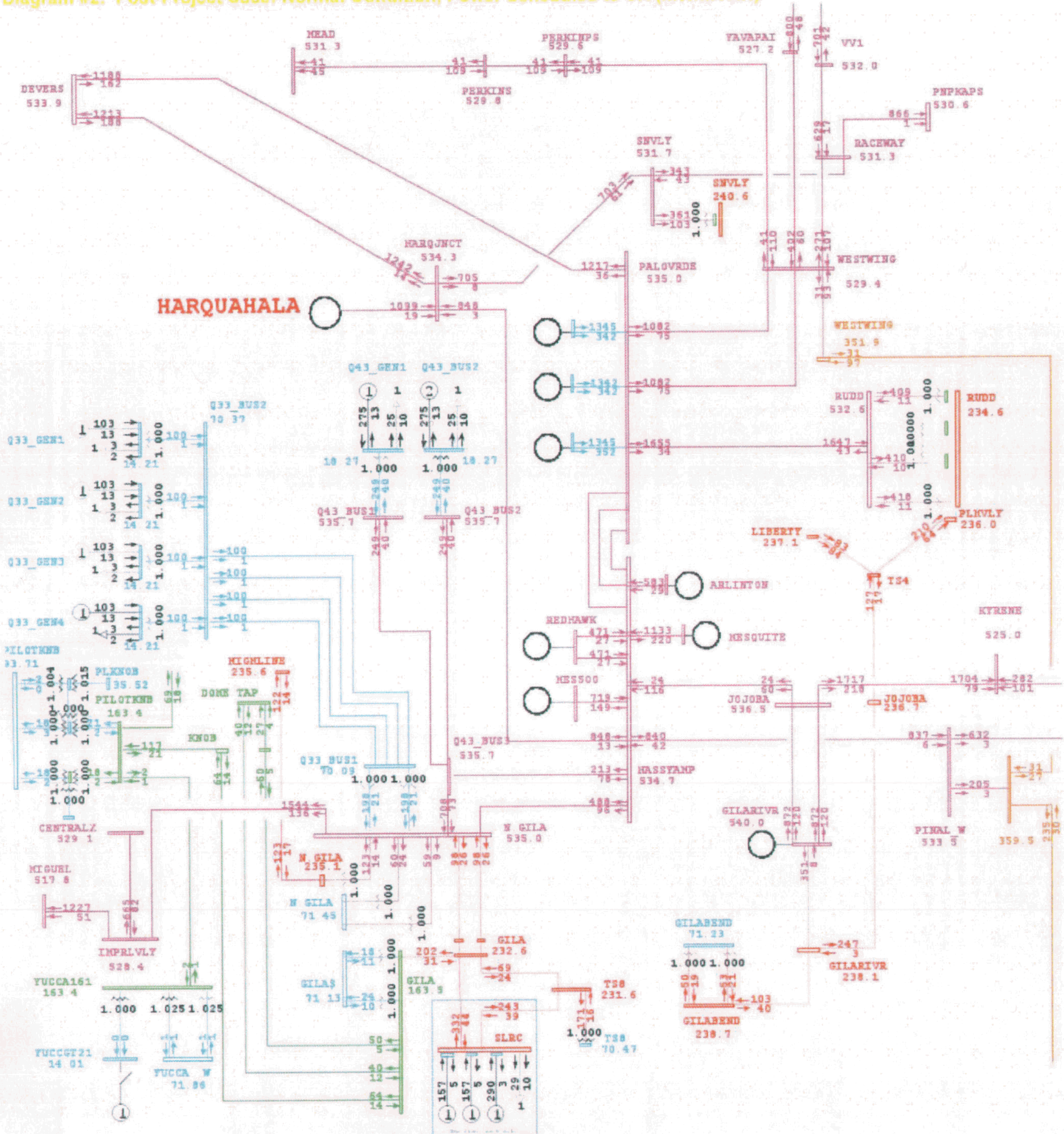


Diagram #3. Post-Project Case: Power Scheduled to AZ (MW/MVAR)

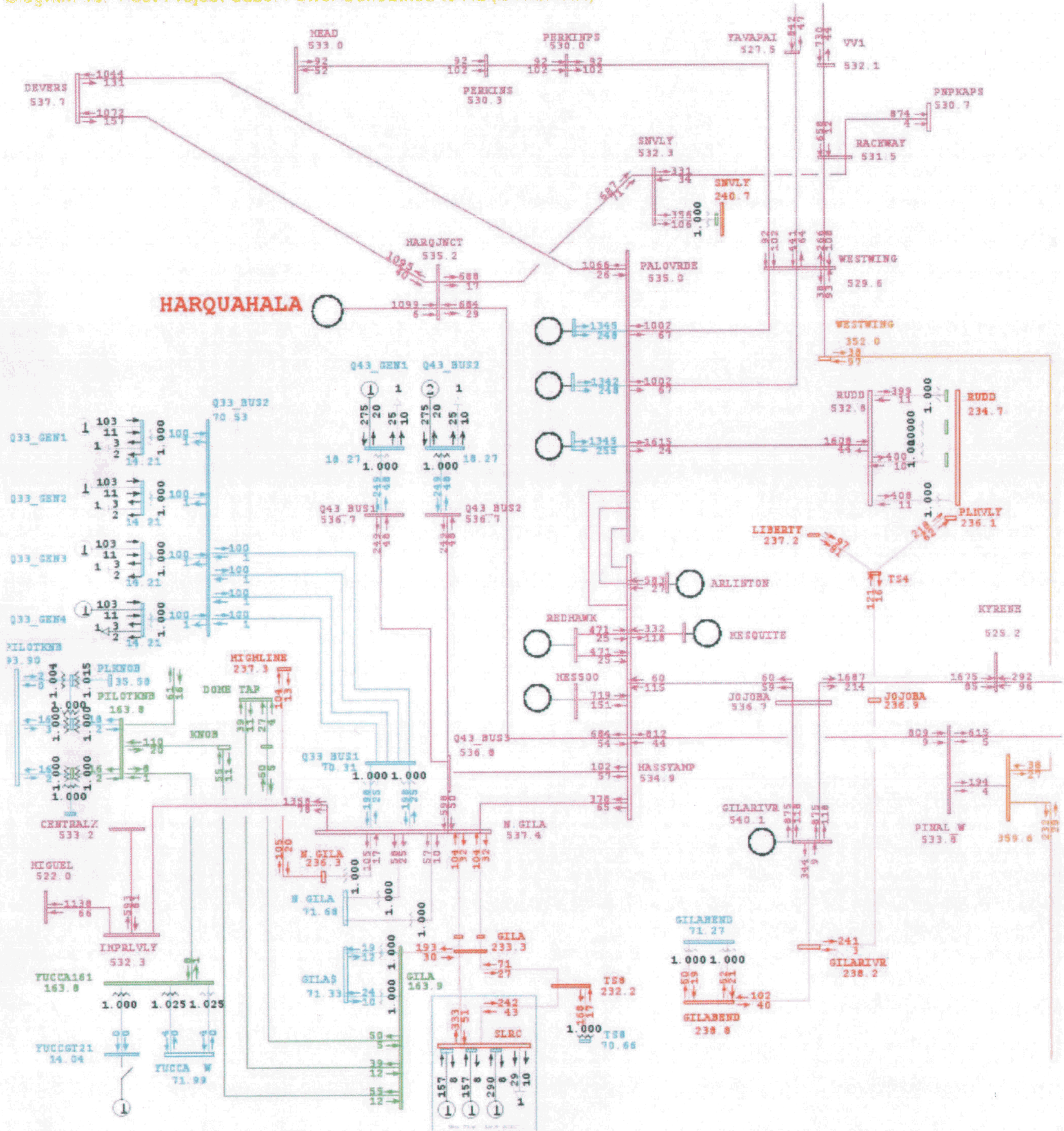


Diagram #4. Pre-Project Case: No Hassayampa-North Gila #2 Line Condition (MW/MVAR)

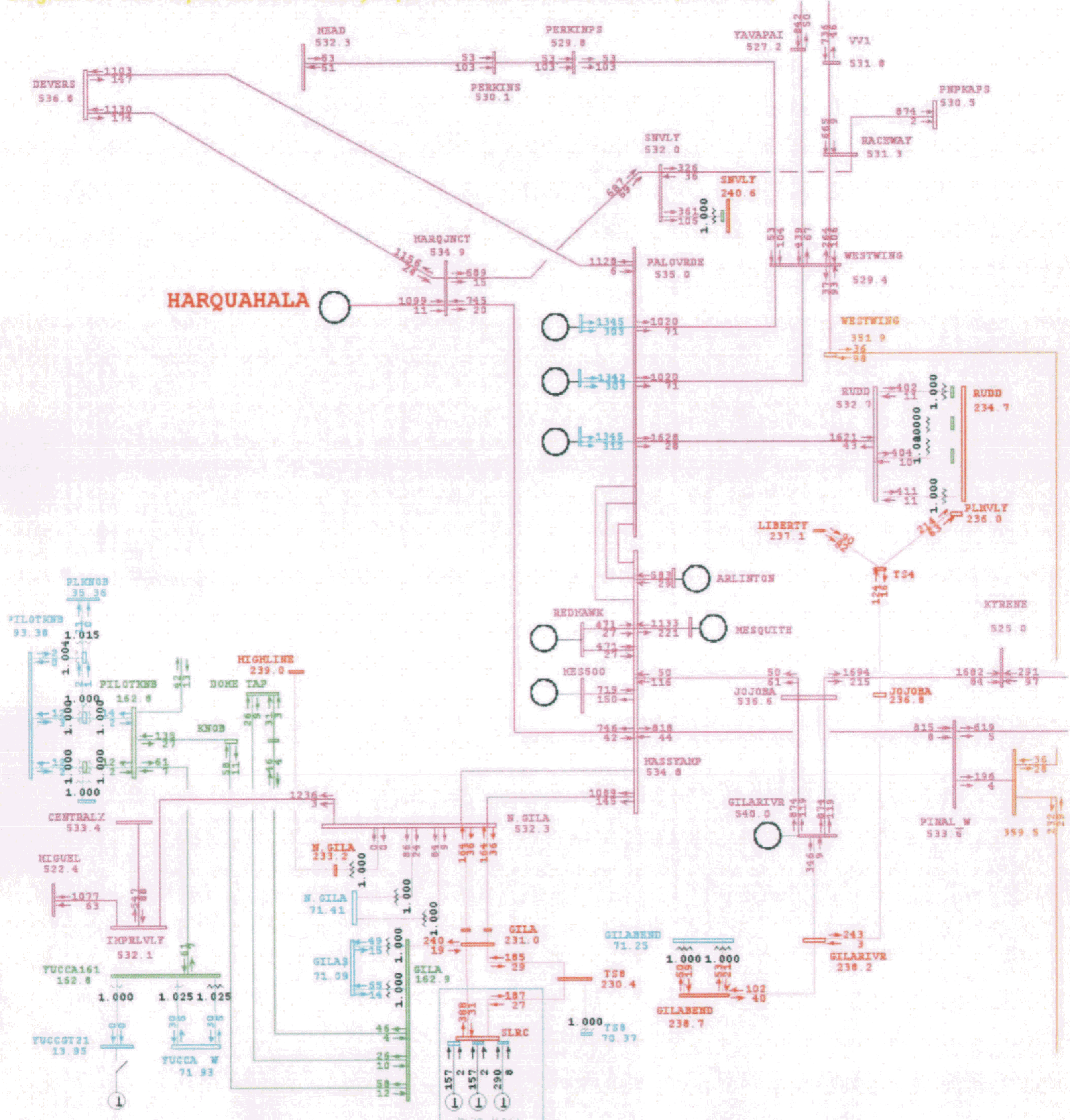


Diagram #5. Post-Project Case: No Hassayampa-North Gila #2 Line Condition, Power Scheduled to CA (MW/MVAR)

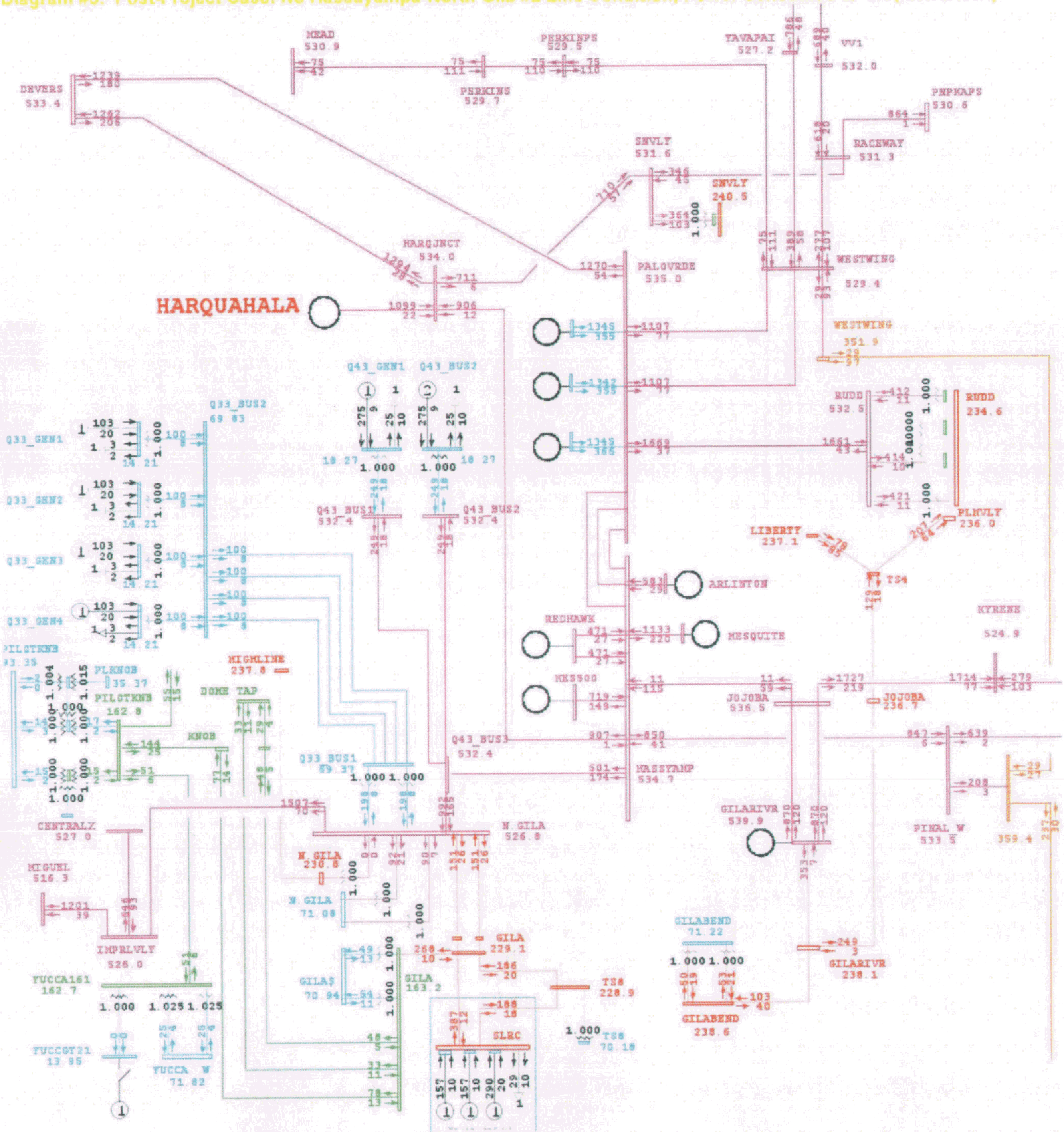


Diagram #6. Post-Project Case: No Hassayampa-North Gila #2 Line Condition, Power Scheduled to AZ (MW/MVAR)

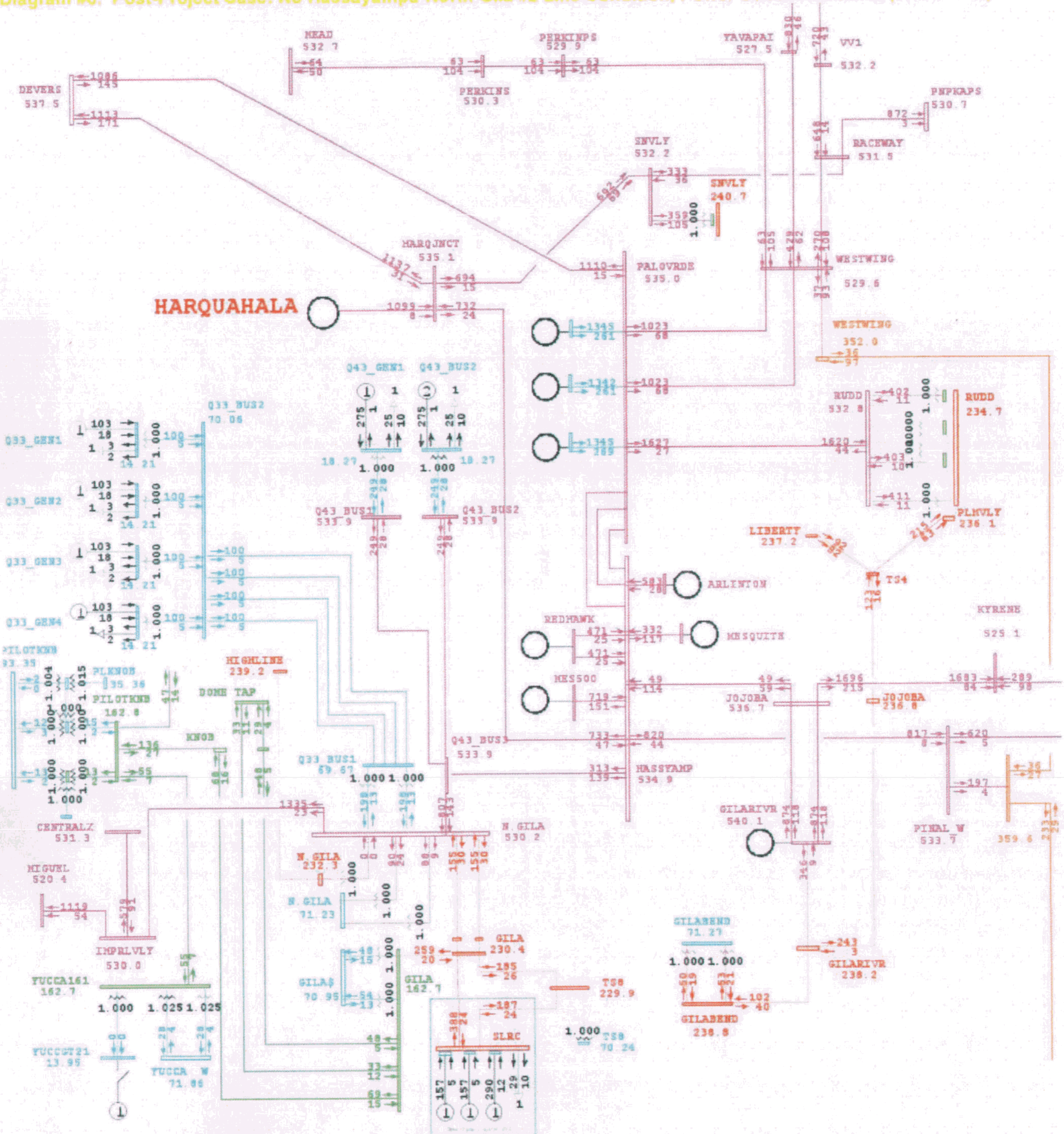


Diagram #7. Pre-Project Case: All Lines in Service Condition (MW/MVAR)

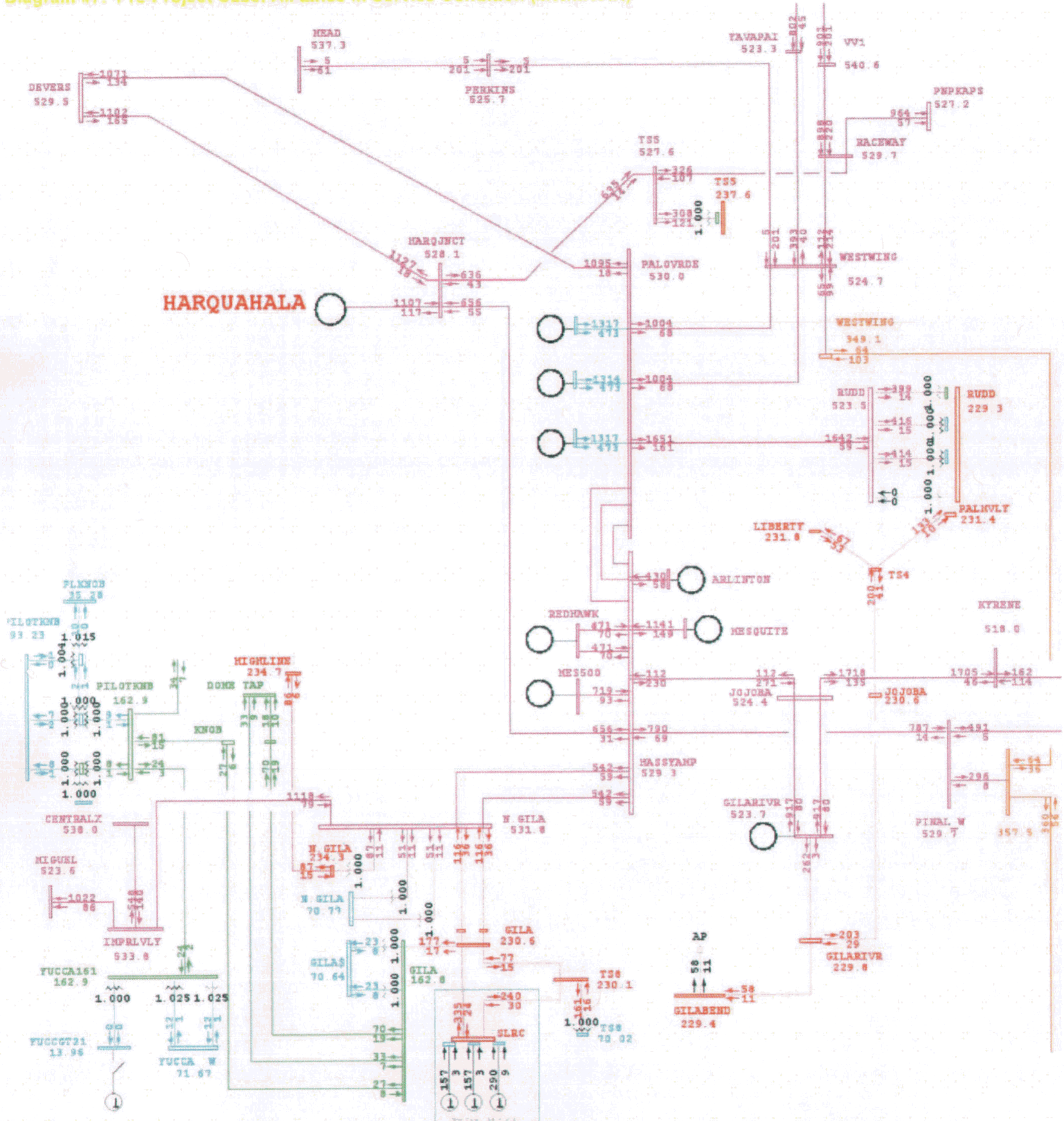


Diagram #8. Post-Project Case: All Lines in Service Condition, Power Scheduled for CA (MW/MVAR)

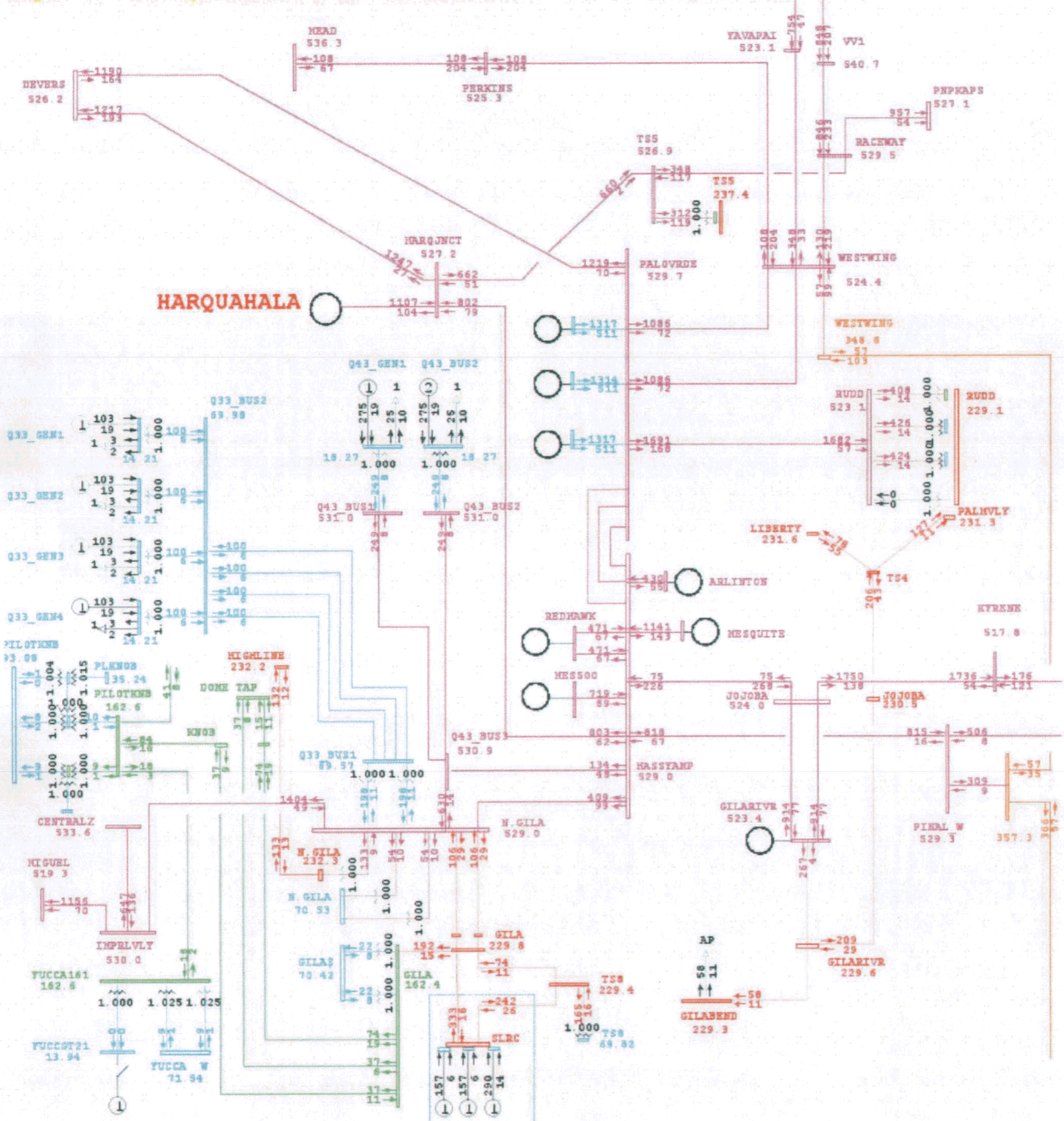


Diagram #9. Pre-Project Case: No Hassayampa-North Gila #2 Condition (MW/MVAR)

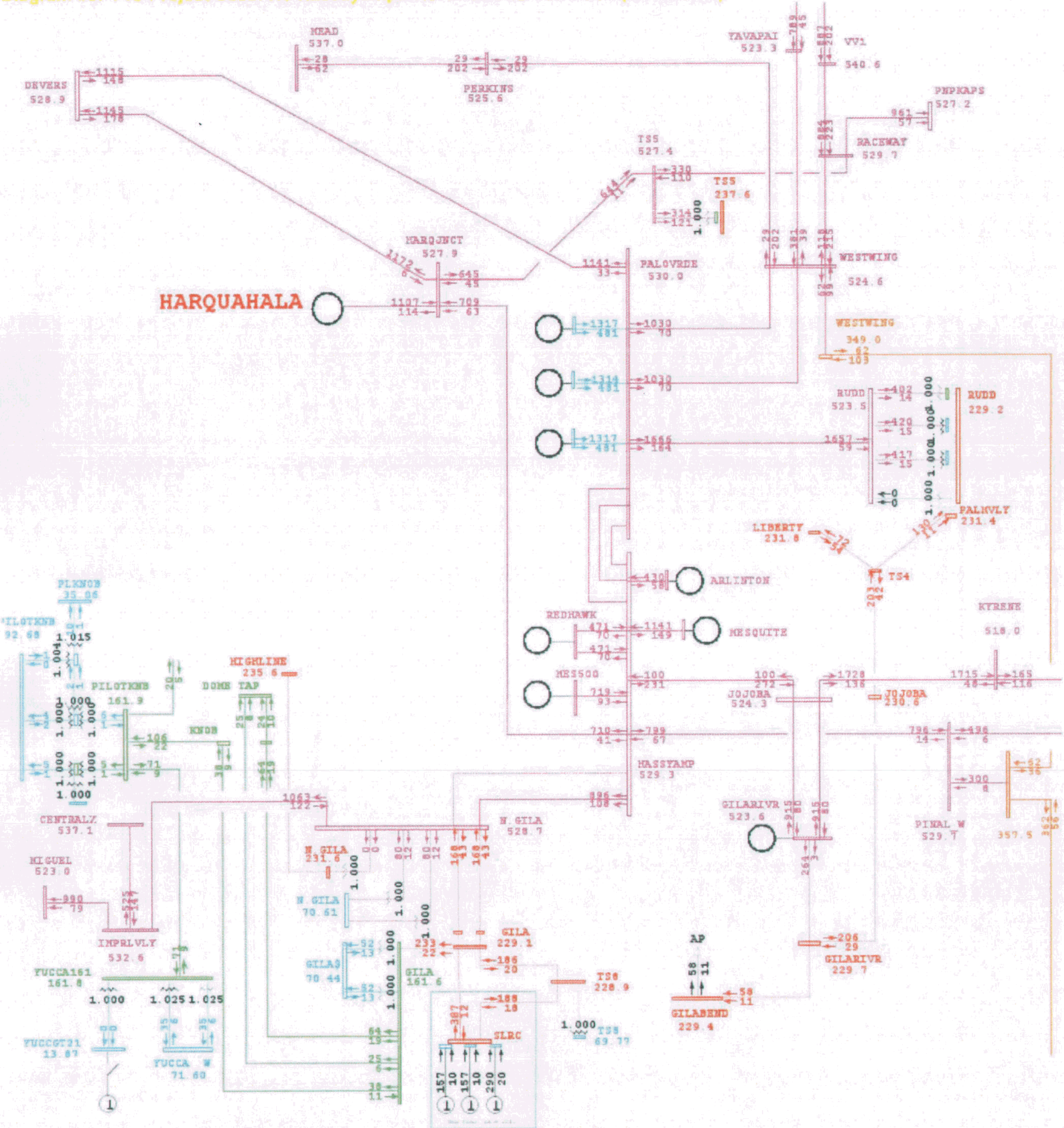


Diagram #10. Post-Project Case: No Hassayampa-North Gila #2 Condition, Power Scheduled to CA (MW/MVAR)

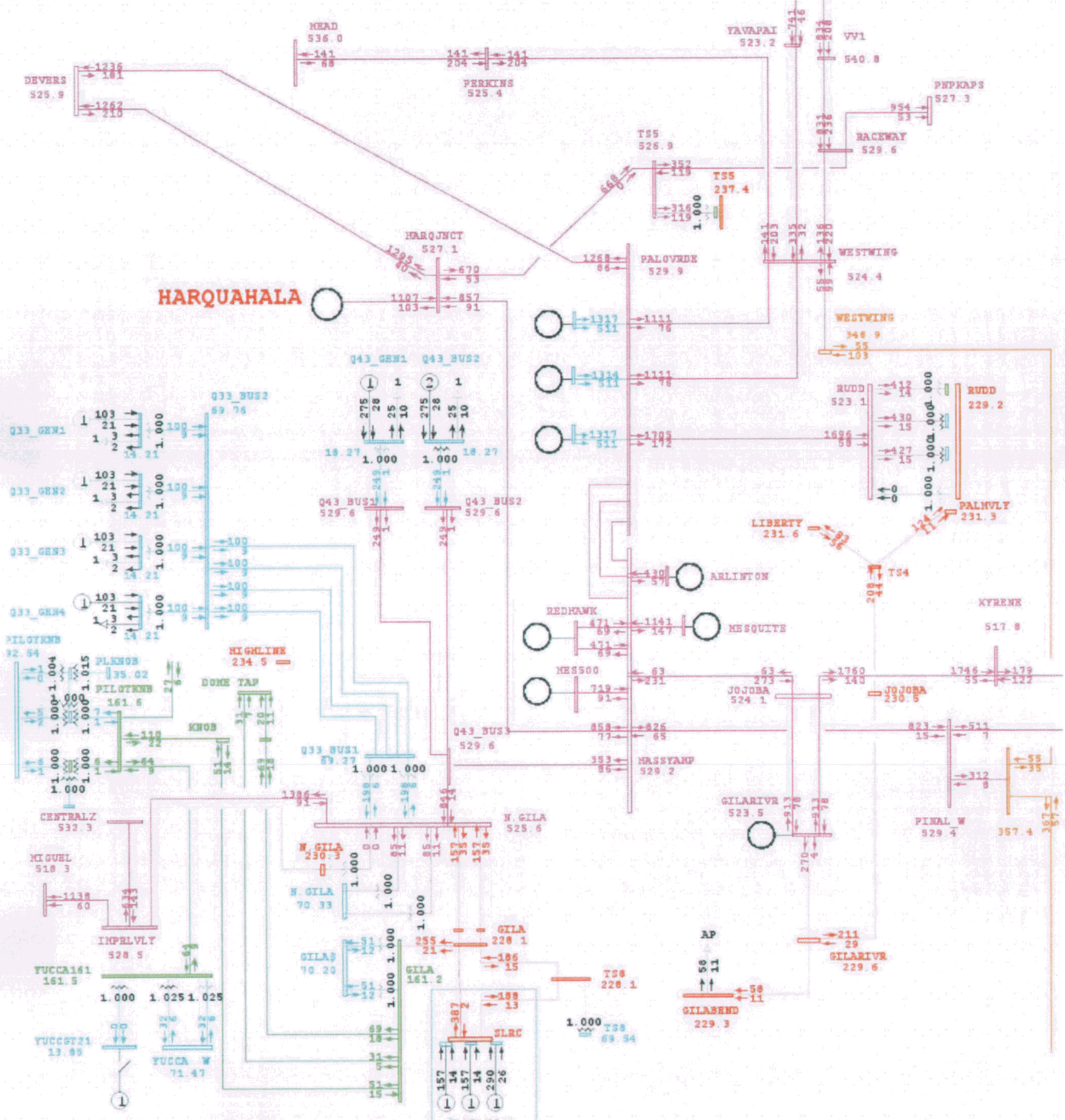


Diagram #11. Pre-Project Case: West of River Stressed Condition (MW/MVAR)

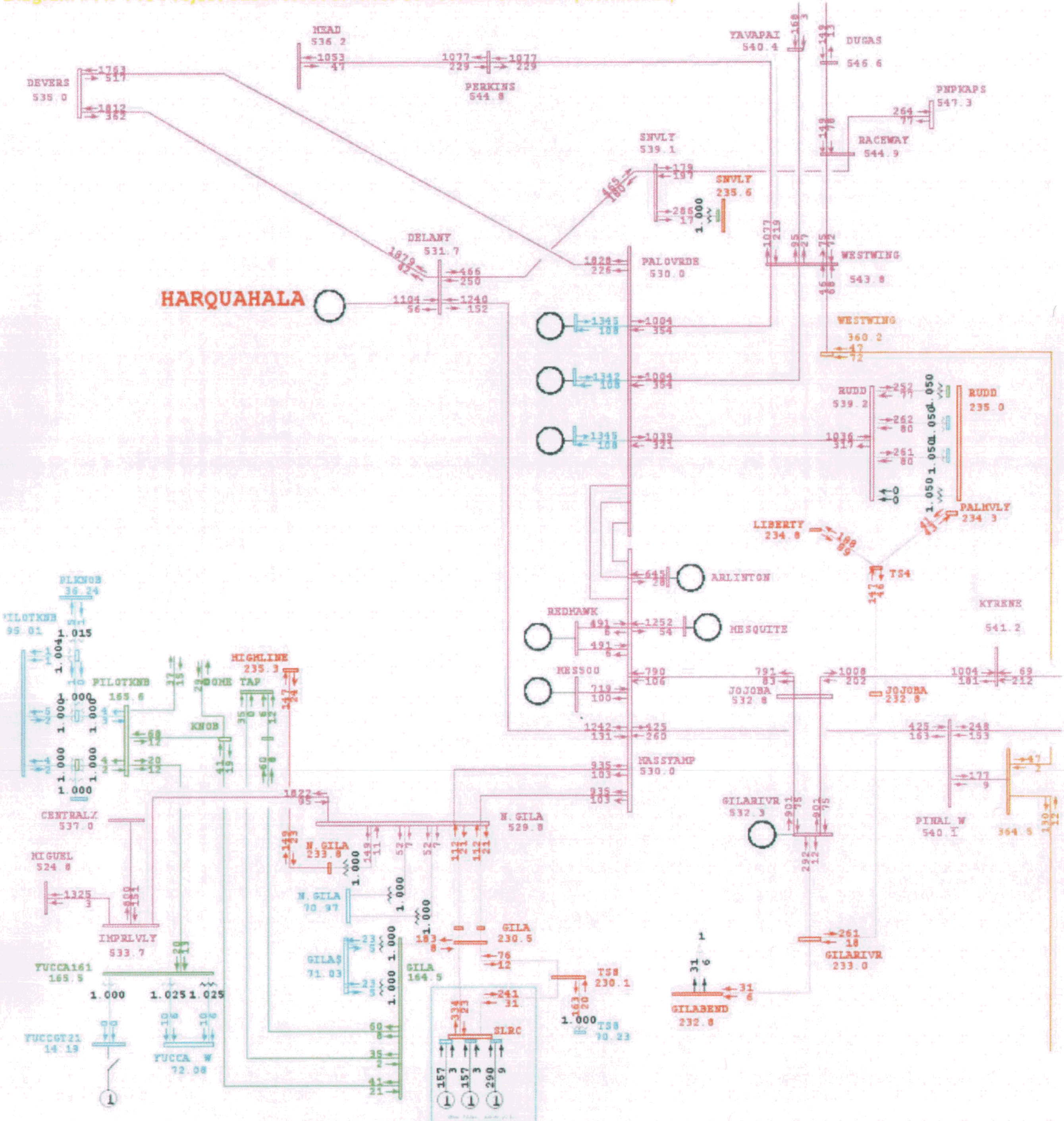


Diagram #12. Post-Project Case: West of River Stressed Condition, Power Scheduled to AZ (MW/MVAR)

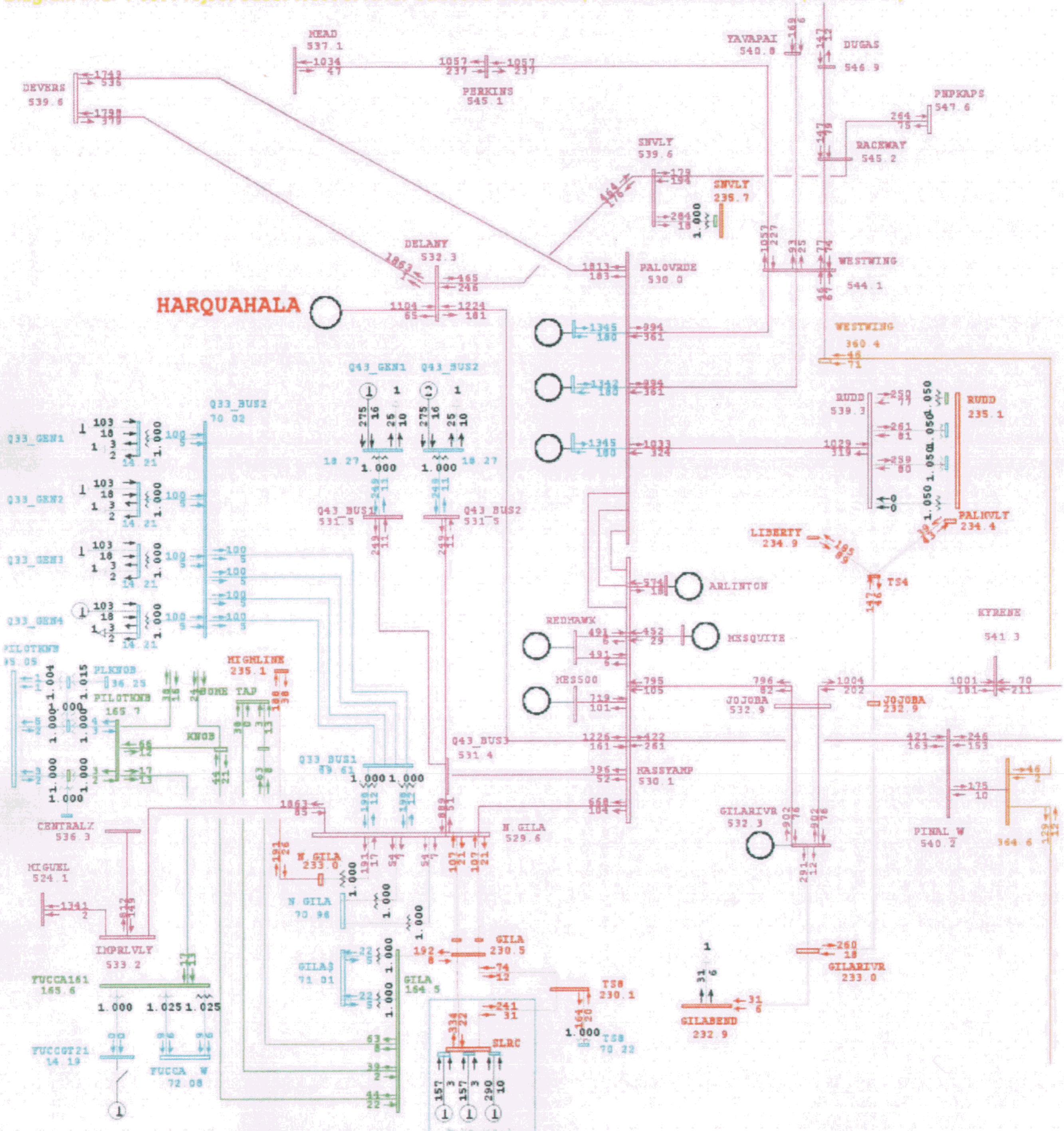


Diagram #13. Mitigation Case: N-1 North Gila-Imperial Valley 500kV line with SLRC SPS, Cluster Curtailed to 620MW, Scheduled to AZ, (MW/% Rate)

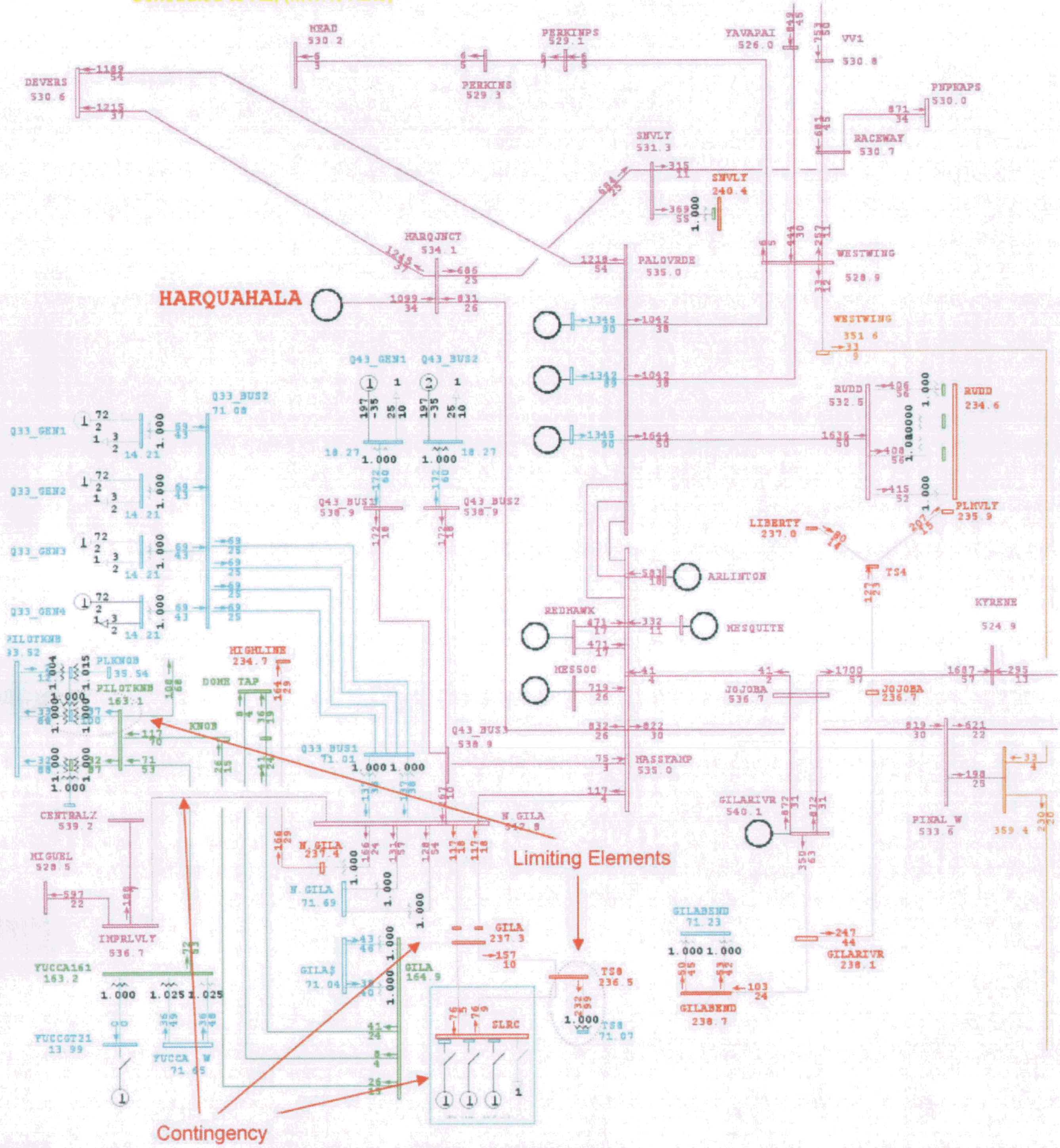
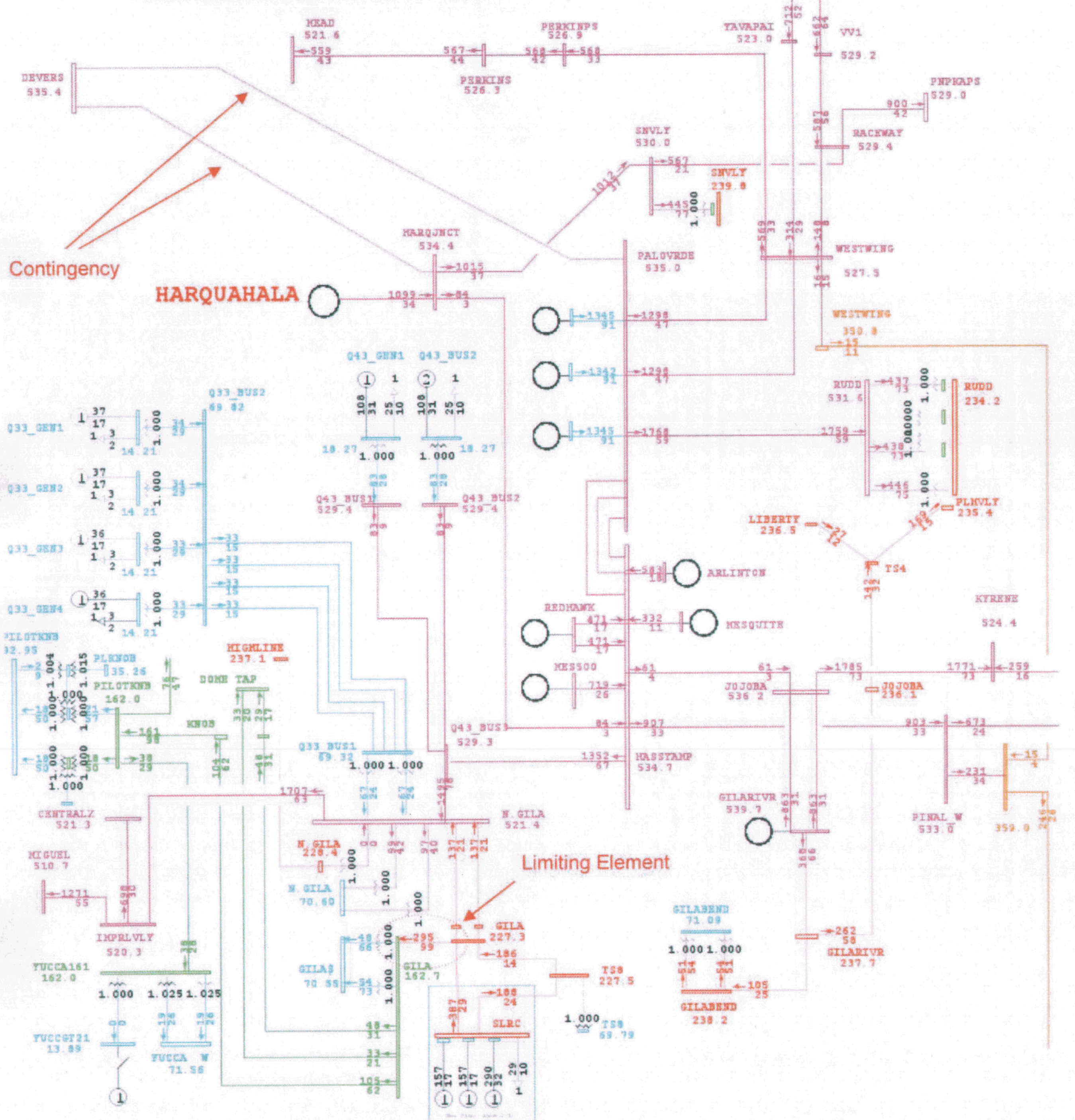


**Diagram #14. Mitigation Case: No Hassayampa-North Gila #2 500kV line, N-2 Palo Verde Devers #1 and #2 500kV line, Cluster Curtailed to 300MW, Scheduled to CA, (MW/% Rate)**



# Appendix
# B

# Appendix B

## List of Contingencies

## Power Flow Contingency List

a) The following single contingency (N-1) category B outages were analyzed:

1. Outage of the North Gila-Imperial Vally 500kV line (without SLRC SPS)
2. Outage of the North Gila-Imperial Vally 500kV line (with SLRC SPS)
3. Outage of the Browning-Silver King 500kV line
4. Outage of the Coronado-Secnol 500kV line
5. Outage of the Cholla-Secnol 500kV line
6. Outage of the Coronado-Silver King 500kV line
7. Outage of the Crystal-McCullough 500kV line
8. Outage of the Four Corners-Moenkopi 500kV line
9. Outage of the Harquahala Jct-Hassayampa 500kV line
10. Outage of the Harquahala Jct-Sun Valley 500kV line
11. Outage of the Hassayampa-Jojoba #1 500kV line
12. Outage of one Hassayampa-North Gila 500kV line
13. Outage of the Hassayampa-Pinal West 500kV line
14. Outage of the Jojoba-Kyrene 500kV line
15. Outage of the Kyrene-Browning 500kV line
16. Outage of the Moenkopi-El Dorado 500kV line
17. Outage of the Moenkopi-Yavapai 500kV line
18. Outage of the Navajo-Crystal 500kV line
19. Outage of the Navajo-VV1 500kV line
20. Outage of the Navajo-Red Mesa 500kV line
21. Outage of the VV1-Raceway 500kV line
22. Outage of the Raceway-Westwing 500kV line
23. Outage of the Palo Verde-Devers No. 1 500kV line
24. Outage of the Palo Verde-Devers No. 2 500kV line
25. Outage of the Palo Verde-Rudd 500kV line
26. Outage of one Palo Verde-Westwing 500kV line
27. Outage of the Peacock-Liberty 345kV line
28. Outage of the Perkins-Mead 500kV line
29. Outage of the Red Mesa-Moenkopi 500kV line
30. Outage of the Red Mesa-Four Corners 500kV line
31. Outage of the Sun Valley-Raceway 500kV line
32. Outage of the Westwing-Pinal West 345kV line
33. Outage of the Yavapai-Westwing 500kV line
34. Outage of the Raceway-Pinnacle Peak 500kV line
35. Outage of the Imperial Valley-Miguel 500kV line (without SPS)
36. Outage of the Imperial Valley-Miguel 500kV line (with SPS)

b) In addition, the following double contingency (N-2) category C outages were analyzed:

37. Outage of the Hassayampa-Jojoba and Hassayampa-Pinal West 500kV lines
38. Outage of the Palo Verde-Devers and Harquahala Jct-Devers 500kV lines
39. Outage of both Palo Verde-Westwing #1 and #2 500kV lines
40. Outage of both Hassayampa-North Gila #1 and #2 500kV lines

## Post Transient Contingency List

a) The following selected single element (N-1) category B outages were simulated:

1. Outage of the Harquahala Jct-Devers 500kV line (PVD 2)
2. Outage of the Hassayampa-N. Gila #1 500kV line
3. Outage of the Hassayampa-N. Gila #2 500kV line
4. Outage of the Palo Verde-Devers 500kV line
5. Outage of one Palo Verde-Westwing 500kV line
6. Outage of the Palo Verde-Rudd 500kV line
7. Outage of the Hassayampa-Jojoba 500kV line
8. Outage of the Hassayampa-Pinal West 500kV line
9. Outage of the Harquahala Jct-Hassayampa 500kV line
10. Outage of the Harquahala Jct-Sun Valley 500kV line
11. Outage of the Sun Valley-Raceway 500kV line
12. Outage of Palo Verde Unit 1
13. Outage of the North Gila-Imperial Valley 500kV line (without SLRC SPS)
14. Outage of the North Gila-Imperial Valley 500kV line (with SLRC SPS)
15. Outage of the Imperial Valley-Miguel 500kV line (without SPS)
16. Outage of the Imperial Valley-Miguel 500kV line (with SPS)

b) The following selected double element (N-2) category C outages were simulated:

17. Outage of both Palo Verde-Westwing 500kV lines
18. Outage of Palo Verde-Westwing and Palo Verde-Rudd 500kV lines
19. Outage of the Palo Verde-Devers & Harq.-Devers 500kV lines[1] no RAS
20. Outage of the Palo Verde-Devers & Harq.-Devers 500kV lines[1] with RAS
21. Outage of the Palo Verde-Devers & Harq.-Hassayampa 500kV lines[1] no RAS
22. Simultaneous tripping/loss of two Palo Verde generators, with no applied fault. (Includes Remedial Action Scheme to drop up to 120MW of Phoenix Valley load.)
23. Outage of both Hassayampa-North Gila 500kV lines

[1] The N-2 of PV-Devers + Harq.-Devers is considered to be one of the defining contingencies of the EOR/WOR Combined Projects study. For post-transient analysis, this outage yields a limiting voltage deviation of -9.6% at the Eagle Mountain 161kV bus.

## Transient Stability Contingency List

a) The following single contingency (N-1) category B outages were analyzed:

1. Three-phase normally cleared fault at the Harquahala Junction end of the Harquahala Jct-Devers 500kV line (PVD 2)
2. Three-phase normally cleared fault at the Hassayampa end of one Hassayampa-N. Gila #2 500kV line
3. Three-phase normally cleared fault at the Palo Verde end of the Palo Verde-Devers 500kV line
4. Three-phase normally cleared fault at the Palo Verde end of the Palo Verde-Westwing No.1 500 kV line
5. Three-phase normally cleared fault at the Palo Verde end of the Palo Verde-Rudd 500 kV line
6. Three-phase normally cleared fault at the Hassayampa end of the Hassyampa-Jojoba #1 500 kV line
7. Three-phase normally cleared fault at the Hassayampa end of the Hassayampa-Pinal West 500kV line
8. Three-phase normally cleared fault at the Harquahala Jct end of the Hassyampa-Harquahala Jct. 500 kV line
9. Three-phase normally cleared fault at the Harquahala Jct end of the Harquahala Jct.- Sun Valley 500 kV line
10. Three-phase normally cleared fault at the Sun Valley end of the Sun Valley-Raceway 500kV line
11. Three-phase normally cleared fault at the Palo Verde 500kV bus with tripping of one Palo Verde unit
12. Three-phase normally cleared fault at the North Gila end of the North Gila-Imperial Valley 500kV line, without the SLRC SPS action
13. Three-phase normally cleared fault at the North Gila end of the North Gila-Imperial Valley 500kV line, with the SLRC SPS action
14. Three-phase normally cleared fault at the Imperial Valley end of the Imperial Valley-Miguel 500kV line (without SPS)
15. Three-phase normally cleared fault at the Imperial Valley end of the Imperial Valley-Miguel 500kV line (with SPS)
16. Three-phase normally cleared fault at the North Gila end of the North Gila-Hassayampa #1 500kV line
17. Three-phase normally cleared fault at the North Gila end of the North Gila-Hassayampa #2 500kV line

b) In addition, the following double contingency (N-2) category C outages were analyzed:

18. Three-phase normally cleared fault at the Palo Verde end of both Palo Verde-Westwing No.1 and No.2 500kV lines
19. Single line-to-ground normally cleared fault at the Palo Verde 500 kV end of both Palo Verde-Westwing No.1 and No.2 500 kV lines

20. Single line-to-ground normally cleared fault at the Palo Verde 500 kV end of the Palo Verde-Westwing and the Palo Verde-Rudd 500 kV lines.
21. Three-phase normally cleared fault at Devers clearing the Harquahala Jct-Devers and Palo Verde-Devers 500kV lines without RAS action
22. Three-phase normally cleared fault at Devers clearing the Harquahala Jct-Devers and Palo Verde-Devers 500kV lines with RAS action
23. Trip Palo Verde Units 1 and 2 (Includes Remedial Action Scheme to drop up to 150MW of Phoenix Valley load)
24. Three-phase normally cleared fault at North Gila clearing both of the North Gila-Hassayampa #1 and #2 500kV lines

# Appendix C

# Appendix C

## Transient Stability Modeling

Project #43 **Units 1 & 2 - Dynamic Data**

Generator Model – Project #43

**Model Name:** **genrou**

**Description** Solid rotor generator represented by equal mutual inductance rotor modeling

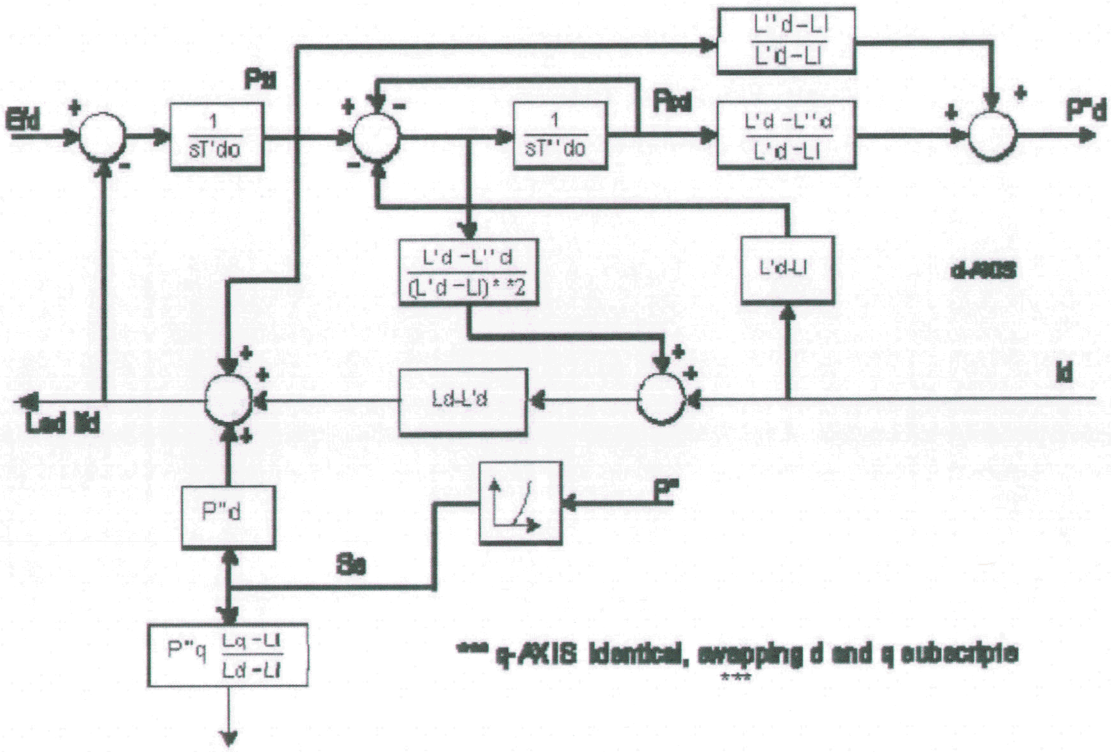
**Invocation:** `genrou [<n>] {<name> <kv>} <id> :`
**Parameters:**

| *EPCL Variable* | *Description* | *MVA=300* *Project Data* |
|---|---|---|
| Tpdo | D-axis transient rotor time constant | **6.8** |
| Tppdo | D-axis sub-transient rotor time constant | **0.024** |
| Tpqo | Q-axis transient rotor time constant | **1.4** |
| Tppqo | Q-axis sub-transient rotor time constant | **0.04** |
| H | Inertia constant, sec. | **3.52** |
| D | Damping factor, p.u. | **0** |
| Ld | D-axis synchronous reactance | **2.17** |
| Lq | Q-axis synchronous reactance | **2.12** |
| Lpd | D-axis transient reactance | **0.289** |
| Lpq | Q-axis transient reactance | **0.478** |
| Lppd | D-axis sub-transient reactance | **0.239** |
| L1 | Stator leakage reactance, p.u. | **0.1750** |
| S1 | Saturation factor at 1 p.u. flux | **0.05** |
| S12 | Saturation factor at 1.2 p.u. flux | **0.3** |
| Ra | Stator resistance, p.u. | **0** |
| Rcomp | Compounding resistance for voltage control, p.u. | **0** |
| Xcomp | Compounding reactance for voltage control, p.u. | **0** |

Notes:

1. Applicant-defined data values selected for this study are shown in **red bold**
2. All rotor time constants must be non-zero.
3. All reactances must be specified. Lppq is taken to be equal to Lppd.
4. D has the dimensions DP(p.u.) / Dspeed(p.u.).
5. S1 and S12 are defined in Figure 3.10.2, and must be non- zero.
6. (Ra+jLppd) overwrites the load flow machine subtransient impedance when the INIT, RDYD, or RDWS command is executed.
7. If Rcomp and Xcomp are absent from the data record read by RDYD, they are set to zero. If Ra is also absent, it is set to the resistance part of the machine subtransient impedance from the load flow generator data table.

Block Diagram, "genrou" model



Excitation System Model - Project #43

**Model Name:** **exst1**

**Description** IEEE (1980) type ST1 excitation system with optional added blocks to extend to IEEE (1992, 2005) ST1A model

**Invocation:** `exst1 [<n>] {<name> <kv>} <id> :`

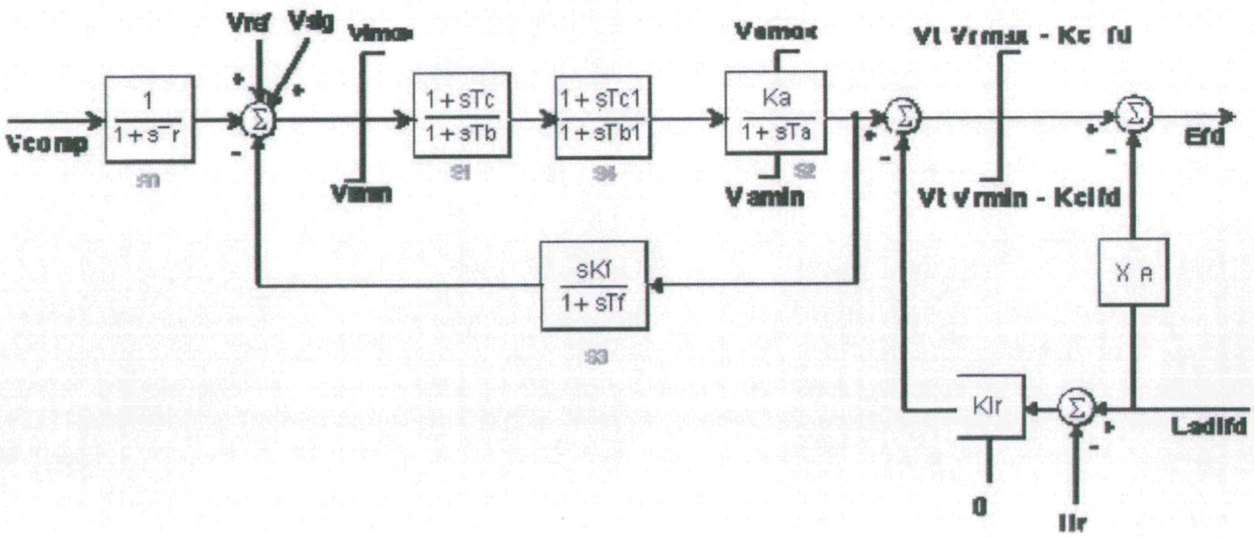
**Parameters:**

| *EPCL Variable* | *Description* | *Project Data* |
|---|---|---|
| Tr | Voltage transducer time constant, sec. | **0** |
| Vimax | Maximum error, p.u. | **0.3** |
| Vimin | Minimum error, p.u. | **-0.3** |
| Tc | Lead time constant, sec. | **0.7** |
| Tb | Lag time constant, sec. | **5.9** |
| Ka | Gain, p.u. (> 0.) | **400** |
| Ta | Time constant, sec | **0.03** |
| Vrmax | Maximum controller output, p.u. | **5.5** |
| Vrmin | Minimum controller output, p.u. | **-3.9** |
| Kc | Edcitation system regulator factor, p.u. | **0.05** |
| Kf | Rate feedback gain | **0** |
| Tf | Rate feedback gain constant, sec. | **1** |
| Tc1 | Lead time constant, sec. (note b) | **1** |
| Tb1 | Lag time constant, sec. (note b) | **1** |
| Vamax | Maximum control element output, p.u. (note b) | **5.5** |
| Vamin | Minimum control element output, p.u (note b) | **-3.9** |
| Xe | Excitation xfmr effective reactance, p.u. (note b) | **0.04** |
| Ilr | Maximum field current, p.u. (note b) | **2.8** |
| Klr | Gain on field current limit (note b) | **5** |

Notes:

1. Applicant -defined data values employed for this study are shown in **red bold**.
2. This model can be used to represent a controlled-rectifier excitation system whose a.c. power source is a simple power transformer fed from the generator terminals. The voltage regulation of the excitation transformer and rectifier are approximated by the parameter Kc.
3. The parameters after Tf were not part of the IEEE (1980) ST1 model. If these are omitted from the input data, they will be set to values so that they have not effect as follows (0., 0., 99., -99., 0., 99., 0.). All of these parameters except Xe are in the IEEE (1992, 2005) ST1A model.
4. Ka must not be zero. If Ta, Tb, or Tb1 are zero, the corresponding block is bypassed. If Tf is zero, the output of the rate feedback block is zero.
5. The integration time step is reduced for this model by a factor of 60 to avoid numerical instability.
6. The "fix bad data" option will do the following:
   a. If non-zero, set **Tr, Ta, Tb, Tb1** and **Tf** to a minimum of delt/15
   b. Set **Ka** to a minimum of 1.
   c. If **Vrmax < Vrmin**, swap the values.
   d. If **Vamax < Vamin**, swap the values.
   e. If **Vimax < Vimin**, swap the values.

Block Diagram, "exst1" model



General Governor Model (Steam Turbine) - Project #43

**Model Name:** **Ieeeg1**

**Description** IEEE steam turbine/governor model (with deadband and nonlinear valve gain added)

**Inputs:** Shaft speed

**Invocation**: ieeeg1 [<nh>] {<nameh> <kvh>} <idh> [<nl>] {<namel> <kvl>} <idl> : [mwcap=<value>]

**Parameters:**

| *EPCL Variable* | *Description* | mwcap=300* |
|---|---|---|
| K | Governor gain (reciprocal of droop), p.u. | 20 |
| T1 | Governor lag time constant, sec. | 0 |
| T2 | Governor lead time constant, sec. | 0 |
| T3 | Valve positioner time constant, sec. | 0.15 |
| Uo | Maximum valve opening velocity, p.u./sec. | 0.5 |
| Uc | Maximum valve closing velocity, p.u./sec (< 0.) | -1 |
| Pmax | Maximum valve opening, p.u. of mwcap. | 1.1 |
| Pmin | Minimum valve opening, p.u. of mwcap | 0.05 |
| T4 | Inlet piping/steam bowl time constant, sec. | 0.427 |
| K1 | Fraction of hp shaft power after first boiler pass | 0.3 |
| K2 | Fraction of lp shaft power after first boiler pass | 0 |
| T5 | Time constant of second boiler pass, sec | 10 |
| K3 | Fraction of hp shaft power after second boiler pass | 0.23 |
| K4 | Fraction of lp shaft power after second boiler pass | 0 |
| T6 | Time constant of third boiler pass, sec. | 0.997 |
| K5 | Fraction of hp shaft power after third boiler pass | 0.47 |
| K6 | Fraction of lp shaft power after third boiler pass | 0 |
| T7 | Time constant of fourth boiler pass, sec | 0 |
| K7 | Fraction of hp shaft power after fourth boiler pass | 0 |
| K8 | Fraction of lp shaft power after fourth boiler pass | 0 |
| db1 | Intentional deadband width, Hz. | 0.06 |
| eps | Intentional db hysteresis, Hz. | 0 |
| db2 | Unintentional deadband, MW | 1 |
| GV1 | Nonlinear gain point 1, p.u. gv | 0 |
| Pgv1 | Nonlinear gain point 1, p.u. power | 0 |
| GV2 | Nonlinear gain point 2, p.u. gv | 0 |
| Pgv2 | Nonlinear gain point 2, p.u. power | 0 |
| GV3 | Nonlinear gain point 3, p.u. gv | 0 |
| Pgv3 | Nonlinear gain point 3, p.u. power | 0 |
| GV4 | Nonlinear gain point 4, p.u. gv | 0 |
| Pgv4 | Nonlinear gain point 4, p.u. power | 0 |
| GV5 | Nonlinear gain point 5, p.u. gv | 0 |
| Pgv5 | Nonlinear gain point 5, p.u. power | 0 |
| GV6 | Nonlinear gain point 6, p.u. gv | 0 |
| Pgv6 | Nonlinear gain point 6, p.u. power | 0 |

Notes:

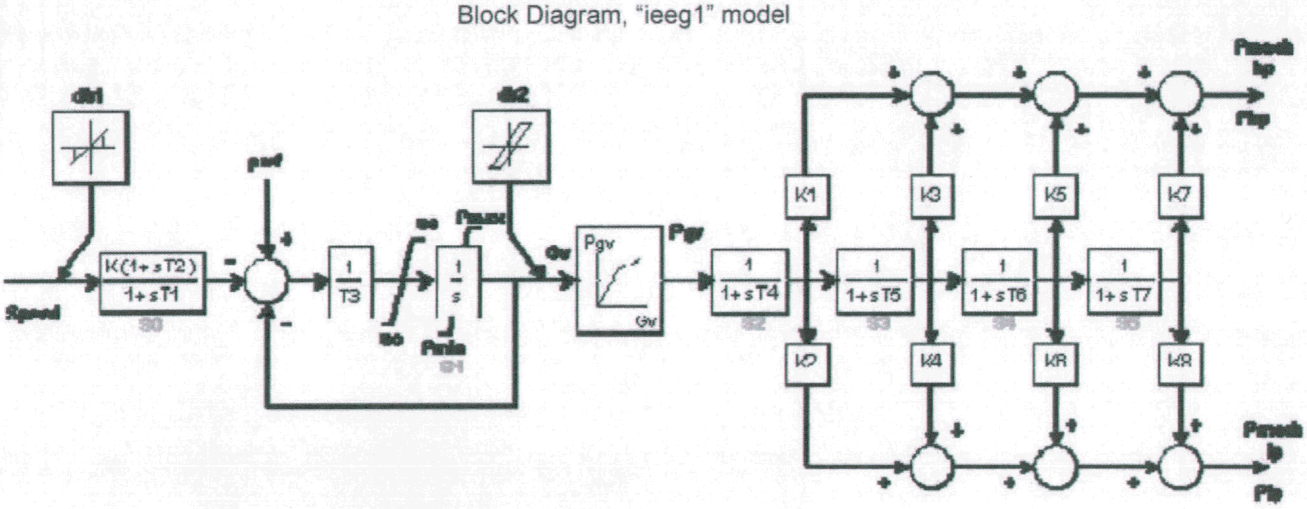
1. Project data values from the application are in **red bold**
2. Per unit parameters are on base of turbine MW capability. If no value is entered for "mwcap", the generator MVA base is used.
3. T3 must be greater than zero. All other time constants may be zero.
4. <nh> <nameh> <kvh> <idh> identify the first of two generators controlled by this governor. These must identify a generator that is in the working case.= 0 for fuel flow dependent speed
   <nl> <namel> <kvl> <idl> identify the second of two generators controlled by this governor. These may be omitted if only one generator is controlled.
5. The two generators identified by the invocation of this model are normally the high and low pressure machines, respectively, of a cross compound steam turbine set, or the gas and steam turbine machines of a combined cycle plant. The second machine may be absent and, in this case, the model can be used to approximate the behavior of a wide range of types of single shaft turbine.
6. The gains K1-K8 and time constants T5-T7 describe the division of power output among turbine stages and the transfer of energy in the boiler or combustion prime mover.
7. Each generator must be represented in the load flow by data stated on its own MVA base. The values of K1, K3, K5, K7 must be specified to describe the proportionate development of power on the first turbine shaft. K2, K4, K6, K8 must describe the second turbine shaft. Normally

   $$K1 + K3 + K5 + K7 = 1.0$$
   $$K2 + K4 + K6 + K8 = 1.0$$

   The division of power between the two shafts is in proportion to the values of MBASE of the two generators. The initial condition load flow should, therefore, have the two generators loaded to the same fraction of the MVA base
8. The deadbands are implemented as described in section 3.10.2.
9. The nonlinear gain between gate position and power may be input with up to 6 points. The (0.,0.) and (1.,1.) points are assumed and need not be input. The output is not allowed to go beyond 0. and 1. However, if Pmax > 1., the input and output are scaled by Pmax.

   If GV1 is input as a negative number, the default full-arc steam valve curve (see section 3.10.2) will be used. If input is omitted or if all zero values are input, a straight line is used.

Block Diagram, "ieeg1" model



Power System Stabilizer Model - Project #43

**Model Name:** **pss2a**

**Description** Dual input Power system stabilizer (IEEE type PSS2A)

**Inputs:** Generator shaft speed, Frequency of generator terminal or system bus voltage, generator electric power or accelerating power, voltage amplitude of generator terminal bus or system bus, current amplitude specified branch

**Invocation:** `pss2a [<n>] {<name> <kv>} <id> :`

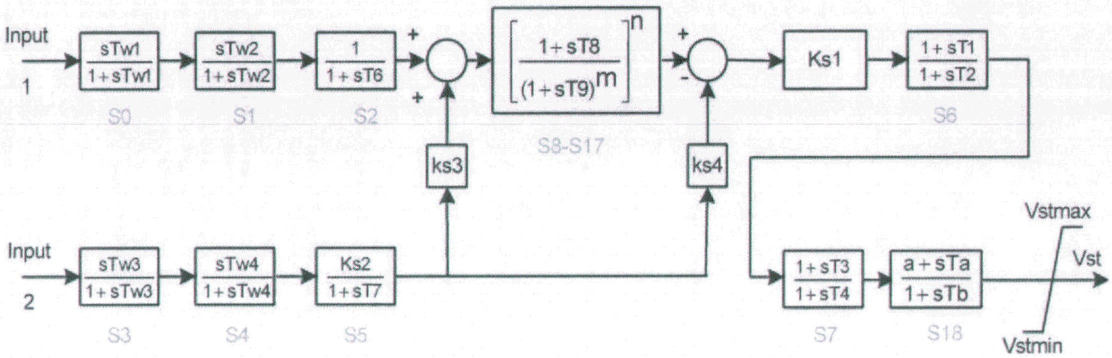
**Parameters:**

| *EPCL Variable* | *Description* | *Project Data* |
|---|---|---|
| J1 | Input signal #1 code | 1 |
| K1 | Input signal #1 remote bus number | 0 |
| J2 | Input signal #2 code | 3 |
| K2 | Input signal #2 remote bus number | 0 |
| Tw1 | First washout on signal #1, sec. | 5.0 |
| Tw2 | Second washout on signal #1, sec. | 5.0 |
| Tw3 | First washout on signal #2, sec. | 5.0 |
| Tw4 | Second washout on signal #2, sec. | 0 |
| T6 | Time constant on signal #1, sec. | 0 |
| T7 | Time constant on signal #2, sec. | 5.0 |
| Ks2 | Gain on signal #2 | 0.36 |
| Ks3 | Gain on signal #2 | 1.0 |
| Ks4 | Gain on signal #2 | 1.0 |
| T8 | Lead of ramp tracking filter | 0.48 |
| T9 | Lag of ramp tracking filter | 0.12 |
| n | Order of ramp tracking filter | 2.0 |
| m | Order of ramp tracking filter | 4.0 |
| Ks1 | Stabilizer gain | 15.71 |
| T1 | Lead/lag time constant, sec. | 0.2 |
| T2 | Lead/lag time constant, sec. | 0.03 |
| T3 | Lead/lag time constant, sec. | 0.2 |
| T4 | Lead/lag time constant, sec. | 0.03 |
| Vstmax | Stabilizer output max limit, p.u. | 0.05 |
| Vstmin | Stabilizer output min limit, p.u. | -0.05 |

Notes:

1. Project data values provided by the Applicant are shown in red.
2. The input signal code j1 and j2 are
   a. 1 for shaft speed
   b. 2 for frequency of bus voltage
   c. 3 for generator electrical power
   d. 4 for generator accelerating power
   e. 5 for amplitude of bus voltage
   f. 6 for amplitude of branch current

Block Diagram, "pss2a" model



Auxilliary Load Model - Project #43

**Model Name:** **blwscc**

**Description** Load voltage/frequency dependence model

**Inputs:**

**Invocation**: `[blwscc] [<n>] {<name> <kv>} <id>:`

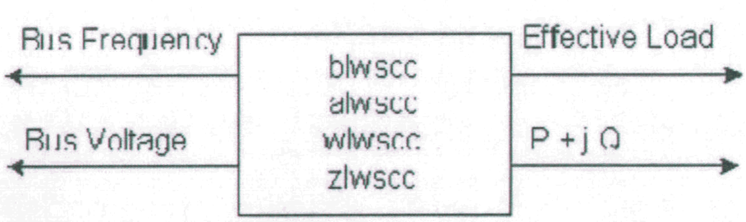
**Parameters:**

| *EPCL Variable* | *Description* | *Project Data* |
|---|---|---|
| area | Filter time constant in seconds (blwscc) | |
| p1 | Constant impedance fraction, p.u. | 25 |
| q1 | | 10 |
| p2 | Constant current fraction, p.u. | 1 |
| q2 | | 1 |
| p3 | Constant power fraction, p.u. | 0 |
| q3 | | 0 |
| p4 | Frequency dependent power fraction, p.u. | 0 |
| q4 | | 0 |
| lpd | Real power frequency index, p.u | 1 |
| lqd | Reactive power frequency index, p.u. | -1 |

Notes:

1. Project data values provided by the Applicant are shown in red.
2. The blwscc model implements the load characteristic for all load or loads at the single bus that is identified in the invocation. The load identifier in the invocation is ignored.
3. The first parameter is the time constant of a filter to smooth the frequency signal. This parameter should normally be zero because frequency is filtered in the network solution and this filtering is normally adequate. A non-zero filter time constant may be used in blwscc either to approximate a delayed load response, or to accommodate a troublesome network solution.

Block Diagram, “blwscc” model



## Project #33 Units - Dynamic Data

Machine Model – Project #33

**Model Name:** **genrou**

**Description** Solid rotor generator represented by equal mutual inductance rotor modeling

**Prerequisites:** Generator present in load flow working case

**Inputs:** Network boundary variables, Field Voltage, Turbine Power

**Invocation**: genrou [<n>] {<name> <kv>} <id> :

**Parameters:**

| *EPCL Variable* | *Description* | *Project Data* |
|---|---|---|
| mva | MVA Base | 115.6 |
| Tpdo | D-axis transient rotor time constant | 5.623 |
| Tppdo | D-axis sub-transient rotor time constant | 0.022 |
| Tpqo | Q-axis transient rotor time constant | 0.477 |
| Tppqo | Q-axis sub-transient rotor time constant | 0.043 |
| H | Inertia constant, sec | 3.8783 |
| D | Damping factor, pu | 0 |
| Ld | D-axis synchronous reactance | 2.3130 |
| Lq | Q-axis synchronous reactance | 2.205 |
| Lpd | D-axis transient reactance | 0.330 |
| Lpq | Q-axis transient reactance | 0.483 |
| Lppd | D-axis transient reactance | 0.229 |
| Ll | Stator leakage reactance, pu | 0.1950 |
| S1 | Saturation factor at 1 pu flux | 0.05 |
| S12 | Saturation factor at 1.2 pu flux | 0.30 |
| Ra | Stator resistance, pu | 0 |
| Rcomp | Compounding resistance for voltage control, pu | 0 |
| Xcomp | Compounding reactance for voltage control, pu | 0 |

**Notes:**

a) Project data values provided by the Applicant are shown in red
b) All rotor time constants must be non-zero.
c) All reactances must be specified. **Lppq** is taken to be equal to **Lppd**.
d) **D** has the dimensions DP(p.u.) / Dspeed (p.u.).
e) **S1** and **S12** are defined in Figure 3.10.2, and must be non- zero.

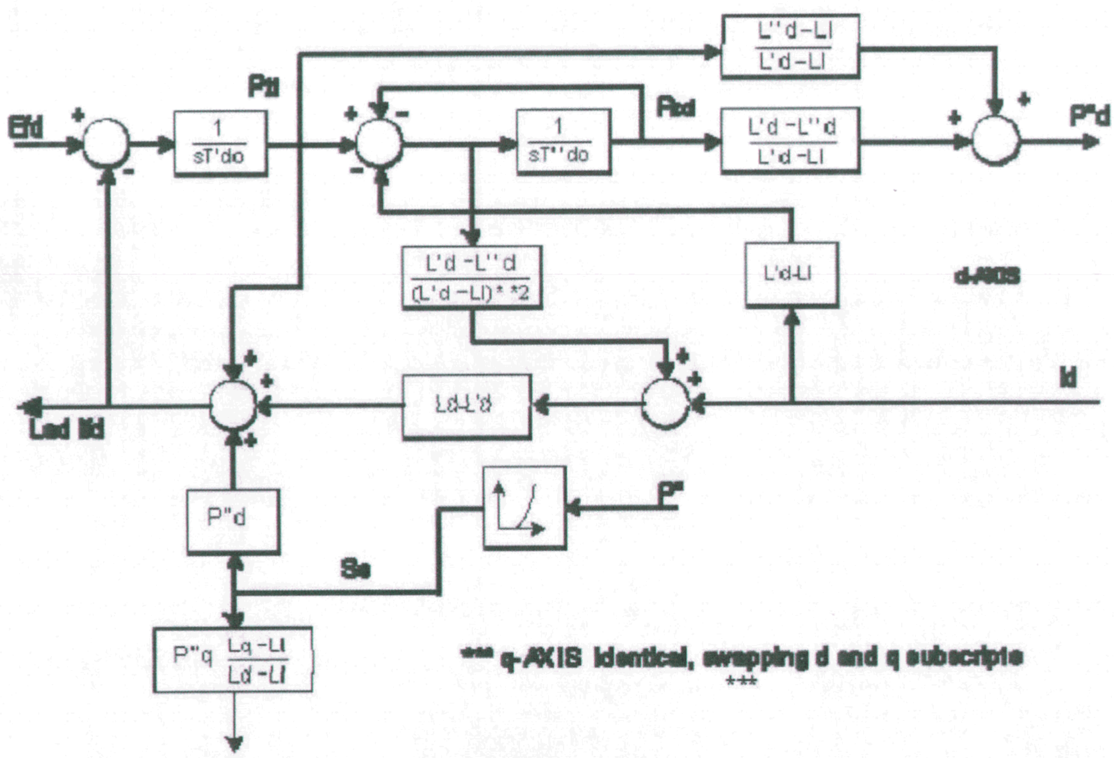
f) (**Ra+jLppd**) overwrites the load flow machine subtransient impedance when the INIT, RDYD, or RDWS command is executed.

g) If **Rcomp** and **Xcomp** are absent from the data record read by RDYD, they are set to zero. If **Ra** is also absent, it is set to the resistance part of the machine subtransient impedance from the load flow data table.

**Output Channels:**

| *Record Level* | *Name* | *Description* |
|---|---|---|
| 1 | spd | Shaft speed, p.u. |
| 1 | ang | Rotor angle, degrees |
| 1 | vt | Terminal voltage, p.u. |
| 1 | pg | Electrical power, MW |
| 1 | qg | Reactive power, MVAR |
| 1 | efd | Field voltage, p.u. |

**Block Diagram:**



Prime Mover Model – Project #33

**Model Name:** **ieeeg1**

**Description** IEEE steam turbine/governor model (with deadband and nonlinear valve gain added)

**Prerequisites:** One or two generator models ahead of this model in the dynamic models table

**Inputs:** Shaft speed

**Invocation:** ieeeg1 [<nh>] {<nameh> <kvh>} <idh> [<nl>] {<namel> <kvl>} <idl> : [mwcap=<value>]

**Parameters:**

| *EPCL Variable* | *Default Data* | *Description* | *Project Data* |
|---|---|---|---|
| mwcap | | | 115.6 |
| K | 25.0 | Governor gain (reciprocal of droop), p.u. | 20 |
| T1 | 0.0 | Governor lag time constant, sec. | 0 |
| T2 | 0.0 | Governor lead time constant, sec. | 0 |
| T3 | 0.1 | Valve positioner time constant, sec. | 0.15 |
| Uo | 1.0 | Maximum valve opening velocity, p.u./sec. | 0.012 |
| Uc | -10.0 | Maximum valve closing velocity, p.u./sec (< 0.) | -0.012 |
| Pmax | 1.0 | Maximum valve opening, p.u. of mwcap. | 1.0 |
| Pmin | 0.0 | Minimum valve opening, p.u. of mwcap | 0 |
| T4 | 0.0 | Inlet piping/steam bowl time constant, sec. | 0.275 |
| K1 | 0.0 | Fraction of hp shaft power after first boiler pass | 0.224 |
| K2 | 0.0 | Fraction of lp shaft power after first boiler pass | 0 |
| T5 | 0.0 | Time constant of second boiler pass, sec | 0.1 |
| K3 | 0.0 | Fraction of hp shaft power after second boiler pass | 0.395 |
| K4 | 0.0 | Fraction of lp shaft power after second boiler pass | 0 |
| T6 | 0.0 | Time constant of third boiler pass, sec. | 0.3 |
| K5 | 0.0 | Fraction of hp shaft power after third boiler pass | 0.381 |
| K6 | 0.0 | Fraction of lp shaft power after third boiler pass | 0 |
| T7 | 0.0 | Time constant of fourth boiler pass, sec | 0 |
| K7 | 0.0 | Fraction of hp shaft power after fourth boiler pass | 0 |
| K8 | 0.0 | Fraction of lp shaft power after fourth boiler pass | 0 |
| db1 | 0.0 | Intentional deadband width, Hz. | 0 |
| eps | 0.0 | Intentional db hysteresis, Hz. | 0 |
| db2 | 0.0 | Unintentional deadband, MW | 0 |
| GV1 | 0.0 | Nonlinear gain point 1, p.u. gv | 0 |
| Pgv1 | 0.0 | Nonlinear gain point 1, p.u. power | 0 |
| GV2 | 0.0 | Nonlinear gain point 2, p.u. gv | 0 |

| | | | |
|---|---|---|---|
| Pgv2 | 0.0 | Nonlinear gain point 2, p.u. power | 0 |
| GV3 | 0.0 | Nonlinear gain point 3, p.u. gv | 0 |
| Pgv3 | 0.0 | Nonlinear gain point 3, p.u. power | 0 |
| GV4 | 0.0 | Nonlinear gain point 4, p.u. gv | 0 |
| Pgv4 | 0.0 | Nonlinear gain point 4, p.u. power | 0 |
| GV5 | 0.0 | Nonlinear gain point 5, p.u. gv | 0 |
| Pgv5 | 0.0 | Nonlinear gain point 5, p.u. power | 0 |
| GV6 | 0.0 | Nonlinear gain point 6, p.u. gv | 0 |
| Pgv6 | 0.0 | Nonlinear gain point 6, p.u. power | 0 |

**Notes:**

a) Project data values provided by the Applicant are shown in red

b) Per unit parameters are on base of total turbine MW capability. If no value is entered for "mwcap", the generator MVA base is used. (If there are two generators, the sum of the MVA bases is used.)

c) T3 must be greater than zero. All other time constants may be zero.

d) <nh> <nameh> <kvh> <idh> identify the first of two generators controlled by this governor. These must identify a generator that is in the working case.

<nl> <namel> <kvl> <idl> identify the second of two generators controlled by this governor. These may be omitted if only one generator is controlled.

e) The two generators identified by the invocation of this model are normally the high and low pressure machines, respectively, of a cross compound steam turbine set, or the gas and steam turbine machines of a combined cycle plant. The second machine may be absent and, in this case, the model can be used to approximate the behavior of a wide range of types of single shaft turbine.

f) The gains K1-K8 and time constants T5-T7 describe the division of power output among turbine stages and the transfer of energy in the boiler or combustion prime mover.

g) Each generator must be represented in the load flow by data stated on its own MVA base. The values of K1, K3, K5, K7 must be specified to describe the proportionate development of power on the first turbine shaft. K2, K4, K6, K8 must describe the second turbine shaft. Normally

$$K1 + K3 + K5 + K7 = 1.0$$
$$K2 + K4 + K6 + K8 = 1.0$$

The division of power between the two shafts is in proportion to the values of MBASE of the two generators. The initial condition load flow should, therefore, have the two generators loaded to the same fraction of the MVA base.

h) The deadbands are implemented as described in section 3.10.2.

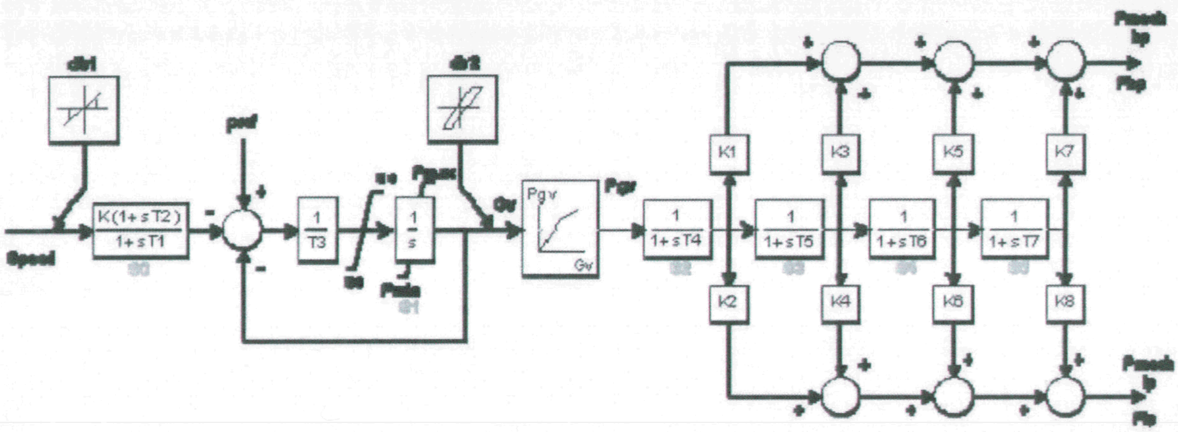
i) The nonlinear gain between gate position and power may be input with up to 6 points. The (0.,0.) and (1.,1.) points are assumed and need not be input. The output is not allowed to go beyond 0. and 1. However, if Pmax > 1., the input and output are scaled by Pmax.

If GV1 is input as a negative number, the default full-arc steam valve curve (see section 3.10.2) will be used. If input is omitted or if all zero values are input, a straight line is used.

## Output Channels:

| *Record Level* | *Name* | *Description* |
|---|---|---|
| 1 | ph | High pressure turbine shaft power, MW. |
| 1 | pl | Low pressure turbine shaft power, MW |

## Block Diagram:



**Excitation Model – Project #33**

**Model Name:** esac2a

**Description** IEEE (1992/2005) type AC2A excitation system

**Prerequisites:** Generator model ahead of this model in dynamic models table

**Inputs:** Compounded generator terminal voltage, generator field current, generator speed

**Invocation:** esac2a [<n>] {<name> <kv>} <id> :

**Parameters:**

| *EPCL Variable* | *Default Data* | *Description* | *Project Data* |
|---|---|---|---|
| Tr | 0.0 | Filter time constant, sec. | 0.01 |
| Tb | 0.0 | TGR lag time constant, sec. | 1 |
| Tc | 0.0 | TGR lead time constant, sec. | 1 |
| Ka | 400.0 | AVR gain (> 0.) | 1000 |
| Ta | 0.01 | AVR time constant, sec. (> 0.) | 0.01 |
| Vamax | 8.0 | Maximum AVR output, p.u. | 8.6 |
| Vamin | -8.0 | Minimum AVR output, p.u. | -8.6 |
| Kb | 25.0 | Exciter field current controller gain, p.u. (> 0.) | 1 |
| Vrmax | 105.0 | Maximum exciter control signal, p.u. | 13.9 |
| Vrmin | -95.0 | Minimum exciter control signal, p.u. | -13.9 |
| Te | 0.6 | Exciter time constant, sec. (> 0.) | 0.66 |
| Vfemax | 4.4 | Exciter field current limit parameter, p.u. Efd | 10.79 |
| Kh | 1.0 | Exciter field current feedback gain, p.u. | 0 |
| Kf | 0.03 | Rate feedback gain, p.u. | 0.05 |
| Tf | 1.0 | Rate feedback time constant, sec. (> 0.) | 1.0 |
| Kc | 0.28 | Rectifier regulation factor, p.u. | 0.1 |
| Kd | 0.35 | Exciter internal reactance, p.u. | 0.8 |
| Ke | 1.0 | Exciter field resistance constant, p.u. | 1.0 |
| E1 | 4.4 | Field voltage value 1, p.u. (note e) | 4.73 |
| S(E1) | 0.037 | Saturation factor at E1 (note e) | 0.02 |
| E2 | 3.3 | Field voltage value 2, p.u. (note e) | 3.55 |
| S(E2) | 0.012 | Saturation factor at E2 (note e) | 0.01 |
| spdmlt | 0 | If = 1, multiply output (Efd) by generator speed (note g) | 0 |

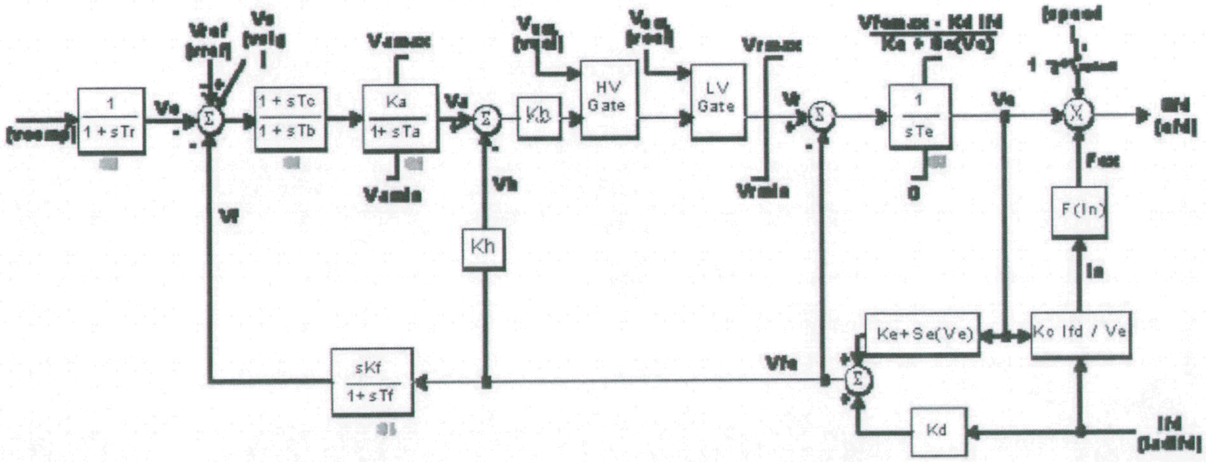
**Notes:**

a) Project data values provided by the Applicant are shown in red
b) For modeling high initial-response alternator-rectifier excitation system with non-controlled rectifiers and feedback from exciter field current, e.g. Westinghouse HIR Brushless system.
c) **Ka, Kb, Ta, Te, Tf** must be non-zero. If **Tr** or **Tb** are zero, the respective blocks are bypassed.
d) To disable the forward path gain reduction, set **Tb** = **Tc** or set **Tb** = 0.. To disable the rate feedback, set **Kf** = 0.
e) Saturation parameters are consistent with the IEEE saturation factor definition using the open circuit magnetization of the exciter. Either point [**E1, S(E1)** or **E2, S(E2)**] may be the higher value and the other the lower.
f) The upper limit on Ve (s3) represents the effect of the field current limiter. If **Vfemax** is zero, this limit will not be enforced. The real system, the limiter is implemented by a low value gate just before Kb. The input to this LV gate is Kl * (Vlr – Vfe). If the values of Kl and Vlr are given, Vfemax can be calculated as Vlr*Kl*Kb / (1 + Kl*Kb).
g) If **spdmlt** is omitted from the input data, it is set to 0 (disabled) to be consistent with the IEEE model, which does not have this option.
h) The integration time step is reduced for this model by a factor of 5 to avoid numerical instability due to the **Kh** feedback loop.
i) The "fix bad data" option will do the following:
   a. Set **Ta, Te**, and **Tf** to a minimum of 4*delt.
   b. If **Kh** is non-zero, set **Te** to a minimum of Ke * Kh * Kb * 4*delt.
   c. If non-zero, set **Tr** and **Tb** to a minimum of 4*delt
   d. If **Vfemax** is non-zero, set it to a minimum of 3.
   e. Set **Ka** and **Kb** to a minimum of 1.
   f. If **Vrmax < Vrmin**, swap the values.
   g. If **Vamax < Vamin**, swap the values.

## Output Channels:

| *Record Level* | *Name* | *Description* |
|---|---|---|
| 1 | ifd | Generator field current (Ladlfd) , p.u. |
| 2 | Vr | Voltage regulator output, p.u. |

## Block Diagram:


1
1 + sTr
1 + sTc
1 + sTb
Ka
1+ sTa
Vamax
Vamin
Kb
HV Gate
LV Gate
Vrmax
Vrmin
1
sTe
0
F(In)
Kh
Ke+Se(Ve)
Kc Ifd / Ve
sKf
1+sTf
Kd
Vfe

**Power System Stabilizer – Project #33**

**Model Name:** pss2a

**Description**

Dual input Power system stabilizer (IEEE type PSS2A)

**Prerequisites:**

Generator model ahead of this model in dynamic models table

**Inputs:**

Generator shaft speed Frequency of generator terminal or system bus voltage
Generator electric power or accelerating power

Voltage amplitude of generator terminal bus or system bus
Current amplitude specified branch

**Invocation**: psssa [<n>] {<name> <kv>} <id> :

**Parameters:**

| *EPCL Variable* | *Default Data* | *Description* | *Project Data* |
|---|---|---|---|
| J1 | 1.0 | Input signal #1 code | **1** |
| K1 | 0.0 | Input signal #1 remote bus number | **0** |
| J2 | 3.0 | Input signal #2 code | **3** |
| K2 | 0.0 | Input signal #2 remote bus number | **0** |
| Tw1 | 2.0 | First washout on signal #1, sec. | **2** |
| Tw2 | 2.0 | Second washout on signal #1, sec. | **2** |
| Tw3 | 2.0 | First washout on signal #2, sec. | **2** |
| Tw4 | 0.0 | Second washout on signal #2, sec. | **0** |
| T6 | 0.0 | Time constant on signal #1, sec. | **0** |
| T7 | 2.0 | Time constant on signal #2, sec. | **2** |
| Ks2 | 0.2 | Gain on signal #2 | **0.2** |
| Ks3 | 1.0 | Gain on signal #2 | **1** |
| Ks4 | 1.0 | Gain on signal #2 | **1** |
| T8 | 0.5 | Lead of ramp tracking filter | **0.5** |
| T9 | 0.1 | Lag of ramp tracking filter | **0.1** |
| n | 1.0 | Order of ramp tracking filter | **1** |
| m | 5.0 | Order of ramp tracking filter | **5** |
| Ks1 | 10.0 | Stabilizer gain | **15** |
| T1 | 0.25 | Lead/lag time constant, sec. | **0.15** |
| T2 | 0.04 | Lead/lag time constant, sec. | **0.03** |
| T3 | 0.2 | Lead/lag time constant, sec. | **0.15** |

| | | | |
|---|---|---|---|
| T4 | 0.03 | Lead/lag time constant, sec. | 0.03 |
| Vstmax | 0.1 | Stabilizer output max limit, p.u. | 0.1 |
| Vstmin | -0.1 | Stabilizer output min limit, p.u. | -0.1 |
| a | 1. | Lead/lag num. Gain. (not in IEEE model) | |
| Ta | 0. | Lead/lag time constant, sec. (not in IEEE model) | |
| Tb | 0. | Lead/lag time constant, sec. (not in IEEE model) | |

**Notes:**

a) Project data values provided by the Applicant are shown in red
b) TW1 and TW3 must be greater than zero.
c) Setting TW2 or TW4 to zero will bypass the washout function.
d) Ta, Tb, a, T1, T2, T3, T4, T6, T7, T8, and T9 may be zero.
e) Set T9 = 0 or n = 0 to get a null effect from the ramp tracking filter.
f) The product of n*m cannot be greater than 10.
g) The input signal code, j, and the remote bus number, k, specify the input signal used by the stabilizer. If k is zero the signal is taken from the shaft or terminals of the generator on which the stabilizer is located. If k is non-zero the signal is taken from bus number k ( for j = 1, 2, 3, 4, or 5 ).
h) To use branch current as an input, the branch is specified using the ( [<mon_i>] {<name> <kv>} [<mon_j>] {<name> <kv>} <ck> <sec> ) data in the DYD file or in the "edds" table. Note that only one branch current may be used as input to this model.

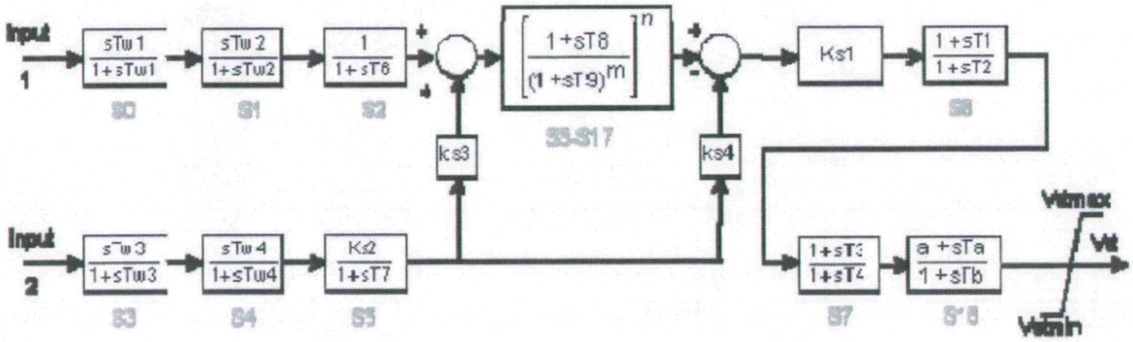
The input signal code, j, is

| | |
|---|---|
| 1 | for shaft speed |
| 2 | for frequency of bus voltage |
| 3 | for generator electrical power |
| 4 | for generator accelerating power |
| 5 | for amplitude of bus voltage |
| 6 | or amplitude of branch current |

**Output Channels:**

| ***Record Level*** | ***Name*** | ***Description*** |
|---|---|---|
| 1 | vs | Stabilizer output signal, p.u. |

**Block Diagram:**


Input 1
sTw1 / 1+sTw1
sTw2 / 1+sTw2
1 / 1+sT6
1+sT8 / (1+sT9)^m
Ks1
1+sT1 / 1+sT2
ks3
ks4
Input 2
sTw3 / 1+sTw3
sTw4 / 1+sTw4
Ks2 / 1+sT7
1+sT3 / 1+sT4
a+sTa / 1+sTb
Vstmax
Vst
Vstmin

Auxilliary Load Model - Project #33

**Model Name:** **blwscc**

**Description** Load voltage/frequency dependence model

**Inputs:**

**Invocation**: [blwscc] [<n>] {<name> <kv>} <id>:

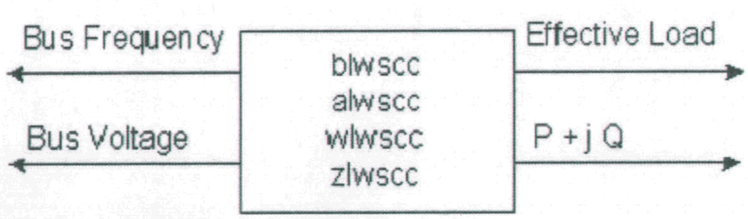
**Parameters:**

| *EPCL Variable* | *Description* | *Project Data* |
|---|---|---|
| area | Filter time constant in seconds (blwscc) | |
| p1 | Constant impedance fraction, p.u. | 3 |
| q1 | | 1.5 |
| p2 | Constant current fraction, p.u. | 1 |
| q2 | | 1 |
| p3 | Constant power fraction, p.u. | 0 |
| q3 | | 0 |
| p4 | Frequency dependent power fraction, p.u. | 0 |
| q4 | | 0 |
| lpd | Real power frequency index, p.u | 1 |
| lqd | Reactive power frequency index, p.u. | -1 |

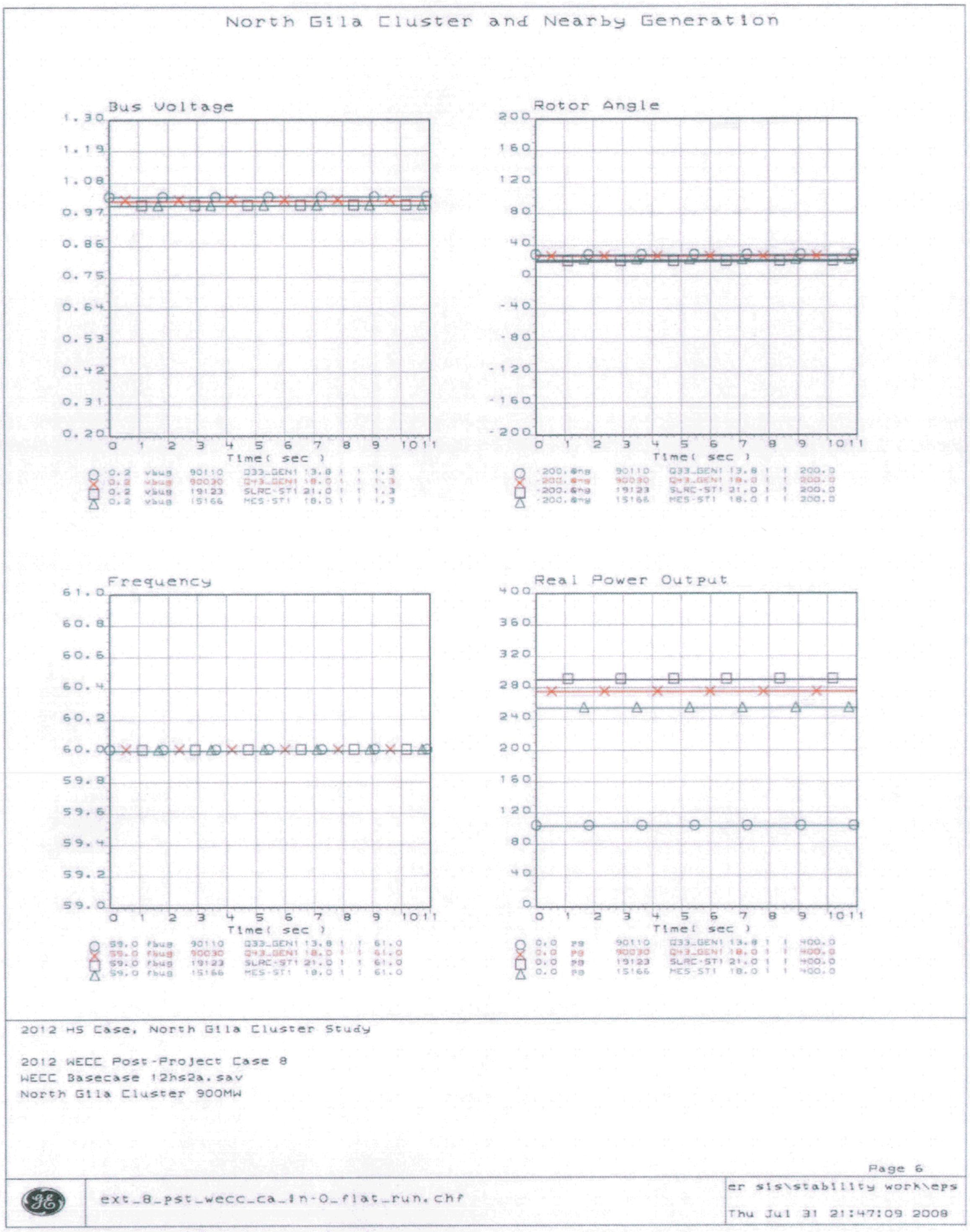
Notes:

1. Project data values provided by the Applicant are shown in red.
2. The blwscc model implements the load characteristic for all load or loads at the single bus that is identified in the invocation. The load identifier in the invocation is ignored.
3. The first parameter is the time constant of a filter to smooth the frequency signal. This parameter should normally be zero because frequency is filtered in the network solution and this filtering is normally adequate. A non-zero filter time constant may be used in blwscc either to approximate a delayed load response, or to accommodate a troublesome network solution.

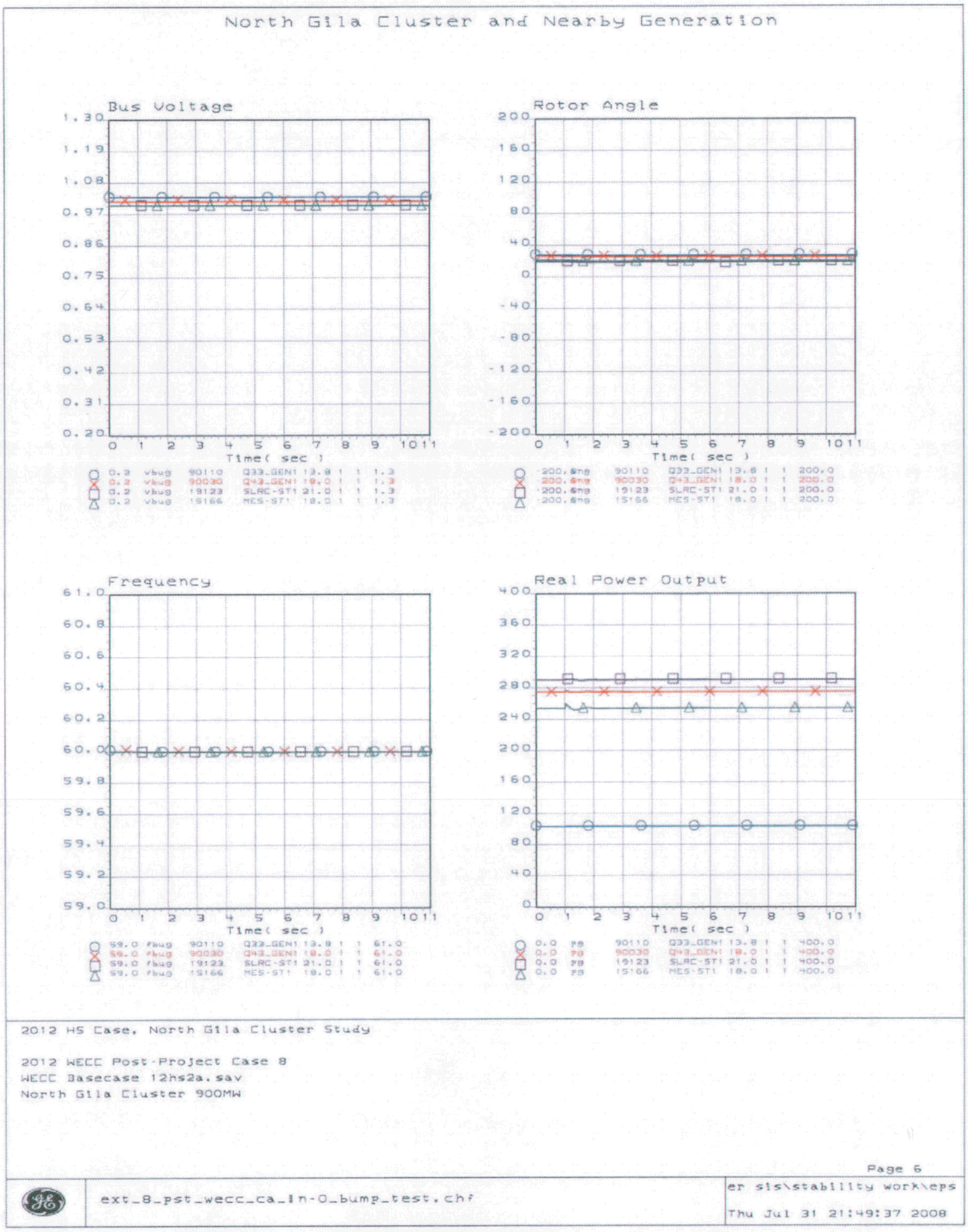
Block Diagram, "blwscc" model



## Figure E-1: Flat Run WECC Case #8



## Figure E-2: Bump Test WECC Case #8



## Figure E-2: Flat Run WOR Case #12

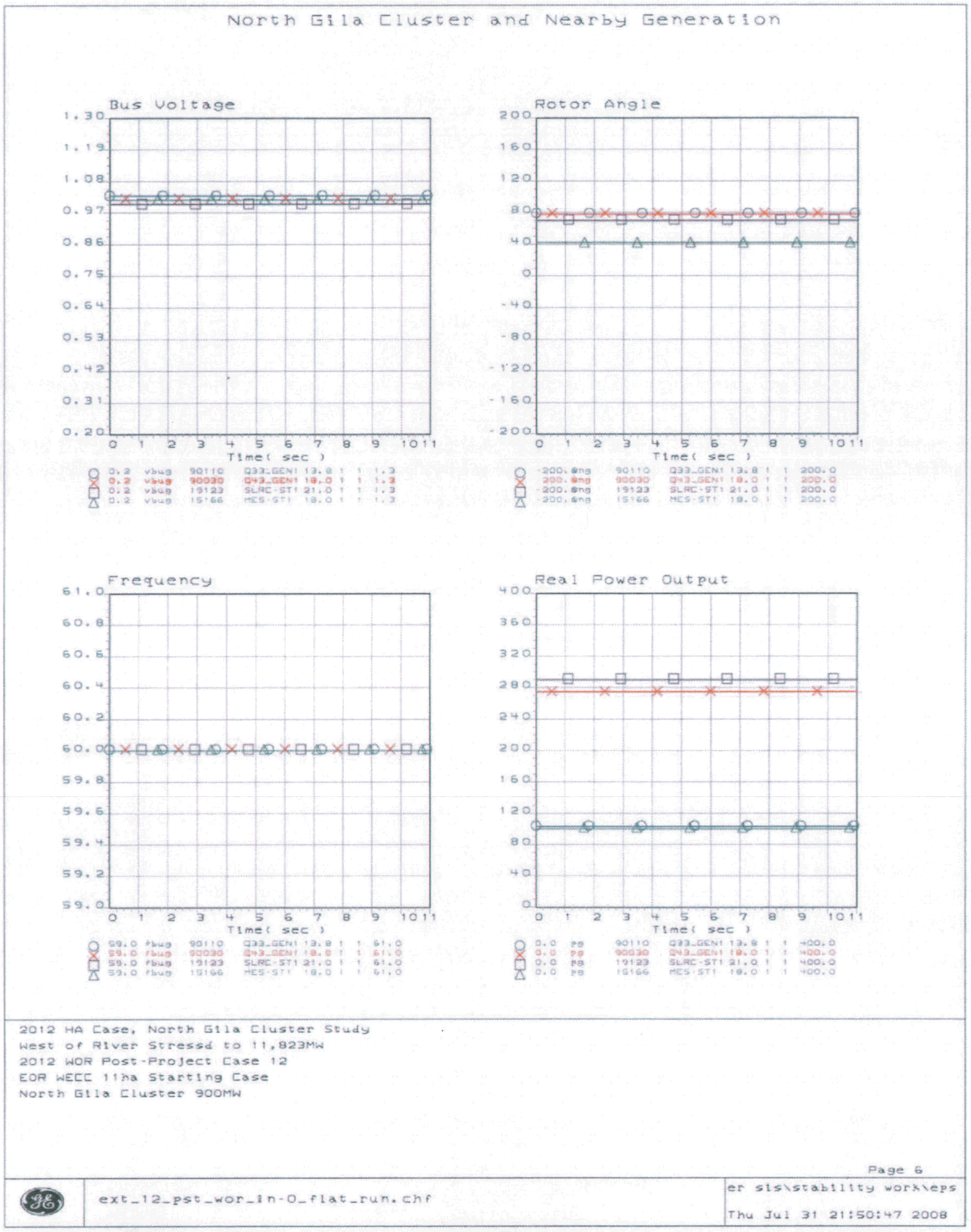
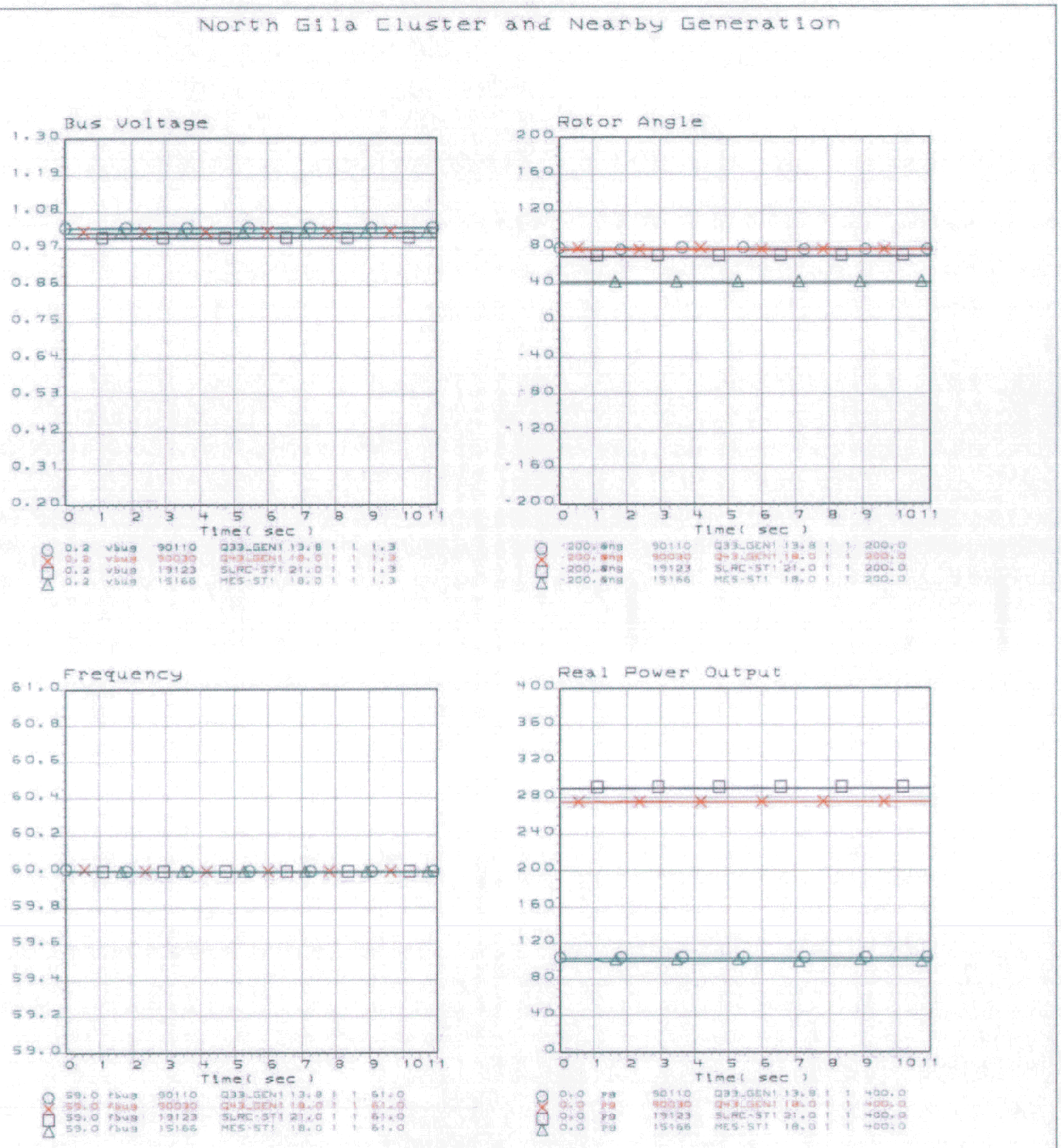


**Figure E-2: Bump Test WOR Case #12**




2012 HA Case, North Gila Cluster Study
West of River Stressd to 11,823MW
2012 WOR Post-Project Case 12
EOR WECC 11ha Starting Case
North Gila Cluster 900MW

Page 6

ext_12_pst_wor_in-0_bump_test.chf

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Thu Jul 31 21:51:21 2008

# Appendix D

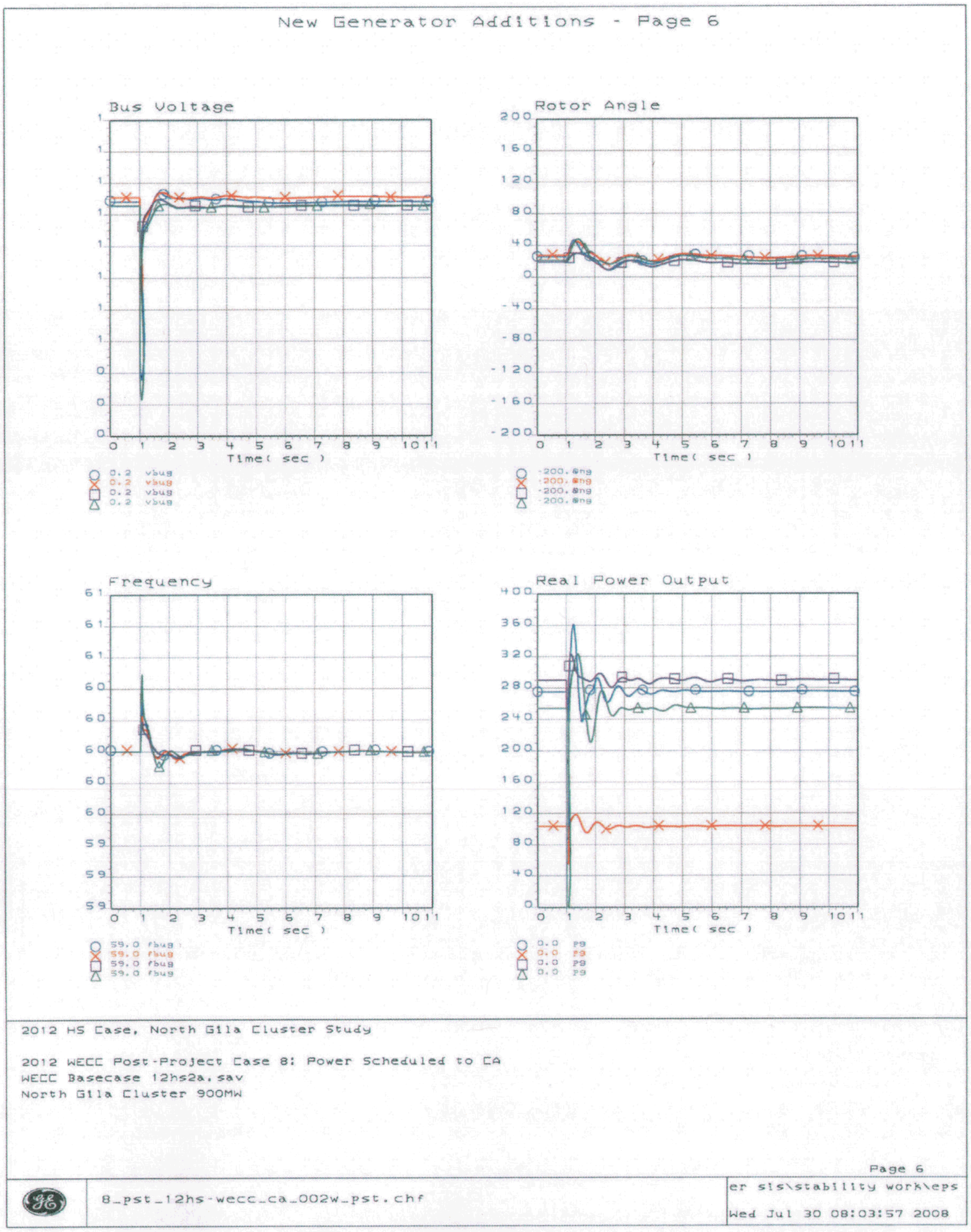
# Appendix D

## Transient Stability Plots

# Transient Stability Plots: North Gila Cluster System Impact Study

| Diagram | Case | Description |
|---|---|---|
| | 8 | **Post-Project Case: Normal Initial Conditions, Power Scheduled to CA** |
| Plot #1 | 8 | Three-phase fault at North Gila followed by an outage of the Hassayampa-North Gila #2 |
| Plot #2 | 8 | Three-phase fault at North Gila followed by an outage of the North Gila-Imperial Valley 500kV line with SLRC SPS actions. |
| Plot #3 | 8 | Three-phase fault at North Gila followed by an outage of both Hassayampa-North Gila #1 and #2 500kV lines. |
| | 10 | **Post-Project Case: No Hassayampa-North Gila #2, Power Scheduled to CA** |
| Plot #4 | 10 | Three-phase fault at Hassayampa followed by an outage of the Hassayampa-North Gila #1 |
| Plot #5 | 10 | Three-phase fault at North Gila followed by an outage of the Hassayampa-North Gila #1 |
| Plot #6 | 10 | Three-phase fault at Devers followed by an outage of both Palo Verde-Devers #1 and #2 500kV lines. |
| | 12 | **Post-Project Case: West of River Stressed** |
| Plot #7 | 12 | Three-phase fault at North Gila followed by an outage of the Hassayampa-North Gila #2 |
| Plot #8 | 12 | Three-phase fault at North Gila followed by an outage of the North Gila-Imperial Valley 500kV line with SLRC SPS actions. |
| Plot #9 | 12 | Three-phase fault at Devers followed by an outage of both Palo Verde-Devers #1 and #2 500kV lines with SPS action that drops 1159MW in SCE. |

Plot #1


New Generator Additions - Page 6
Bus Voltage
Rotor Angle
Frequency
Real Power Output
Time( sec )
2012 HS Case, North Gila Cluster Study
2012 WECC Post-Project Case 8: Power Scheduled to CA
WECC Basecase 12hs2a.sav
North Gila Cluster 900MW
Page 6
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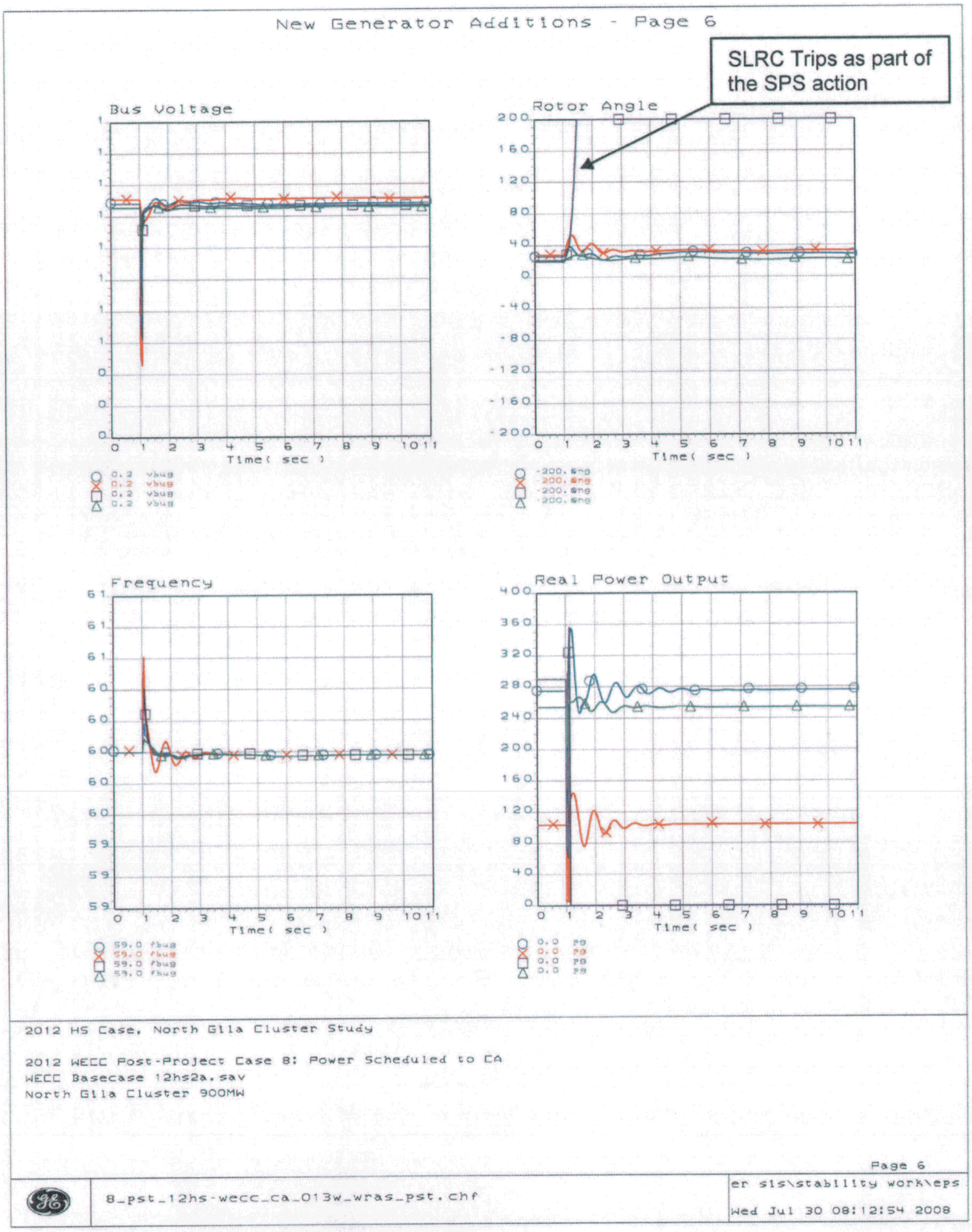
Plot #2


New Generator Additions - Page 6
SLRC Trips as part of the SPS action
Bus Voltage
Rotor Angle
Frequency
Real Power Output
Time( sec )
2012 HS Case, North Gila Cluster Study
2012 WECC Post-Project Case 8: Power Scheduled to CA
WECC Basecase 12hs2a.sav
North Gila Cluster 900MW
Page 6
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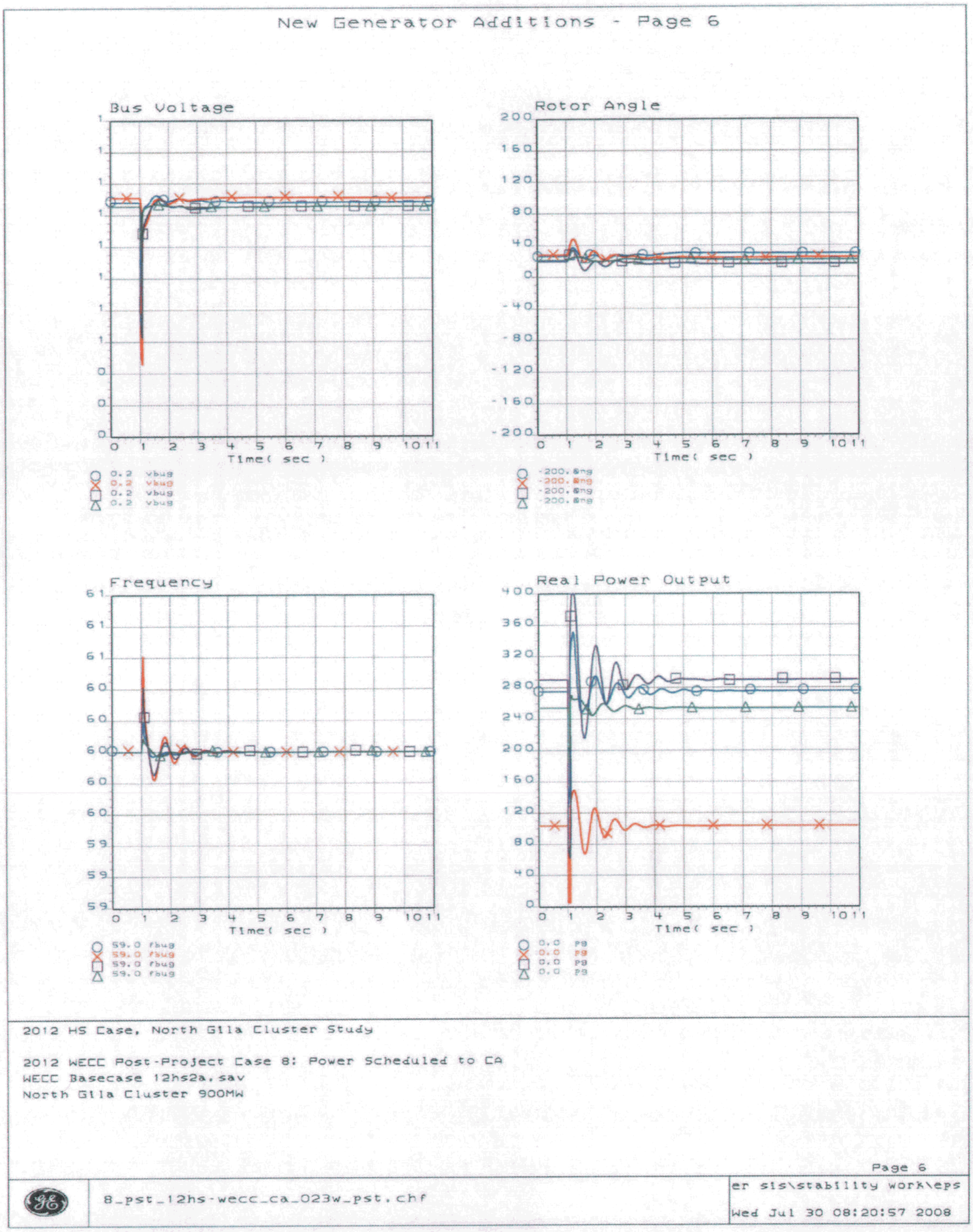
## Plot #3



New Generator Additions - Page 6
Bus Voltage
Rotor Angle
Frequency
Real Power Output
Time( sec )
2012 HS Case, North Gila Cluster Study
2012 WECC Post-Project Case 8: Power Scheduled to CA
WECC Basecase 12hs2a.sav
North Gila Cluster 900MW
Page 6
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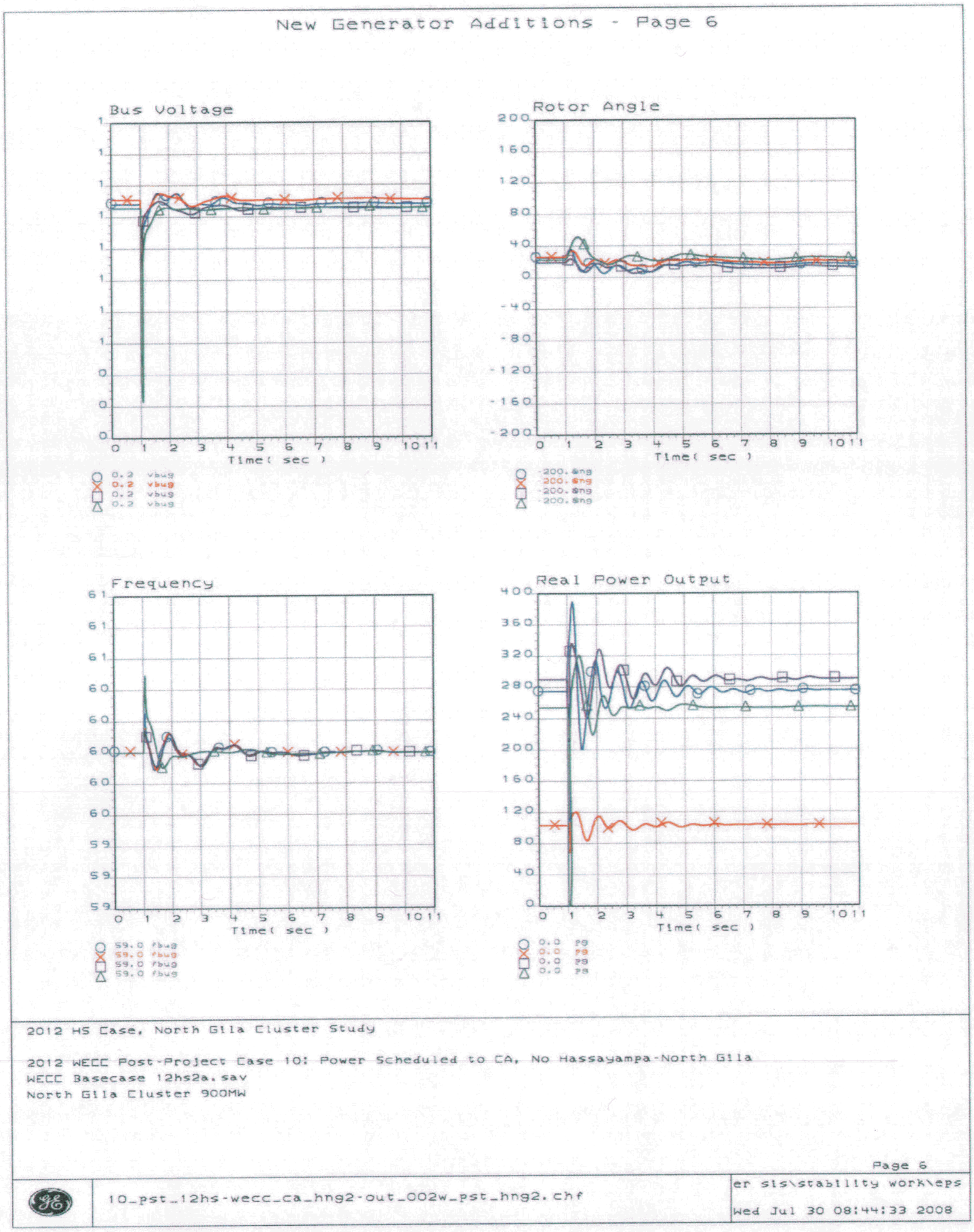
Wed Jul 30 08:20:57 2008

Plot #4


New Generator Additions - Page 6
Bus Voltage
Time( sec )
0.2 vbug
0.2 vbug
0.2 vbug
0.2 vbug
Rotor Angle
Time( sec )
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Frequency
Time( sec )
59.0 fbug
59.0 fbug
59.0 fbug
59.0 fbug
Real Power Output
Time( sec )
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0.0 pg
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0.0 pg
2012 HS Case, North Gila Cluster Study
2012 WECC Post-Project Case 10: Power Scheduled to CA, No Hassayampa-North Gila
WECC Basecase 12hs2a.sav
North Gila Cluster 900MW
Page 6
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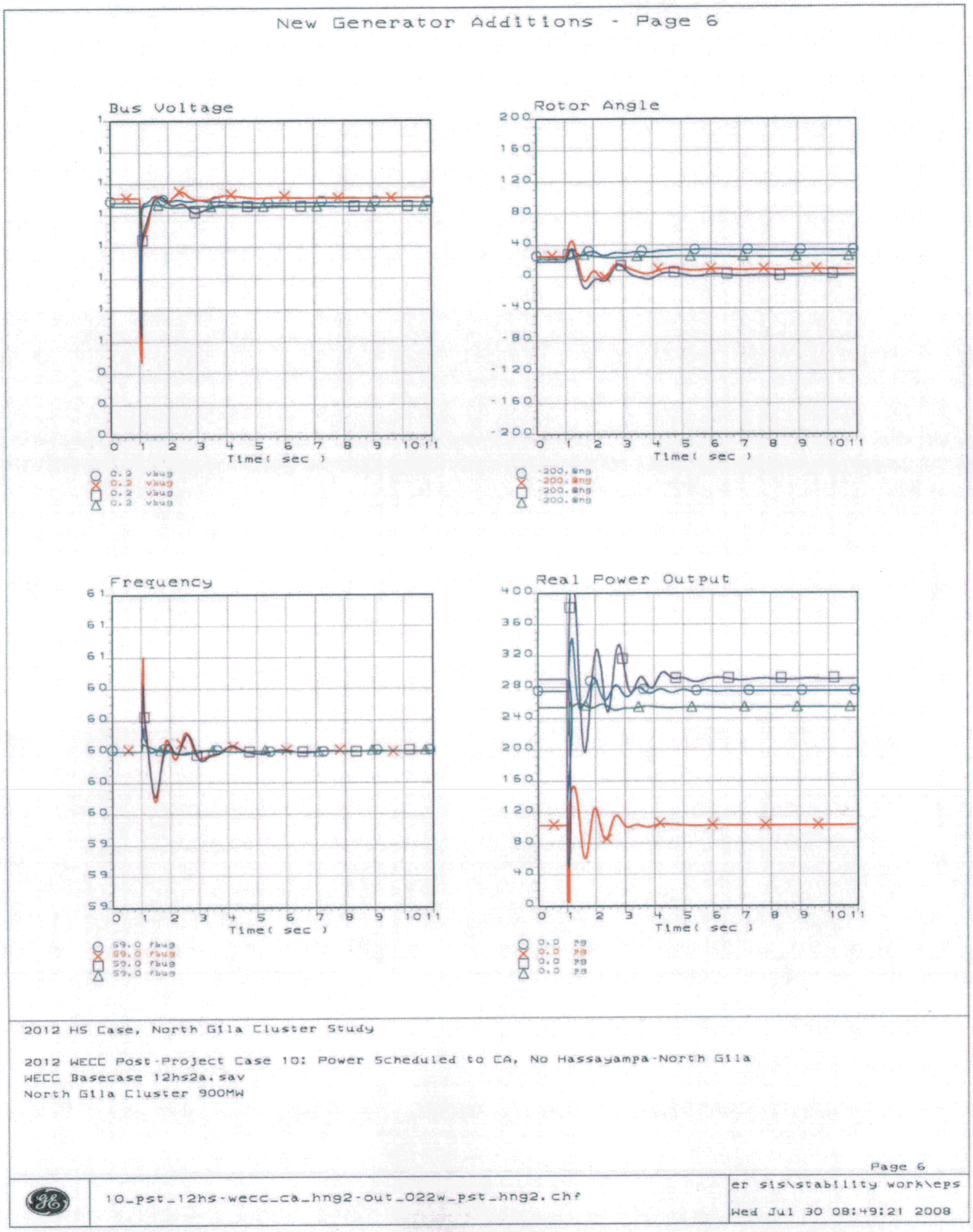
Plot #5


New Generator Additions - Page 6
Bus Voltage
Rotor Angle
Frequency
Real Power Output
Time( sec )
2012 HS Case, North Gila Cluster Study
2012 WECC Post-Project Case 10: Power Scheduled to CA, No Hassayampa-North Gila
WECC Basecase 12hs2a.sav
North Gila Cluster 900MW
Page 6
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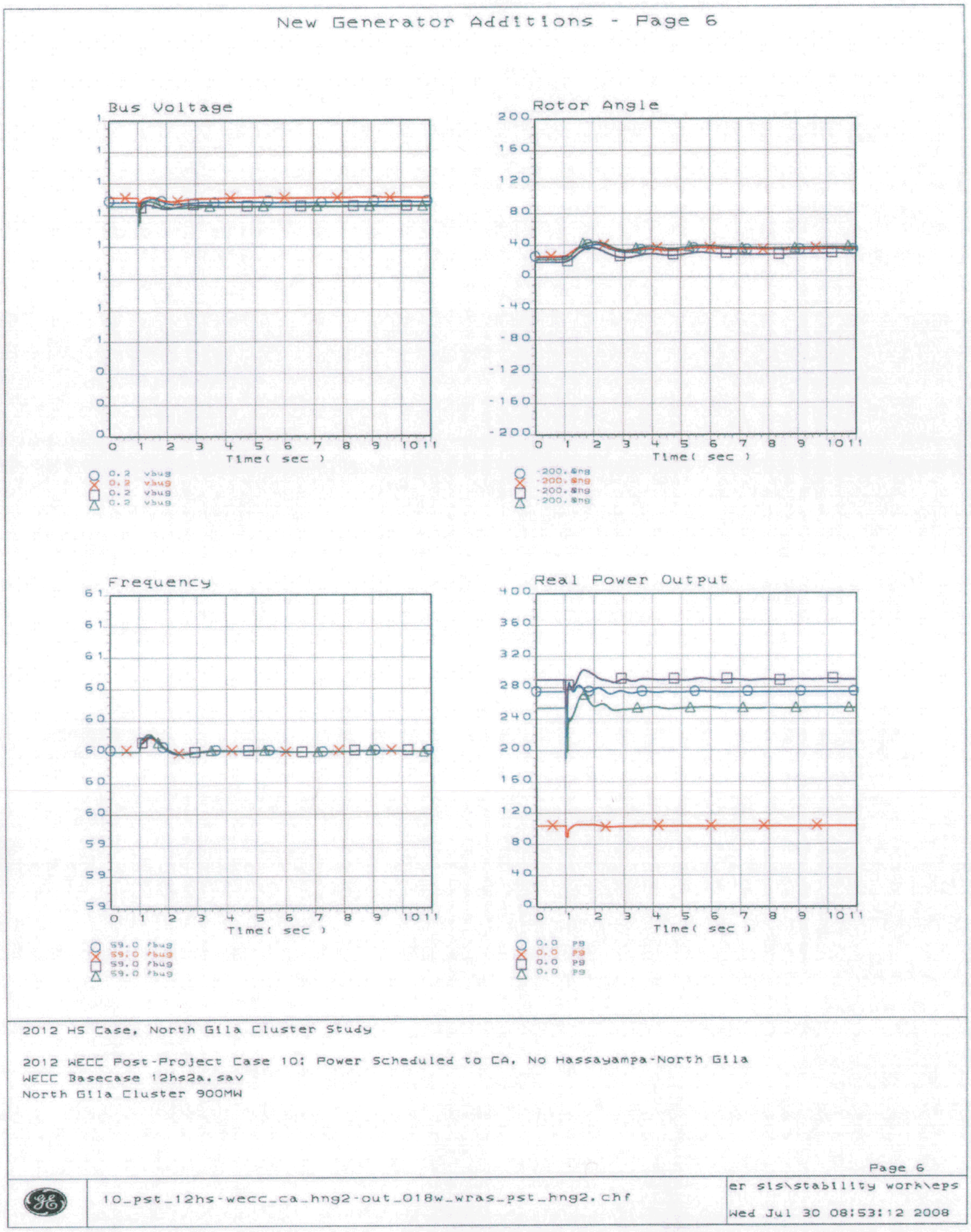
## Plot #6


New Generator Additions - Page 6
Bus Voltage
Rotor Angle
Frequency
Real Power Output
Time( sec )
2012 HS Case, North Gila Cluster Study
2012 WECC Post-Project Case 10: Power Scheduled to CA, No Hassayampa-North Gila
WECC Basecase 12hs2a.sav
North Gila Cluster 900MW
Page 6
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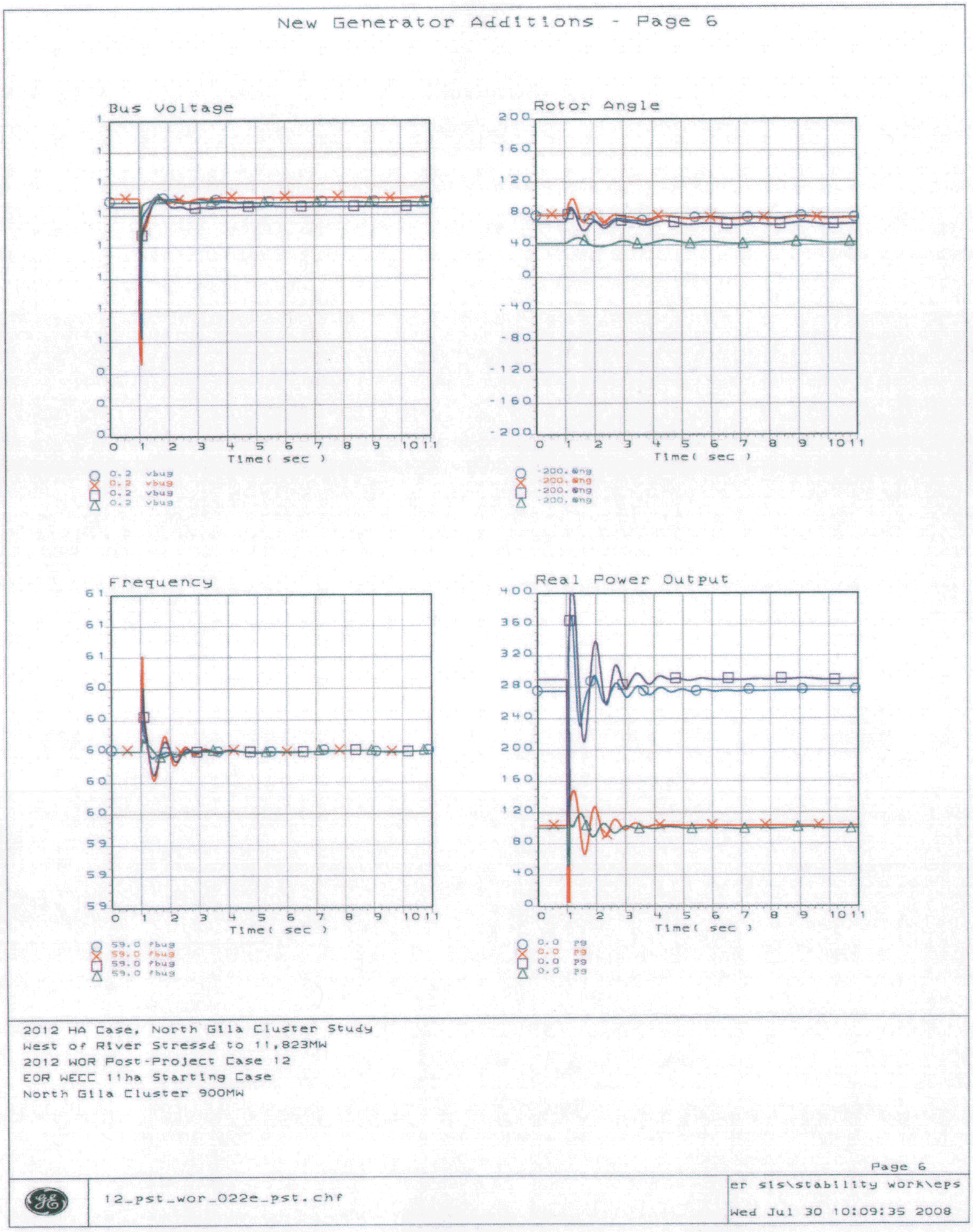
Plot #7


New Generator Additions - Page 6
Bus Voltage
Rotor Angle
Frequency
Real Power Output
Time( sec )
0.2 vbus
-200.
59.0 fbus
0.0 pg
2012 HA Case, North Gila Cluster Study
West of River Stressd to 11,823MW
2012 WOR Post-Project Case 12
EOR WECC 11ha Starting Case
North Gila Cluster 900MW
Page 6
12_pst_wor_022e_pst.chf
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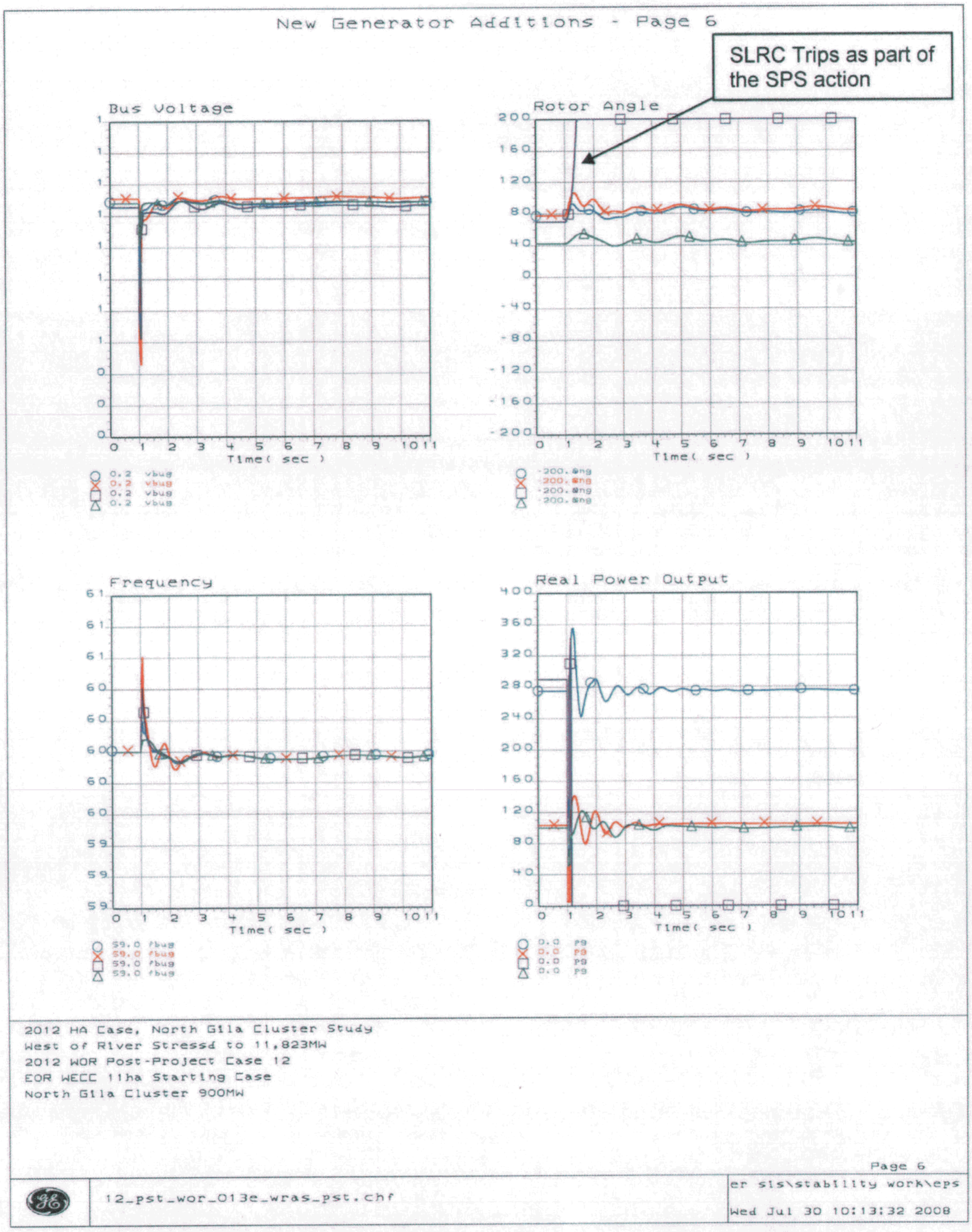
Wed Jul 30 10:09:35 2008

Plot #8


New Generator Additions - Page 6
SLRC Trips as part of the SPS action
Bus Voltage
Rotor Angle
Frequency
Real Power Output
Time( sec )
0.2 vbus
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59.0 fbus
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2012 HA Case, North Gila Cluster Study
West of River Stressd to 11,823MW
2012 WOR Post-Project Case 12
EOR WECC 11ha Starting Case
North Gila Cluster 900MW
Page 6
12_pst_wor_013e_wras_pst.chf
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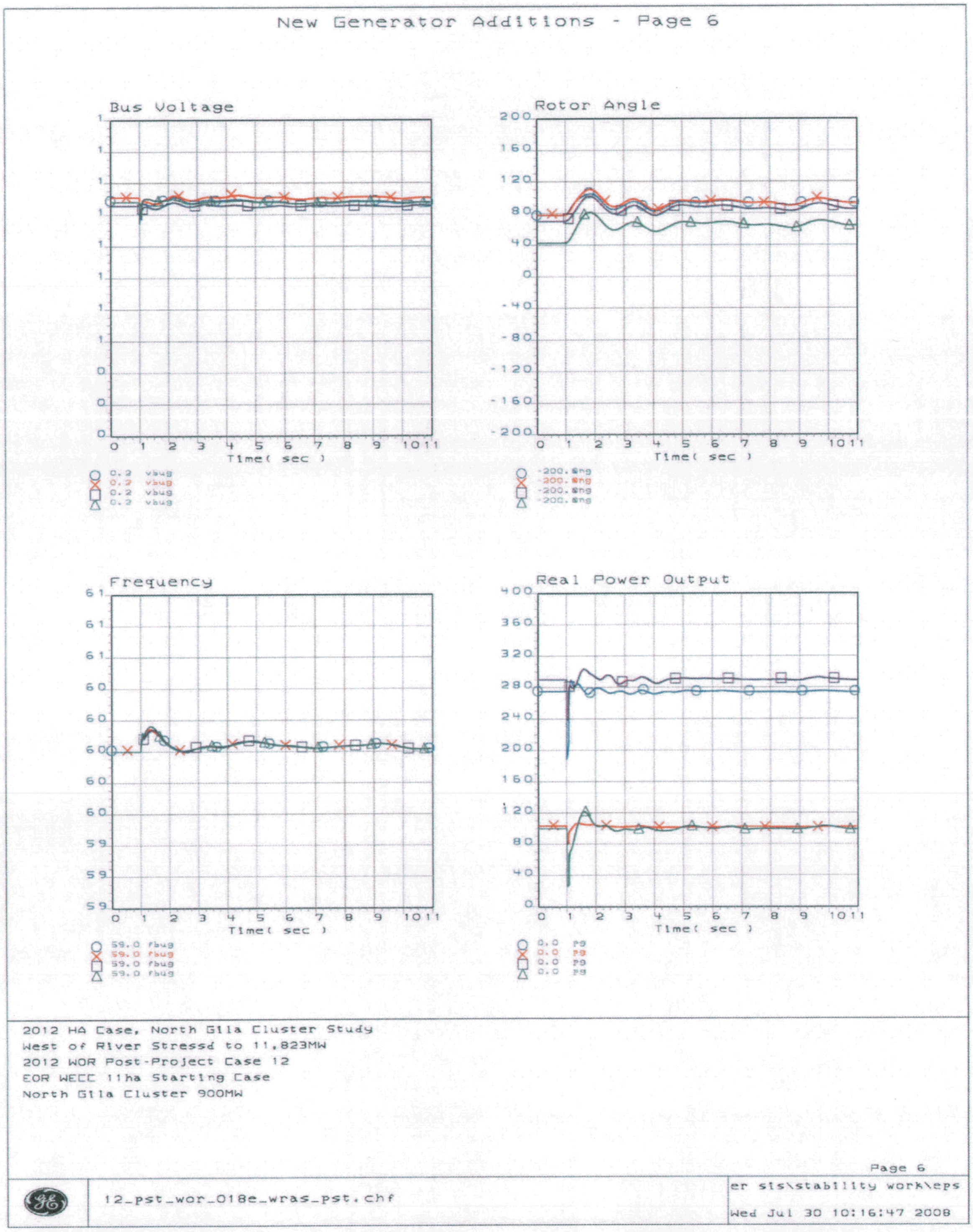
Plot #9


New Generator Additions - Page 6
Bus Voltage
Rotor Angle
Frequency
Real Power Output
Time( sec )
2012 HA Case, North Gila Cluster Study
West of River Stressd to 11,823MW
2012 WOR Post-Project Case 12
EOR WECC 11ha Starting Case
North Gila Cluster 900MW
Page 6
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# Appendix E

# Palo Verde Proximity Generation Cluster Study

Including:
Short Circuit

August 07, 2008

Salt River Project

# 1 EXECUTIVE SUMMARY

The Salt River Project (SRP) on request from APS performed a short circuit study that determined the technical impact of the multiple proposed generation projects (the "Projects") on the Palo Verde and Hassayampa switchyard. The study was conducted with and without the proposed generation projects.

The Projects terminated at various 230kV and 500kV buses. The short circuit analysis will be limited to the impact at Palo Verde and Hassayampa 500kV bus.

The short circuit duty determined that, while there was an impact (5.4kA at most) due to the addition of the Projects on a 2008 ASPEN case, no circuit breakers required upgrading or replacement.

# 2 TABLE OF CONTENTS

## 3 INTRODUCTION

The Salt River Project (SRP) on request from APS performed a short circuit study that determined the technical impact of the multiple proposed generation projects (the "Projects") on the Palo Verde and Hassayampa switchyard. The study was conducted with and without the proposed generation projects.

The Projects consist of wind and solar generation with a total of 3,230 MW output. The Projects are separated into two phases. The Projects interconnect various buses: Gila Bend, North Gila, Harquahala Junction and Moenkopi. The Projects are anticipated to be in service starting in 2011.

## 4 STUDY ASSUMPTIONS

- Voltage Level studied at 525kV, 530kV, 535kV and 550kV
- Some zero sequence data was approximated from the positive sequence. Please refer to the Appendices of Data inputted into Aspen program for Short Circuit Analysis.
- 2011 system additions:
  - APS
    - 500kV Pinnacle Peak/ Raceway
    - 500kV Raceway/TS5
    - 500kV TS5/Harquahala Junction
    - 230kV Pinnacle Peak/ Raceway
    - 230kV Palm Valley/TS5
    - 230kV Pinal Central/Sundance
  - SRP
    - 500kV Pinal West/Santa Rosa
    - 500kV Santa Rosa/Pinal Central
    - 500kV Pinal Central/Abel
    - 500kV Abel/Browning
    - 230kV Pinal Central/ Desert Basin

## 5 STUDY DESCRIPTION AND METHODOLOGY

Although the Projects will not interconnect directly at Palo Verde/Hassayampa 500kV buses, the impact on short circuit values at Palo Verde/Hassayampa had to be evaluated. The study included the following technical analyses and cases:

- Short Circuit
  - SRP current (2008) short circuit (Aspen) case
  - SRP 2011 short circuit (Aspen) case

The study focused on the impact of the Projects on existing Palo Verde/Hassayampa Switchyards by studying the following scenarios:

- Scenario A: PV/HAA fault duties for 2008
- Scenario B: PV/HAA fault duties for 2011

The Projects consist of multiple generation clusters. The generation clusters with capacity are the following (Q marks the generator position in APS queue):

- Gila Bend Cluster
    - Q44 – 280MW

- North Gila Cluster
    - Q33 – 400MW
    - Q41 – 250MW
    - Q43 – 500MW

- Harquahala Junction Cluster
    - Q38 – 400MW
    - Q39 – 800MW
    - Q42 – 500MW

- Moenkopi Cluster
    - Q36 – 1000MW

The Projects will be divided into two phases. Phase 1 and Phase 2 Clusters consist of the following Projects:

- Phase 1 Cluster
    - Q33 – 400MW
    - Q36 – 1000MW
    - Q42 – 500MW
    - Q43 – 500MW
    - Q44 – 280MW

- Phase2 Cluster
    - Q38 – 400MW
    - Q39 – 800MW
    - Q41 – 250MW

## 5.1 Short Circuit

### 5.1.1 Description

The following items were the objective of the short circuit analysis:

- Determine the impact on the circuit breaker duties at the Palo Verde/Hassayampa Switchyard from the interconnection point of the Projects.
- Identify the requirements, including replacements and upgrades of the existing 500kV circuit breakers at the Palo Verde/Hassayampa Switchyards as impacted by the Projects.

### 5.1.2 Methodology

The short circuit fault duties due to single line to ground and three phase faults were conducted on an SRP Aspen short circuit cases reflecting 1) the existing SRP system and 2) the "proposed" 2011 system and the Projects. The fault duty under the simulated faults for breakers at Palo Verde/Hassayampa Switchyard was documented.

### 5.1.3 Study Criteria

Circuit breakers exposed to fault currents in excess of 100% of their interrupting capabilities will be replaced or upgraded, whichever is appropriate.

# 6 FINDINGS

## *6.1 Short Circuit*

The addition of the Projects increased fault duty at breakers in the system, however the addition of the Projects did not show the need to replace or upgrade breakers. The highest impact was at the 550kV of Phase 2 from 2008 with a 5.4kA increase due to a single phase fault at the Hassayampa bus.

The fault duty of the breakers from phase 2 of 2011 increased by an average of 2.8kA at 525kV, 2.9kA at 530kVand 535kV, and 3.0kA at 550kV for Palo Verde and Hassayampa buses compared to the base case.

## 2008 SHORT CIRCUIT IMPACT – PHASE 1

| Fault Location | Breaker Rating (kA) | FAULT CURRENT (KA) Pre Project | Post Project | Pre Project | Post Project | Pre Project | Post Project | Pre Project | Post Project |
|---|---|---|---|---|---|---|---|---|---|
| Palo Verde/Hassayampa 500kV | | @ 525kV | | @ 530kV | | @ 535kV | | @ 550kV | |
| 3 Phase | 63 | 49.5/49.0 | 50.9/50.6 | 50.0/49.5 | 51.4/51.1 | 50.4/50.0 | 51.9/51.6 | 51.8/51.3 | 53.3/53.0 |
| SLG | 63 | 52.5/51.1 | 54.2/53.1 | 53.0/51.6 | 54.7/53.6 | 53.5/52.1 | 55.2/54.1 | 55.0/53.5 | 56.8/55.6 |

**Table 1 - 2008 Short Circuit, Phase 1, no outage**

## 2008 SHORT CIRCUIT IMPACT – PHASE 2

| Fault Location | Breaker Rating (kA) | FAULT CURRENT (KA) Pre Project | Post Project | Pre Project | Post Project | Pre Project | Post Project | Pre Project | Post Project |
|---|---|---|---|---|---|---|---|---|---|
| Palo Verde/Hassayampa 500 kV | | @ 525kV | | @ 530kV | | @ 535kV | | @ 550kV | |
| 3 Phase | 63 | 49.5/49.0 | 53.6/53.6 | 50.0/49.5 | 54.2/54.1 | 50.4/50.0 | 54.7/54.6 | 51.8/51.3 | 56.2/56.1 |
| SLG | 63 | 52.5/51.1 | 56.8/56.2 | 53.0/51.6 | 57.3/56.7 | 53.5/52.1 | 57.9/57.3 | 55.0/53.5 | 59.5/58.9 |

**Table 2 - 2008 Short Circuit, Phase 2, no outage**

## 2011 SHORT CIRCUIT IMPACT – PHASE 1

| Fault Location | Breaker Rating (kA) | FAULT CURRENT (KA) Pre Project | Post Project | Pre Project | Post Project | Pre Project | Post Project | Pre Project | Post Project |
|---|---|---|---|---|---|---|---|---|---|
| Palo Verde/Hassayampa 500 kV | | @ 525kV | | @ 530kV | | @ 535kV | | @ 550kV | |
| 3 Phase | 63 | 52.2/52.4 | 53.6/53.7 | 52.7/52.7 | 54.1/54.2 | 53.2/53.2 | 54.6/54.7 | 54.7/54.7 | 56.1/56.2 |
| SLG | 63 | 54.8/53.8 | 56.0/55.0 | 55.3/54.2 | 56.5/55.5 | 55.8/54.7 | 57.0/56.1 | 57.4/56.2 | 58.6/57.6 |

**Table 3 - 2011 Short Circuit, Phase 1, no outage**

## 2011 SHORT CIRCUIT IMPACT – PHASE 2

| Fault Location | Breaker Rating (kA) | FAULT CURRENT (KA) Pre Project | Post Project | Pre Project | Post Project | Pre Project | Post Project | Pre Project | Post Project |
|---|---|---|---|---|---|---|---|---|---|
| Palo Verde/Hassayampa 500 kV | | @ 525kV | | @ 530kV | | @ 535kV | | @ 550kV | |
| 3 Phase | 63 | 52.2/52.4 | 55.2/55.5 | 52.7/52.7 | 55.7/56.0 | 53.2/53.2 | 56.3/56.5 | 54.7/54.7 | 57.8/58.1 |
| SLG | 63 | 54.8/53.8 | 57.2/56.4 | 55.3/54.2 | 57.8/56.9 | 55.8/54.7 | 58.3/57.4 | 57.4/56.2 | 60.0/59.0 |

**Table 4 - 2011 Short Circuit, Phase 2, no outage**

**Figure 1 – 2008 Short Circuit, Phase 2, 3 Phase Fault @ Palo Verde**

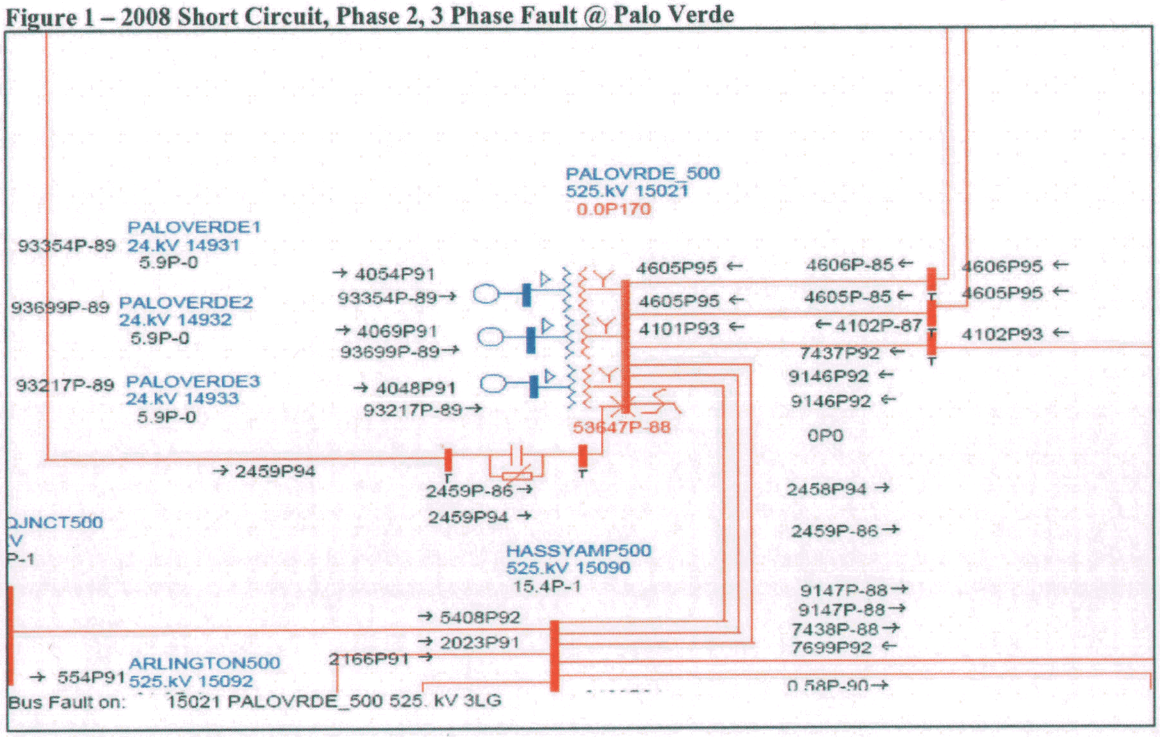



**Figure 2 – 2008 Short Circuit, Phase 2, Single Line Fault @ Palo Verde**

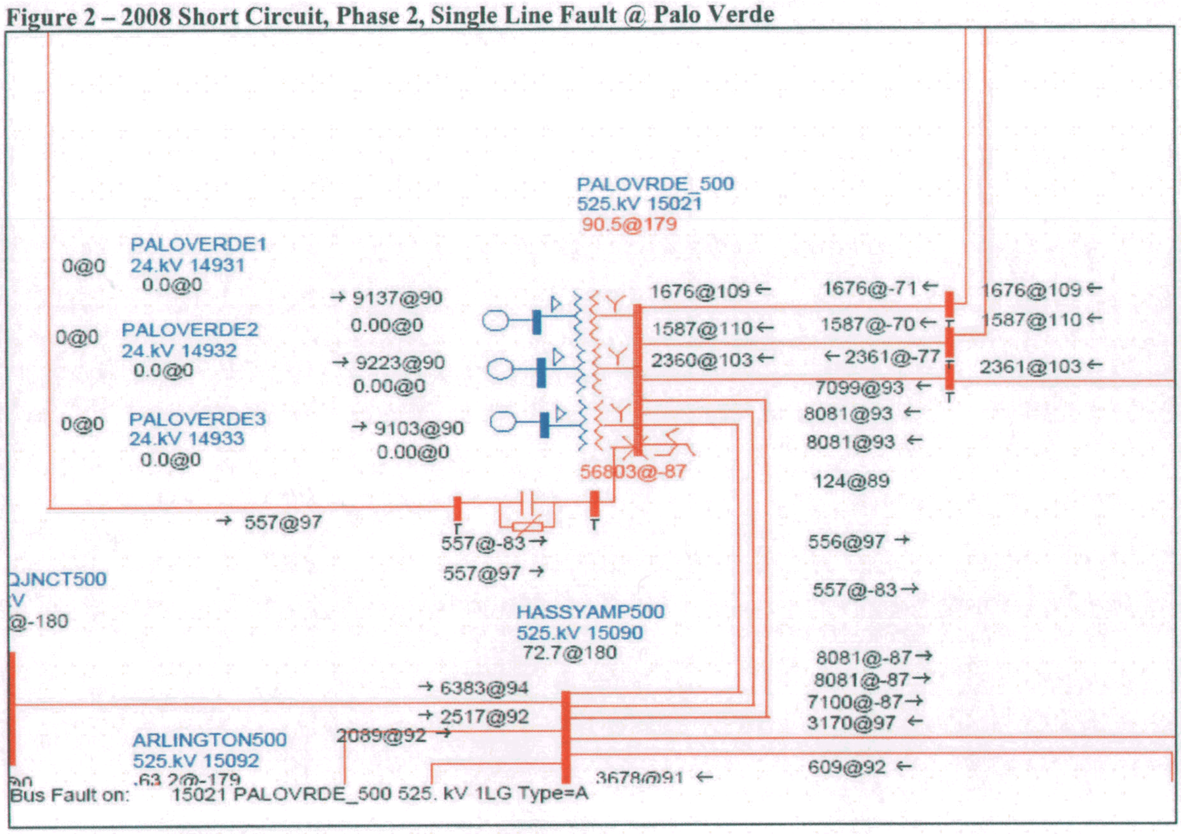


Figure 3 – 2011 Short Circuit, Phase 2, 3 Phase Fault @ Palo Verde

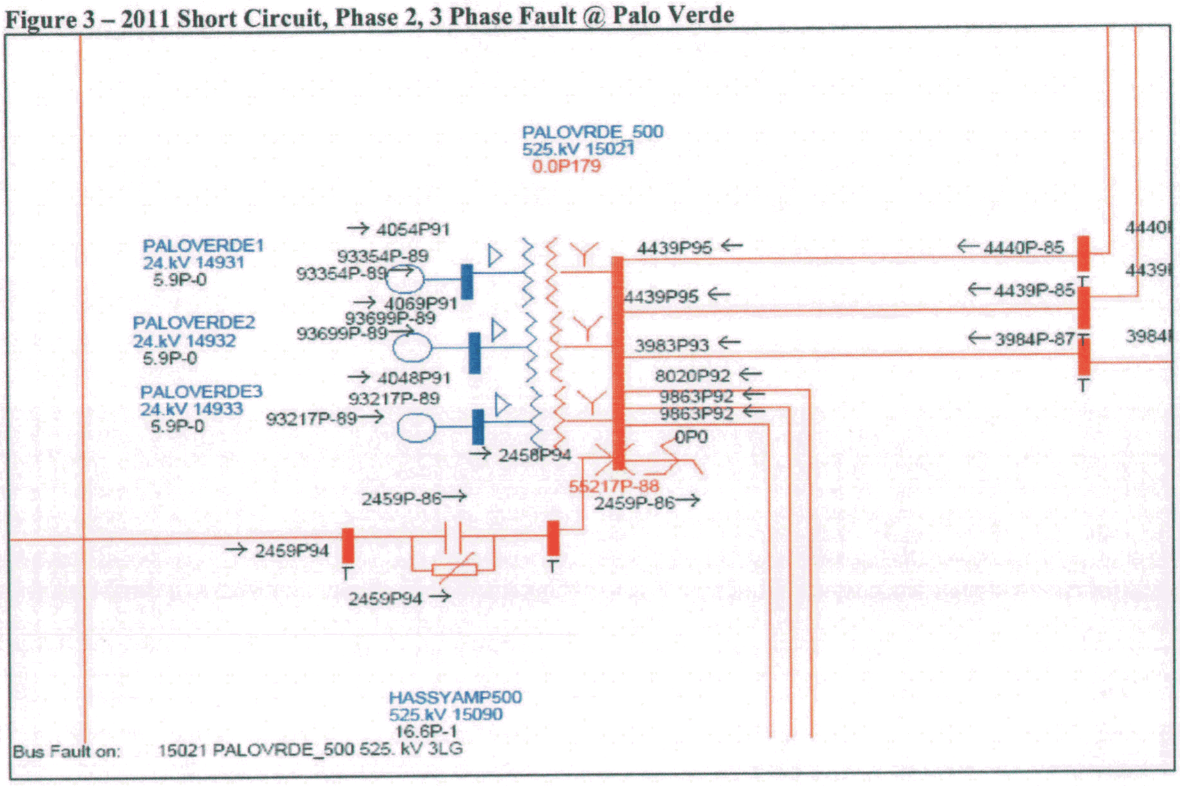
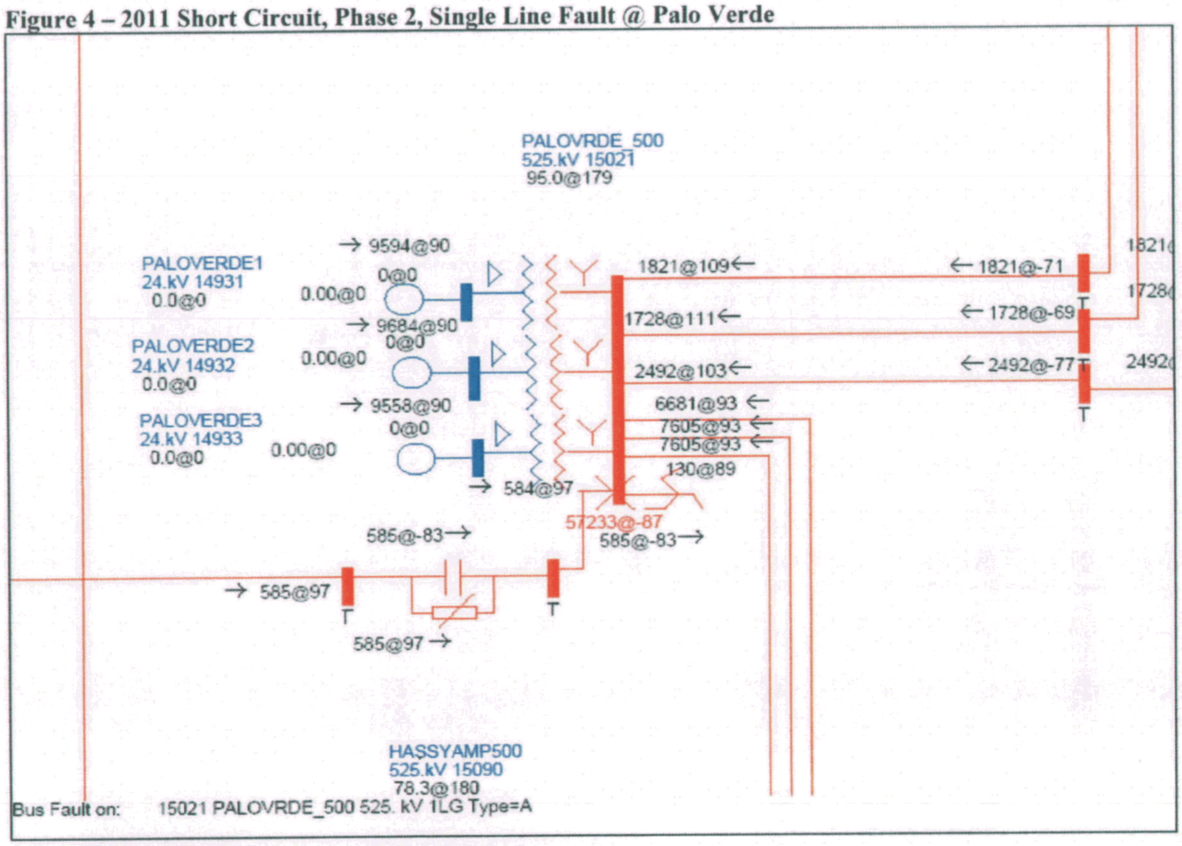



Figure 4 – 2011 Short Circuit, Phase 2, Single Line Fault @ Palo Verde



**Appendix 1 –Gila Bend Data Sheet**

Gila Bend Cluster

| | | | | | | |
|---|---|---|---|---|---|---|
| Station: | Q44 | # Units: 2 | GSU Transformer Data | 230/13.8kV | Connection: | Δ - Y |
| Generator Data | | 280MW | | R | X | |
| | R | X | | 0.08 | 0.05714 | |
| | 0.001 | 0.095 | | | | |
| | | | | RΦ | XΦ | |
| | | | | 0.24 | 0.1742 | |
| Line Data | 14mile | 954ACSR | | | | |
| | R | X | | | | |
| | 0.0286 | 0.02066 | | | | |
| | | | | | | |
| | RΦ | XΦ | | | | |
| | 0.0857 | 0.06199 | | | | |

**Appendix 2 –Moenkopi Data Sheet**

Moenkopi Cluster

| | | | | | | |
|---|---|---|---|---|---|---|
| Station: | Q36 | # Units: 16 | GSU Transformer Data | 230/13.8kV | Connection: | Δ - Y |
| Generator Data | | 1,000MW | | Zpsr | 0.004 | |
| | R | X | | Zpsx | 0.133 | |
| | 0.0084 | 0.1932 | | Zptr | 0.004 | |
| | | | | Zptx | 0.1345 | |
| | | | | Ztsr | 0.005 | |
| Line Data | 8mile | 795ACSR | | Ztsx | 0.256 | |
| | R | X | | | | |
| | 0.00034 | 0.00267 | Transformer Data | 500/230kV | Connection: | Y -Y |
| | | | | R | X | |
| | RΦ | XΦ | | 0.00115 | 0.075 | |
| | 0.001 | 0.00801 | | | | |
| | | | | RΦ | XΦ | |
| | | | | 0.000345 | 0.0225 | |

**Appendix 3 – North Gila Data Sheet**

North Gila Cluster

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Station: | Q33 | # Units: 4 | | GSU Transformer Data | 69/13.8kV | Connection: | Δ - Y |
| Generator Data | | 400MW | | | R | X | |
| | R | X | | | 0.0018 | 0.07 | |
| | 0.0011 | 0.147 | | | | | |
| | | | | | RΦ | XΦ | |
| | | | | | 0.005 | 0.21 | |
| Line Data | 4mile | 954ACSR | | | | | |
| Quantity: 2 | R | X | | Transformer Data | 500/69kV | Connection: | Δ - Y |
| | 0.01345 | 0.04036 | | Quantity: 2 | R | X | |
| | | | | | 0.002 | 0.08 | |
| | RΦ | XΦ | | | | | |
| | 0.04036 | 0.12108 | | | RΦ | XΦ | |
| | | | | | 0.002 | 0.08 | |
| Station: | Q41 | # Units: 2 | | GSU Transformer Data | 500/18kV | Connection: | Δ - Y |
| Generator Data | | 275MW | | | R | X | |
| | R | X | | | 0.0015 | 0.078 | |
| | 0.0008 | 0.096 | | | | | |
| | | | | | RΦ | XΦ | |
| | | | | | 0.0045 | 0.234 | |
| Line Data | 1mile | | | | | | |
| | R | X | | | | | |
| | 0.00011 | 0.00034 | | | | | |
| | | | | | | | |
| | RΦ | XΦ | | | | | |
| | 0.00034 | 0.00102 | | | | | |
| Station: | Q43 | # Units: 2 | | GSU Transformer Data | 500/18kV | Connection: | Δ - Y |
| Generator Data | | 500MW | | | R | X | |
| | R | X | | | 0.00426 | 0.085 | |
| | 0.0004 | 0.68 | | | | | |
| | | | | | RΦ | XΦ | |
| | | | | | 0.01278 | 0.255 | |
| Line Data | 1mile | 954ACSR | | | | | |
| | R | X | | | | | |
| | 0.00011 | 0.00033 | | | | | |
| | | | | | | | |
| | RΦ | XΦ | | | | | |
| | 0.00033 | 0.00099 | | | | | |

**Appendix 4 –Harqua\hala Junction Data Sheet**

Harquahala Junction Cluster

| | | | | | | |
|---|---|---|---|---|---|---|
| Station: | Q38 | # Units: 4 | GSU Transformer Data | 230/13.8kV | Connection: | Δ - Y |
| Generator Data | | 400MW | | R | X | |
| | R | X | | 0.0009 | 0.035 | |
| | 0.0011 | 0.147 | | | | |
| | | | | RΦ | XΦ | |
| | | | | 0.0027 | 0.105 | |
| Line Data | 5mile | 954ACSR | | | | |
| | R | X | Transformer Data | 500/230kV | Connection: | Δ - Y |
| | 0.00243 | 0.00738 | | R | X | |
| | | | | 0.00187 | 0.075 | |
| | RΦ | XΦ | | | | |
| | 0.00728 | 0.02214 | | RΦ | XΦ | |
| | | | | 0.00187 | 0.075 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Station: | Q39 | # Units: 8 | GSU Transformer Data | 230/13.8kV | Connection: | Δ - Y |
| Generator Data | | 800MW | | R | X | |
| | R | X | | 0.0009 | 0.035 | |
| | 0.0011 | 0.147 | | | | |
| | | | | RΦ | XΦ | |
| | | | | 0.0027 | 0.105 | |
| Line Data | 5mile | 954ACSR | | | | |
| Quantity: 2 | R | X | Transformer Data | 500/230kV | Connection: | Δ - Y |
| | 0.00176 | 0.00528 | Quantity: 2 | R | X | |
| | | | | 0.00187 | 0.075 | |
| | RΦ | XΦ | | | | |
| | 0.00528 | 0.01584 | | RΦ | XΦ | |
| | | | | 0.00187 | 0.075 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Station: | Q42 | # Units: 2 | GSU Transformer Data | 500/18kV | Connection: | Δ - Y |
| Generator Data | | 500MW | | R | X | |
| | R | X | | 0.0014 | 0.028 | |
| | 0.0004 | 0.68 | | | | |
| | | | | RΦ | XΦ | |
| | | | | 0.0042 | 0.084 | |
| Line Data | 1mile | | | | | |
| | R | X | | | | |
| | 0.0001 | 0.00033 | | | | |
| | | | | | | |
| | RΦ | XΦ | | | | |
| | 0.00003 | 0.00099 | | | | |

# Appendix F

# Appendix F. No Mesquite Solar Sensitivity

Due to speculation over inclusion of the 720MW Mesquite Solar project in this study, Applicants #33 and #43 requested an assessment of the Mesquite Solar impact upon the results of this study. The 720MW plant was turned offline and the KYRENE 4 and 5, DBG CT1-2 and ST1, and OCOTGT2 units were turned online. The project appears to have a minimal impact upon the magnitude of the overloads. However due to the small distribution factors of the units in the cluster, the small decrease in overloads results in a large decrease in the generation curtailment.

**Table 1** summarizes the thermal loading results from the power flow simulation. The change from the original case is included in the parentheses. Since the post-transient simulation is anticipated to be similar the power flow, only the power flow solution was simulated.

**Table 1. Thermal Results without Mesquite Solar**

| CONTINGENCY / AFFECTED ELEMENTS | Normal/ Emerg. Rating (MVA) | Power Flow Simulation | | | |
|---|---|---|---|---|---|
| | | All Planned Projects In Service | | No Hass-N. Gila #2 500kV | |
| | | *CA* | *AZ* | *CA* | *AZ* |
| **N-1 N.Gila-Imperial Valley 500kV Line 1 (+ SLRC SPS to trip Gila 230/161kV Xfmr and SLRC units)** Blythe SPS triggered on overload of the Blythe-Niland 161kV line, dropping Blythe Unit 1 (144 MW) for cases 2, 5 only | | | | | |
| Pilot Knob 161/92kV Xfmr. (IID) | 37/37 | 112.2% (+0.2) | 100.5% (-0.9) | 86.2% (-0.1) | 77.7% (-0.1) |
| TS8 230/69kV Xfmr. (APS) | 187/233 | 112.3% (-0.3) | 100.6% (-0.7) | *Not Applicable* | |
| **N-2 Palo Verde-Devers #1 and #2** | | | | | |
| Gila 230/161kV Xfmr (WALC) | 300/300 | 84.5% (-0.9) | < 80.0% | 108.9% (-0.9) | 103.4% (-0.9) |
| Pilot Knob-Knob 161kV line (IID/WALC) | 165/165 | 84.0% (+0.4) | < 80.0% | 104.5% (+0.0) | 97.1% (+0.1) |
| | **Case** | **2** | **3** | **5** | **6** |

The small change in overload percentage translates to a smaller generation curtailment. **Table 2** summarizes the impacts upon the generation capability of the cluster with no transmission upgrades. As with **Table 1**, the change from the original case is included in the parentheses.

**Table 2. Cluster Curtailment Levels to Mitigate Thermal Loading Concerns without Mesquite Solar**

| Cluster Total | Scheduling Breakdown CA | AZ | Limiting Contingency | Limiting Element | Type |
|---|---|---|---|---|---|
| All Planned Projects In Service | | | | | |
| **590 (+120)** | 0 | 590 (+120) | N-1 N.Gila-Imperial Valley 500kV line w SLRC SPS | Pilot Knob 161/92kV Xfmr. | PT |
| **380 (+85)** | 60 (+15) | 320 (+70) | N-1 N.Gila-Imperial Valley 500kV line w SLRC SPS | Pilot Knob 161/92kV Xfmr. | PT |
| **100 (+10)** | 100 (+10) | 0 | N-1 N.Gila-Imperial Valley 500kV line w SLRC SPS | Pilot Knob 161/92kV Xfmr. | PT |
| No Hasayampa-North Gila #2 500kV line | | | | | |
| **350 (+140)** | 0 | 350 (+140) | N-2 Palo Verde-Devers #1 & #2 500kV lines | Gila 230/161kV Xfmr. | PF |
| **270 (+110)** | 100 (+40) | 170 (+70) | N-2 Palo Verde-Devers #1 & #2 500kV lines | Gila 230/161kV Xfmr. | PF |
| **190 (+80)** | 190 (+80) | 0 | N-2 Palo Verde-Devers #1 & #2 500kV lines | Gila 230/161kV Xfmr. | PF |

The change in generation curtailment impacts the point at which transmission upgrades are required. **Table 3** summarizes the capacity trigger points for the transmission upgrades discussed in section 3.6 of the report.

**Table 3. Upgrade Requirements for MW Injection Levels without Mesquite Solar**

| Schedule to CA | Schedule to AZ | Upgrade Requirement |
|---|---|---|
| ***All Planned Projects in Service*** | | |
| < 100 | < 590 | No Projects Required |
| 100 - 900 | 590 - 900 | TS8 230/69kV Transformer Overload Protection |
| ***No Hassayampa-North Gila #2*** | | |
| < 190 | < 350 | No Projects Required |
| 190 - 900 | 350 - 900 | Modify the planned Gila SPS or Gila 230/161kV Short Term Emergency Rating |
| ***West of River Stressed*** | | |
| n/a | < 850 | No Projects Required |
| n/a | 850 - 900 | Upgrade the Niland-CVSUB 161kV line |

# Appendix G

# Appendix G. All to PG&E Scheduling Sensitivity for Q#43 Only

Due to speculation over impact of the scheduling methodology used in this study, Applicant #43 requested an assessment of scheduling cluster entirely to PG&E for cases where the cluster was scheduled to CA. A total of 600MW of generation was increased in SCE and SDG&E combined and the power was shipped north to PG&E. Specifically, the changes comprised of:

PG&E

- MOSSLND6 was decreased from 550MW to 250MW (-300MW).
- MOSSLND7 was decreased from 550MW to 250MW (-300MW).

SCE

- REDON8 G was increased from 370MW to 470MW (+100MW).
- TOT037C1 was increased from 305MW to 405MW (+100MW).
- TOT037C2 was increased from 305MW to 405MW (+100MW).

SDG&E

- ENCINA 5 was increased from 170MW to 320MW (+150MW).
- PEN_ST was increased from 125MW to 200MW (+75MW).
- OTAYMST1 was increased from 135MW to 210MW (+75MW).

**Table 1** summarizes the thermal loading results from the power flow simulation. The change from the original case is included in the parentheses. Since the post-transient simulation is anticipated to be similar the power flow, only the power flow solution was simulated. In addition to the changes in overload percentage, the Blythe SPS is no longer triggered because the Blythe-Niland 161kV line is not overloaded (99%).

**Table 1. Thermal Results with all to PG&E Scheduling Sensitivity**

| CONTINGENCY / AFFECTED ELEMENTS | Normal/ Emerg. Rating (MVA) | Power Flow Simulation | | | |
|---|---|---|---|---|---|
| | | All Planned Projects In Service | | No Hass-N. Gila #2 500kV | |
| | | PG&E | AZ | PG&E | AZ |
| **N-1 N.Gila-Imperial Valley 500kV Line 1 (+ SLRC SPS to trip Gila 230/161kV Xfmr and SLRC units)** No Blythe SPS action | | | | | |
| Pilot Knob 161/92kV Xfmr. (IID) | 37/37 | 109.0% (-3.4) | 101.4% | 85.0% (-1.3) | 77.8% |
| TS8 230/69kV Xfmr. (APS) | 187/233 | 105.9% (-6.7) | 101.3% | *Not Applicable* | |
| **N-2 Palo Verde-Devers #1 and #2** | | | | | |
| Gila 230/161kV Xfmr (WALC) | 300/300 | 85.1% (-0.3) | < 80.0% | 110.0% (+0.2) | 104.3% |
| Pilot Knob-Knob 161kV line (IID/WALC) | 165/165 | 81.0% (-2.6) | < 80.0% | 101.5% (-3.0) | 97.0% |
| | **Case** | **2** | **3** | **5** | **6** |

The small change in overload percentage translates to a small change in generation curtailment. **Table 2** summarizes the impacts upon the generation capability of the cluster with no transmission upgrades. As with **Table 1**, the change from the original case is included in the parentheses.

**Table 2. Cluster Curtailment Levels to Mitigate Thermal Loading Concerns without Mesquite Solar**

| Cluster Total | Scheduling Breakdown CA | Scheduling Breakdown AZ | Limiting Contingency | Limiting Element | Type |
|---|---|---|---|---|---|
| All Planned Projects In Service | | | | | |
| **470** | 0 | 470 | N-1 N.Gila-Imperial Valley 500kV line w SLRC SPS | Pilot Knob 161/92kV Xfmr. | PT |
| **330 (+35)** | 80 (+35) | 250 (0) | N-1 N.Gila-Imperial Valley 500kV line w SLRC SPS | Pilot Knob 161/92kV Xfmr. | PT |
| **150 (+60)** | 150 (+60) | 0 | N-1 N.Gila-Imperial Valley 500kV line w SLRC SPS | Pilot Knob 161/92kV Xfmr. | PT |
| No Hasayampa-North Gila #2 500kV line | | | | | |
| **210** | 0 | 210 | N-2 Palo Verde-Devers #1 & #2 500kV lines | Gila 230/161kV Xfmr. | PF |
| **150 (-10)** | 50 (-10) | 100 (0) | N-2 Palo Verde-Devers #1 & #2 500kV lines | Gila 230/161kV Xfmr. | PF |
| **100 (-10)** | 100 (-10) | 0 | N-2 Palo Verde-Devers #1 & #2 500kV lines | Gila 230/161kV Xfmr. | PF |

The change in generation curtailment impacts the point at which transmission upgrades are required. **Table 3** summarizes the capacity trigger points for the transmission upgrades discussed in section 3.6 of the report.

**Table 3. Upgrade Requirements for MW Injection Levels**

| Schedule to CA | Schedule to AZ | Upgrade Requirement |
|---|---|---|
| ***All Planned Projects In Service*** | | |
| < 150 | < 470 | No Projects Required |
| 150 - 900 | 470 - 900 | TS8 230/69kV Transformer Overload Protection |
| ***No Hassayampa-North Gila #2*** | | |
| < 100 | < 210 | No Projects Required |
| 100 - 900 | 210 - 900 | Modify the planned Gila SPS or Gila 230/161kV Short Term Emergency Rating |
| ***West of River Stressed*** | | |
| n/a | < 850 | No Projects Required |
| n/a | 850 | Upgrade the Niland-CVSUB 161kV line |