ABENGOA SOLAR INC.

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ORIGINAL

January 29, 2009

Ernest Johnson
Director, Utilities Division
Arizona Corporation Commission
1200 W. Washington St.
Phoenix, Arizona 85007

Subject: Abengoa Solar Inc. – Ten Year Plan Filing
E-00000D-09-0020

Dear Mr. Johnson,

In conformance with A.R.S. § 40-360.02 and pursuant to the Arizona Corporation Commission's Decision No. 63876 (July 25, 2001), Abengoa Solar Inc is pleased to submit this Ten Year Plan on behalf of Arizona Solar One, LLC. ("Arizona Solar One"). Arizona Solar One is a special purpose entity created to develop and operate the 280 MW Solana Generating Station near Gila Bend, Arizona, and is a wholly owned subsidiary of Abengoa Solar Inc. ("Abengoa Solar"). Abengoa Solar is currently developing the 280 MW Solana Solar Generating Facility near Gila Bend, AZ. That project and its associated transmission line are further discussed in this filing.

If you have questions or need further information regarding this filing, please contact me at 480-370-6355.

Sincerely,

Kate Maracas
Vice President, Operations
Abengoa Solar Inc.

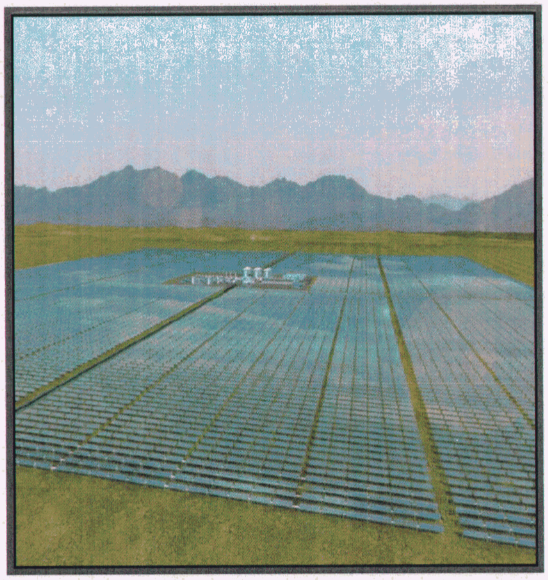
cc: Docket Control
Mr. Tom Campbell, Lewis & Roca

2009 – 2018
Ten Year Plan

Submitted By:

January 2009

ABENGOA SOLAR INC.



Submitted to:

The Arizona Corporation Commission
Pursuant to ARS §40-360.02

Submitted on Behalf of:

Arizona Solar One, LLC.
A Wholly Owned Subsidiary of
Abengoa Solar Inc.

Technical Contact:

Kate Maracas
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ABENGOA SOLAR INC.

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General Information, Summary, and Overview

In conformance with A.R.S. § 40-360.02, Abengoa Solar Inc is pleased to submit this Ten Year Plan on behalf of Arizona Solar One, LLC. ("Arizona Solar One"). Arizona Solar One is a special purpose entity created to develop and operate the 280 MW Solana Generating Station near Gila Bend, Arizona, and is a wholly owned subsidiary of Abengoa Solar Inc. ("Abengoa Solar"). Abengoa Solar is currently developing the 280 MW Solana Solar Generating Facility near Gila Bend, AZ. That project and its associated transmission line are further discussed in this filing.

A.R.S. § 40-360.02 requires that:

> "Every person contemplating construction of any transmission line within the state during any ten year period shall file a ten year plan with the Commission on or before January 31 of each year."

Pursuant to those requirements, Abengoa Solar submits this document, which provides further detail about its only planned transmission facility as of January 31, 2009. That planned facility is a 230 kV overhead transmission line that will span approximately 22 miles between a substation located at the Solana plant site and APS's Gila River[1] 230 kV substation. The transmission line will be a dedicated generator intertie ("Gen-Tie") line, delivering power directly to APS's transmission system.

Also pursuant to A.R.S. § 40-360.02, Abengoa Solar filed with the ACC on July 17, 2008 a "90 Day" Solana Project Plan, which described in detail the location, operation date, average and maximum power output, capacity factor, and power flow and stability analysis for the Solana Generating Station.

Finally, also pursuant to A.R.S. § 40-360.02, this filing includes technical study results for the planned Solana 230 kV Gen-Tie line.

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[1] The APS Gila River Substation is also known as the "Panda 230 kV Substation". Exhibit 2 of this filing makes reference to Panda, while APS's interconnection studies refer to the station as Gila River.

Transmission Project Description

About Solana

Solana is located approximately 70 miles southwest of Phoenix and eight miles west of the Town of Gila Bend, Arizona. The Solana site will be located on approximately 3,000 acres of private land north of Interstate 8 (I-8), west of Painted Rock Dam Road, south of Powerline Road and east of Bureau of Land Management ("BLM") lands within unincorporated Maricopa County. Solana will use Concentrating Solar Power ("CSP") technology with storage capability. The technology uses parabolic mirrors to focus the sun's heat on a receiver tube containing heat transfer fluid. The fluid can reach a temperature of 735 degrees Fahrenheit. To produce electricity, the hot fluid transfers its heat energy to water, creating steam for two 140 MW conventional steam turbines. The heat energy in the fluid also can be diverted to molten salt storage tanks that can create steam for energy production up to six hours after sunset, or through cloudy periods. Solana will use conventional cooling towers and an evaporation pond. The source of water will be groundwater supplied by the Paloma Irrigation and Drainage District.

Size and Proposed Route for the Solana Gen-Tie Line

On December 5th, 2008, the ACC affirmed a recommendation by the Arizona Power Plant and Transmission Line Siting Committee and thereby granted individual Certificates of Environmental Compatibility ("CECs") for both the Solana Generating Facility and the 230 kV Gen-Tie line (see Docket Numbers L-00000GG-08-0407-00139 - Decision No. 70638, and L-00000GG-08-0407-00140 - Decision No. 70639).

The size of the Gen-Tie line may be described as:

- Voltage: 230 kV
- Configuration: Steel Monopole Structures with capacity for a future second (double) circuit
- Rated Capacity: 560 MVA (planned capacity)

The certificated route for the Solana Gen-tie originates at a proposed 230 kV substation within the proposed Solana site. The Solana Gen-tie would begin at the center of Solana site, proceeding east to the edge of the Solana site at Painted Rock Dam Road, then north in an alignment on Painted Rock Dam Road to Watermelon Road. At Watermelon Road, the route would turn east and continue in an alignment adjacent to Watermelon Road all the way to the Gila River Substation. The total length of this route is approximately 20.2 miles.

General vicinity maps and a route map for the Solana Gen-Tie line are shown in Figures 1 and 2 below.

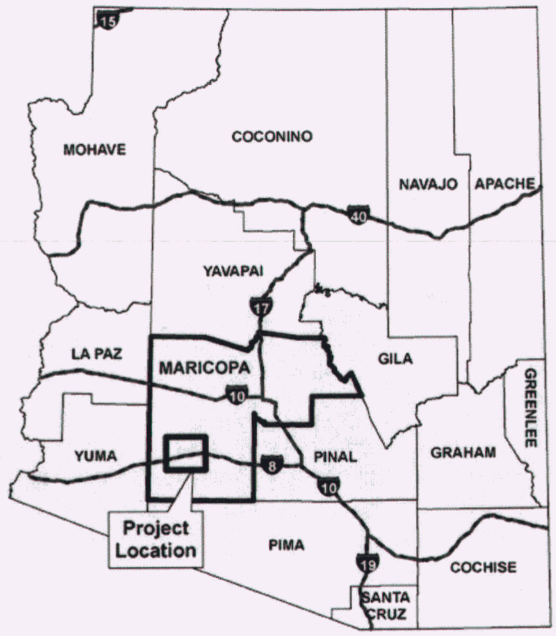

Figure 1. General Vicinity Map

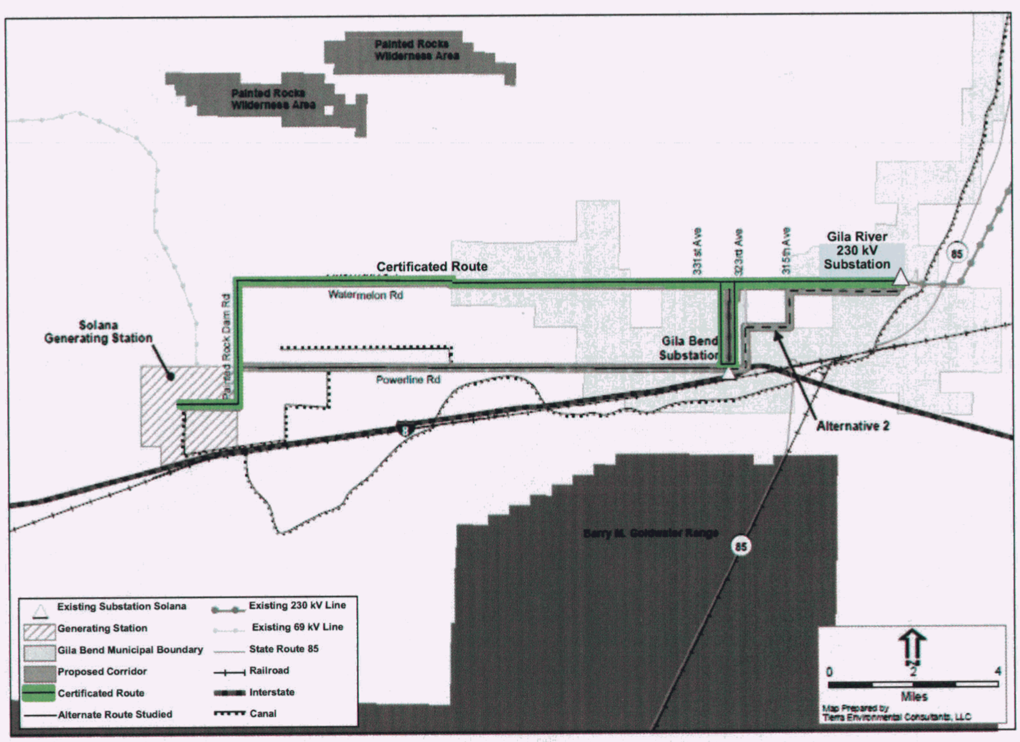

Figure 2. Transmission Route Map

Pending results of ongoing interconnection studies conducted by APS, the Project may interconnect with (loop in and out of) the APS Gila Bend Substation in addition to terminating at the existing APS Gila River 230 kV Substation. Note that Figure 2 depicts the potential loop to and from the APS Gila Bend 69kV Substation. A detailed Project Description Sheet is enclosed as Exhibit 1 of this Plan.

Purpose to be Served by the Planned Transmission Line

The purpose to be served by the 230kV Solana Gen Tie Project is to interconnect the Solana Generating Station to the regional transmission grid at the existing APS Gila River Substation.

The plant will in turn produce electricity generated by solar thermal energy, which is a renewable resource. Arizona Solar One has a 30-year contract with APS for purchase of all output of the plant. This will provide APS with an energy resource to meet local and regional demand for renewable energy. The Arizona Corporation Commission has implemented Renewable Energy standards for regulated utilities, which require the utilities to acquire increasing amounts of renewable energy, up to fifteen percent by 2025. The output of the plant will assist APS to meet this requirement, and to enable APS to meet its increasing demand. An additional purpose served by the plant is to provide diversity of fuel supply in the production of electricity. Access to energy produced by renewable resources reduces dependence on fossil fuels, which are subject to market price volatility.

Estimated Date of Operation

The 230 kV Solana Gen-Tie line has a planned in-service date on or before December 2011.

Power Flow and Stability Analysis

In February 2008, Abengoa Solar filed an interconnection request for the Solana Generating Facility with APS. The interconnection request is for a 280 MW of net power injection into APS's transmission system. Abengoa Solar entered into a System Impact Study ("SIS") Agreement with APS on March 30, 2008. The SIS is being performed by APS as part of its quarterly cluster study. The SIS is not yet complete, but preliminary results indicate that no short-circuit or transient stability problems are anticipated as a result of Solana's interconnection.

In addition to the SIS in progress, Abengoa Solar retained Navigant Consulting Inc. ("NCI") to perform a comprehensive feasibility study for the purpose of the 90-Day filing, and for the purpose of general planning and development of the project. NCI completed its "Solana Solar Projects Preliminary Interconnection Studies" report on June 24, 2008. The

NCI report is attached as Exhibit 2 and consists of a power flow and stability analysis report for this project. It demonstrates the effect of the Solana 1 project on the current Arizona electric transmission system. The study also investigated a variety of interconnection options, the potential for interconnecting a second CSP project, and the possibility of the presence of a "senior queued" 110 MW generation project ("Q31") proposed for interconnection at the Gila Bend 69 kV Substation or the Gila River (Panda) 230 kV Substation. The conclusion derived from the NCI study is that the proposed Solana Project has no adverse power flow or stability impact on the Arizona transmission system provided eleven miles of APS 69 kV lines are upgraded.

Exhibit 1

Project Description Sheet

Exhibit 1: Project Description Sheet

Solana Generating Station Transmission Intertie

Project Sponsor: Abengoa Solar Inc. on behalf of Arizona Solar One, LLC.

Project Participants: Abengoa Solar Inc. (Owner of Arizona Solar One, LLC.)

Project Description: Interconnect a new 280 MW Solar Generating Plant to the APS 230 kV Panda Substation.

Voltage Class: 230kV AC

Facility Rating: 560 MVA

Point of Origin: Solana Generating Station (to be operational in 2011), bound on the north primarily by the northern boundary of the Township 6 South line; on the east by Painted Rock Dam Road; on the south by Interstate 8 (I-8); and on the west by the midsection line of sections 5 and 8, Township 6 South, Range 7 West.

Point of Termination: Gila River 230 kV Substation

Length of Line: 20.2 Miles

Type of Project: Planned

Routing: The Solana generator Intertie line will proceed from the new substation within the Solana site and head to the intersection of Painted Rock Dam Road and Powerline Road. The line will proceed north on the Painted Rock Dam Road alignment and then east on Watermelon Road. The Project will end at the existing APS Gila River Substation (Line Siting Case No. 99) located in Section 20, Township 5 South, Range 4 West, Gila Bend, Arizona.

Purpose of Project: This project is needed to serve APS's growing demand of nearly 300 MW per year, and to provide a clean, reliable, and price-stable resource to APS's customers.

Estimated Cost: $26,000,000 (in 2008 Dollars)

Schedule:

Construction Start: 2009

Planned In-Service: 2011

Permitting Status: Certificate of Environmental Compatibility granted in December 2008.

Contact Information: Kate Maracas
(480) 705-9439
Kate.maracas@solar.abengoa.com

Exhibit 2

Solana Solar Projects Preliminary Interconnection Studies

Exhibit 2: Solana Solar Projects Preliminary Interconnection Studies

NAVIGANT
CONSULTING

SOLANA SOLAR PROJECTS

PRELIMINARY INTERCONNECTION STUDIES

Presented to

ABENGOA SOLAR, INC.

June 24, 2008

Prepared by

Navigant Consulting, Inc.
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NAVIGANT
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OVERVIEW

In February 2008 Abengoa Solar, Inc. (Abengoa Solar) filed an interconnection request with Arizona Public Service Company (APS) for a 250 MW (net) solar project which would be interconnected with the APS Gila Bend Substation. Subsequently, Abengoa Solar and APS entered into an agreement whereby APS would acquire the output of this proposed project (Solana 1) which has a proposed in-service date of November 1, 2010. Solana 1 would consist of two steam generators (each with a gross output of 140 MW) and would have a total internal load of approximately 30 MW. Abengoa Solar is also in discussions with other parties relative to the development of a second 250 MW (net) facility (Solana 2) which would be located in the same area as would Solana 1. The geographic relationship between the Solana Project siting area and the major substations (Gila Bend, Gila River/Panda, and Jojoba) in the Solana Project area is depicted in Figure 1.

Figure 1 – Solana Project Area and Major Substations

Abengoa Solar requested that Navigant Consulting, Inc. (NCI) undertake preliminary powerflow and transient stability studies to assess the impacts which the addition of the Solana 1 Project and the Solana 2 Project would have on the interconnected transmission system in Arizona. These studies were performed using a 2011 summer peak powerflow case which was obtained from APS and investigated system impacts for numerous pre-and post-Solana Project scenarios.

The pre-Solana studies assessed system impacts if the 110 MW "senior queued" project (the "Q31 project") proposed for interconnection at the Gila Bend 69-kV bus or the Gila River (Panda) 230-kV bus was in service. Information relative to the Q31 project was obtained from the final feasibility study reports for it prepared by APS in January 2008 (contract number 52056). These pre-Project studies were performed to establish benchmark information for the post-Project scenarios and to provide a correlation with the results of the feasibility study for the Q31 project as undertaken by APS.

SUMMARY OF FINDINGS

This report discusses the results of studies done to assess the system impacts associated with interconnecting the Solana 1 Project:

- At a new Gila Bend 230-kV bus (as specified in the interconnection application),
- At the Panda 230-kV bus, or
- At a new Watermelon 500/230-kV Substation which would be interconnected with one of the Gila River-Jojoba 500-kV lines.

In addition to assessing impacts for the above interconnection options these studies assessed how such impacts would change if:

- A second 230-kV line was built between Gila Bend and Panda,
- The Q31 project was in-service and was interconnected at the Gila Bend 69-kV bus, the Panda 230-kV bus, or the Gila Bend 230-kV bus, and
- The Solana 2 Project was interconnected at the Gila Bend, Panda, or Watermelon Substations.

These studies indicated that:

- The powerflow impacts on the system due to the addition of the Solana 1 Project would vary depending on its interconnection point, whether or not a second Gila Bend-Panda line was built, and on the status and interconnection point for the Q31 project.
- The subsequent addition of the Solana 2 Project would result in some additional powerflow impacts on the system and would, therefore, require additional mitigation actions.
- The addition of the Solana 1 and 2 Projects did not have a negative impact on the transient stability performance of the transmission system.

Table 1 presents comparative information on the miles of impacted 69-kV lines and on the post-contingency generation curtailments that would be necessary <u>if the impacted lines were not upgraded</u>:

- When only the Solana 1 Project was in-service,
- When both the Solana 1 Project and the Q31 project were in-service, and
- When all three projects (Solana 1 and 2 and Q31) were in-service.

As summarized in Table 1:

- If only the Solana 1 Project was in-service:
  - Up to 110 MW of Project curtailments would be required to mitigate post-contingency overloads on approximately 58 miles of 69-kV line and on the #2 230/69-kV transformer at Gila Bend if the Project was interconnected at Gila Bend and a second Gila Bend-Panda line was not built.
  - Approximately 11 miles of 69-kV line[2] would be subject to post-contingency overloads if the Project was interconnected at Gila Bend (and a second Gila Bend-Panda 230-kV line was built) or was interconnected at Panda. Project curtailments required to mitigate these overloads would range from 15 MW (if the Project was interconnected at Panda) to 60 MW (if the Project was interconnected at Gila Bend).
- If both the Solana 1 Project and the Q31 project were interconnected at Gila Bend it would be necessary to build a second Gila Bend-Panda 230-kV line to mitigate the voltage collapse problems that would arise due to an outage of the existing Gila Bend-Panda line. Even with the second Gila Bend-Panda 230-kV line, approximately 19 miles of 69-kV line could become overloaded as the result of Category B outages. Mitigating the impacts of these outages would require:
  - That all of the Solana 1 Project generation be curtailed if the Q31 project was interconnected with the Gila Bend 69-kV bus.
  - Project generation curtailments of 70 MW (to mitigate the impacts of an outage of the Jojoba 230/69-kV transformer) or of 140 MW (to mitigate the impacts of an outage of the Panda-Jojoba 230-kV line) if the Q31 project was interconnected at the Gila Bend 230-kV bus.
- If the Solana 1 Project was interconnected at Gila Bend and the Q31 project was interconnected at the Panda 230-kV bus, the following Project curtailments would be required:
  - 110 MW to mitigate the impacts on about 58 miles of 69-kV line due to an outage of the existing Gila Bend-Panda line <u>if</u> a second Gila Bend-Panda line was not built,
  - 150 MW to mitigate the impacts of an outage of the Panda-Jojoba 230-kV line on

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[2] Per the Feasibility Study report for the Q31 project, these lines are proposed for upgrading by APS in the 2014 time frame.

about 19 miles of 69-kV line,
    - 80 MW to mitigate the impacts of an outage of the Jojoba 230/69-kV transformer on about 19 miles of 69-kV line.
- If the Solana 1 Project and the Q31 project were both interconnected at the Panda 230-kV bus, Project curtailments of as much as 125 MW would be required to mitigate the impacts on about 11 miles of 69-kV line due to an outage of the Panda-Jojoba 230-kV line.
- If the Solana 1 and 2 Projects and the Q31 project were in-service and the Solana Projects were interconnected at Gila Bend or Panda, the amounts of Project curtailments required to mitigate post-contingency overloads would increase by 250 MW above the amounts discussed above.
- If one or both of the Solana Projects were interconnected at the new Watermelon Substation it would not be necessary to curtail Project generation for any Category B outages on the main transmission grid[3].

NCI also developed information regarding the facilities required to interconnect the Project and the system upgrades required to maximize Project deliverability. The results of this effort are summarized in Table 2 and show that, with respect to required 230-kV lines:
- The lengths of 230-kV line required to interconnect the Project with Gila Bend, Panda, and Watermelon Substations would be 14 miles, 22 miles, and 23 miles, respectively.
- However, a second Gila Bend-Panda line would be required to:
    - Provide the same level of deliverability for the Gila Bend interconnection option as would be provided by the other two interconnection options when only the Solana 1 Project was in-service, and
    - Avoid Category A overloads on the existing Gila Bend-Panda line when the Solana 2 project is added.
- Adding the second Gila Bend-Panda line with the Gila Bend interconnection option would increase the total miles of 230-kV line required for this option to approximately 21 miles.

The information in Table 2 also shows that, relative to interconnection point facilities:
- If the Project was interconnected at Gila Bend:
    - A new 230-kV switchyard would be required at Gila Bend to accommodate the interconnection. The number of 230-kV breakers (and related equipment)

[3] At least some Project generation would likely have to be curtailed should a Category C outage occur on the two 500-kV lines between the Gila River and Jojoba Substations. This would likely be the case for any of the interconnection options.

required at the new station would range from three (if only the Solana 1 Project was interconnected at Gila Bend) to eight (if both the Solana Project and the Q31 project were interconnected at Gila Bend and a second Gila Bend-Panda line was built).

  - Additions would be required at the Panda 230-kV switchyard to accommodate the termination of a second Gila Bend-Panda line. The number of 230-kV breakers (and related equipment) required would range from one (if the Q31 project was not interconnected at Panda) to four (if the Q31 project was interconnected at Panda). For this situation it would likely be necessary to develop a new four breaker ring-bus station interconnected with the Panda-Jojoba 230-kV line.
- If the Project was interconnected at the Panda 230-kV bus the number of 230-kV breakers (and related equipment) required would range from one (if the Q31 project was not interconnected at Panda) to four (if the Q31 project was interconnected at Panda). As was the case above, it would likely to develop a new four breaker ring-bus station interconnected with the Panda-Jojoba 230-kV line for this configuration.
- If the Project was interconnected at Watermelon a new 500/230-kV substation would have to be developed to accommodate the interconnection. This facility would likely include three 500-kV circuit breakers, a 500/230-kV transformer, and at least one 230-kV circuit breaker.

With respect to upgrades to maximize Project deliverability, the information in Table 2 shows that:

- If the Project was interconnected at Gila Bend, the miles of impacted 69-kV line would range from 58 miles (if a second Gila Bend-Panda line was not built) to 19 miles (if the second 230-kV line was built and the Q31 project was developed) to 11 miles (if the second 230-kV line was built and the Q31 project was not developed).
- If the Project was interconnected at Panda the miles of impacted 69-kV line would range from 11 miles (to accommodate the Solana 1 Project) to 19 miles (to accommodate both the Solana 1 and 2 Projects).

CONCLUSIONS

Based on the above, NCI concludes that, to minimize costs and maximize Project deliverability:

- Interconnecting the Solana Project(s) at the Panda 230-kV bus should be pursued
- The impacted APS 69-kV lines should be upgraded.

TABLE 1
SOLANA 1 AND 2 PROJECTS
SUMMARY OF STUDY RESULTS

Interconnection Points		Gila Bend-Panda #2 Line In-Service	Gila Bend-Panda Line Outage		Panda-Jojoba Line Outage		Jojoba Transformer Outage	
Solana Project	Senior Queued Project		Miles of Impacted Line	Estimated Curtailments (MW)	Miles of Impacted Line	Estimated Curtailments (MW)	Miles of Impacted Line	Estimated Curtailments (MW)
With Only the Solana 1 Project On-Line								
Gila Bend 230-kV	n/a	No	58[4]	110	11	70	0	0
	n/a	Yes[5]	0	0	11	60	0	0
Panda 230-kV	n/a	No	0	0	11	15	0	0
Watermelon 230-kV	n/a	No	0	0	0	0	0	0
With the Solana 1 Project and the Queued Project On-Line								
Gila Bend 230-kV	Gila Bend 69-kV	Yes[4,6]	0	0	19	250	19	250
	Gila Bend 230-kV	Yes[4,5]	0	0	19	140	19	70
	Panda 230-kV	No	58	110	19	150	19	80
	Panda 230-kV	Yes[4]	0	0	19	150	19	80
Panda 230-kV	Panda 230-kV	No	0	0	11	125	0	0
Watermelon 230-kV	Panda 230-kV	No	0	0	0	0	0	0
With the Solana 1 and Solana 2 Projects and the Queued Project On-Line								
Gila Bend 230-kV	Gila Bend 230-kV	Yes[4,5]	0	0	19	390	19	340
Panda 230-kV	Panda 230-kV	No	0	0	19	375	19	265
Watermelon 230-kV	Panda 230-kV	No	0	0	0	0	0	0

4 The Gila Bend 230/69-kV #2 transformer is also overloaded for this contingency.

5 Project generation would also have to be curtailed (dropped via a remedial action scheme – RAS) for an outage of both Gila Bend-Panda 230-kV line. These curtailments range from 110 MW (with only the Solana 1 Project in-service), to 195 MW with the Solana 1 Project and the Q31 project in-service, to 445 MW (with all three projects in-service).

6 Without the second Gila Bend-Panda line an outage of the existing line results in voltage collapse in the area.

TABLE 2
SOLANA 1 AND 2 PROJECTS
SUMMARY OF INTERCONNECTION FACILITY AND POTENTIAL SYSTEM UPGRADE REQUIREMENTS

Solana Project Configuration	Senior Queued Project Status	Facilities Required to Interconnect Solana Project(s)	Facilities Required to Maximize Deliverability of Solana Project(s)
250 MW interconnected at Gila Bend	Not developed or Interconnected at Gila Bend 69-kV bus or 230-kV bus	• 14 miles of 230-kV line • New, 3 breaker 230-kV yard at Gila Bend	• Upgrade 58 miles of 69-kV line • Increase 230/69-kV transformer capacity at Gila Bend • Add reactive support on 69-kV system or • Build seven mile long, 230-kV line between Gila Bend and Panda (one 230-kV breaker required at each substation) • Upgrade 11 miles of 69-kV line (without Q31 project) or 19 miles of 69-kV line (with Q31 project)
	Interconnected at Panda 230-kV bus	• 14 miles of 230-kV line • New, 3 breaker 230-kV yard at Gila Bend	• As above except that two breakers would be required at Panda if the second Gila Bend-Panda line was built
500 MW interconnected at Gila Bend	Interconnected at Gila Bend 230-kV bus	As above, plus • Second Gila Bend-Panda 230-kV line • One 230-kV breaker at Gila Bend and one 230-kV breaker at Panda	• Upgrade 19 miles of 69-kV line[7]
250 MW interconnected at Panda	Not developed	• 22 miles of 230-kV line • One 230-kV breaker in existing Panda substation	• Upgrade 11 miles of 69-kV line
	Interconnected at Panda 230-kV bus	• 22 miles of 230-kV line • Expand Panda substation by adding a four breaker ring bus and looping the Panda-Jojoba line into it	• Upgrade 11 miles of 69-kV line
500 MW interconnected at Panda	Interconnected at Panda 230-kV bus	As above	• Upgrade 19 miles of 69-kV line
250 MW or 500 MW interconnected at Watermelon	Not developed or interconnected at Panda 230-kV bus	• 23 miles of 230-kV line • New 500/230-kV substation at Watermelon	• None

[7] The upgrades required when both Solana 1 and 2 are in-service would have to provide approximately 20% more capacity than that required when only the Solana 1 Project is in service.

SOLANA 1 PROJECT - POWER FLOW ANALYSIS

Thermal Loading Results

These studies revealed that, as would be expected, the impacts on the system would vary depending on the amounts of proposed resources installed and the interconnection points for these resources. The following summarizes the findings of the studies assessing pre-Solana Project conditions and for studies assessing the impacts if the Solana 1 Project was developed.

Pre-Project Case

The results of studies on two pre-Project cases are summarized in Table 3 (Category B contingencies) and Table 4 (Category C contingencies) and indicated that:

- If the Q31 project was interconnected with the Gila Bend 69-kV bus, approximately 11 miles of 69-kV line would have to be upgraded to allow the entire project output to be delivered under post-contingency conditions. Without such upgrades the deliverable capacity of the project would be limited to 85 MW for the most critical outage.
- The Q31 project could be interconnected with the Panda 230-kV bus and would be fully deliverable under both normal operating conditions and with critical transmission facilities out of service.

Post-Project Scenarios

The results of studies on four scenarios with the Solana 1 Project in-service (and without the Q31 project in-service) are also summarized in Tables 3 and 4. Review of the study results for these four scenarios indicates that:

- Interconnection of the Solana 1 Project with the Gila Bend Substation would require that approximately 58 miles of 69-kV line be upgraded to allow the entire Project output to be delivered under post-contingency conditions. Without such upgrades the Project output would have to be curtailed by 110 MW (to mitigate the impacts due to an outage of the Gila Bend-Panda 230-kV line) or by 70 MW (to mitigate the impacts of an outage of the Panda-Jojoba 230-kV line).
- Adding a second 230-kV line (approximately 7 miles in length) between Gila Bend and Panda would mitigate the need to curtail generation for the Gila Bend-Panda outage and would reduce the curtailments required for the Panda-Jojoba line outage to 60 MW. Approximately 11 miles of 69-kV line would have to be upgraded to avoid any curtailments for Category B contingencies.
- In addition to the curtailments required to mitigate the impacts of the Panda-Jojoba line contingency, Project generation curtailments of 110 MW would be required to mitigate the impacts of an outage of both Gila Bend-Panda 230-kV lines if the 69-kV lines are not upgraded.

- Interconnecting the Solana 1 Project at the Panda 230-kV bus would increase the amounts of power that could be delivered with critical transmission facilities out of service to 235 MW. However, 11 miles of 69-kV line would have to be upgraded to allow the full 250 MW to be delivered should an outage occur on the Panda-Jojoba 230-kV line.
- Interconnection of the Solana 1 Project with a new Watermelon 500/230-kV substation (which was assumed to be interconnected with one of the Gila River-Jojoba 500-kV lines) would allow for full deliverability of the Project generation without any upgrades to the local 69-kV system.

The results of studies for five scenarios with the Solana 1 Project and the 110 MW Q31 project in-service are also summarized in Tables 3 and 4. Review of the study results for these five scenarios indicates that:

- If the Solana Project was interconnected at the Gila Bend 230-kV bus and the Q31 project was interconnected at the Gila Bend 69-kv or 230-kV bus, it would be necessary to build a second Gila Bend-Panda 230-kV line to avoid voltage collapse in the area should an outage occur on the existing Gila Bend-Panda line. Even if such were done, approximately 19 miles of 69-kV line would have to be upgraded to allow the full 250 MW output of the Solana Project to be delivered under all conditions. Without upgrades to the 69-kV lines the Solana Project generation would have to be curtailed as follows:
  - By 250 MW to mitigate the impacts of the critical outages (the Panda-Jojoba 230-kV line or of the Jojoba 230/69-kV transformer) if the Q31 project is interconnected at the Gila Bend 69-kV bus.
  - If the Q31 project was interconnected at the Gila Bend 230-kV bus:
    - By 140 MW to mitigate the impacts of an outage of the Panda-Jojoba 230-kV line,
    - By 70 MW to mitigate the impacts of an outage of the Jojoba 230/69-kV transformer.
- In addition to the above generation curtailments required to mitigate the impacts of Category B outages, the Solana Project output would have to be completely curtailed should a Category C outage involving both Gila Bend-Panda lines occur.
- If the Solana Project was interconnected at the Gila Bend 230-kV bus and the Q31 project was interconnected at the Panda 230-kV bus, approximately 58 miles of 69-kV line would have to be upgraded to allow the full 250 MW output of the Solana Project to be delivered under all conditions if a second Gila Bend-Panda 230-kV line was not built. If the impacted 69-kV lines were not upgraded the Project output would have to be curtailed by 110 MW (to mitigate the impacts of the Gila Bend-Panda line outage), by 150 MW (to mitigate the impacts of an outage of the Panda-Jojoba 230-kV line), and by 80 MW (to mitigate the impacts of an outage of the Jojoba 230/69-kV transformer).
- If both projects were interconnected at the Panda 230-kV bus, approximately 11 miles of 69-kV line would have to be upgraded to allow the full 250 MW output of the Solana

Project to be delivered under all conditions. If these 69-kV lines were not upgraded the output of the Solana Project would have to be curtailed by 125 MW to mitigate the impacts of an outage of the Panda-Jojoba 230-kV line.

- Interconnection of the Project at the new Watermelon 500/230-kV Substation would allow for full deliverability of the Project for all conditions studied.

Impacts on System Voltages

Comparison of post-contingency 69-kV bus voltages for the 2011 case obtained from APS, Solana Project Cases 1 and 2, and Solana Project-Q31 project Case 6 indicated that the only significant voltage impacts would occur as the result of an outage of the Gila Bend-Panda line for the post-Solana Case 1. In this instance there were 25 69-kV busses where voltages dropped below 95% (the lowest was about 83% at the Aztec bus); the largest voltage deviation (15.7%) also occurred at the Aztec bus. Table 5 summarizes the noted voltage impacts.

Appendices A and B to this report contain lists of the Category B and Category C contingencies simulated on the various cases discussed above. Appendix C contains representative powerflow plots for both Category A and critical Category B conditions for the various cases.

TABLE 3
SOLANA 1 PROJECT - SUMMARY OF STUDY RESULTS - COMPARISON OF CATEGORY B OVERLOADS

				APS 2011 Case	Pre-Solana Cases ("11hs_pre_case_")		Solana Project Cases ("11hs_solana_case_")				Cases With Solana Project & Q31 Project ("11hs_both_case_")				
					1	2	1	2	3	4	1	2	3	4	5
	Gila Bend Area Generation (MW)	APS Queue # 31		0	110	110	0	0	0	0	110	110	110	110	110
		Solana		0	0	0	250	250	250	250	250	250	250	250	250
		Total		0	110	110	250	250	250	250	360	360	360	360	360
	Generation Interconnection Points	APS Queue #31		n/a	G.B 69	Panda	n/a	n/a	n/a	n/a	G.B. 69	G. Bend	Panda	Panda	Panda
		Solana		n/a	n/a	n/a	G. Bend	G. Bend	Panda	New Sub	G. Bend	G. Bend	G. Bend	Panda	New Sub
	No. of Gila Bend-Panda 230-kV Lines ?				1	1	1	2	1	1	2	2	1	1	1
230-kV Outage	**Impacted Facility**	**Rating [1]**	**Length**	**Post-Contingency Loading (%)**											
Panda-Gila Bend Line	Jojoba-Patterson 69-kV Line [2]	532	4.2	121		122	158		124	121			157	125	122
	Gillespie-Patterson 69-kV Line [2]	532	3.8	109		110	160		112	109			159	113	110
	Gila Bend-Butterfield Tap 69-kV Line	658	6.0				225						225		
	Butterfield Tap-Cotton Center 69-kV Line	658	5.0				225						225		
	Cotton Center-Gillespie 69-kV Line	658	7.5				215						215		
	Bunyan-Agua C Tap 69-kV Line [3]	388	20.0				110						110		
	Agua C Tap-Hy 1 69-kV Line [3]	388	11.0				108						108		
	Gila Bend 230/69-kV #2 Transformer	120	-----				102						102		
Panda-Jojoba Line	Gila Bend-Butterfield Tap 69-kV Line	658	6.0		105		106	105	101		127	114	114	110	
	Butterfield Tap-Cotton Center 69-kV Line	658	5.0		105		105	105	101		127	114	114	109	
	Cotton Center-Gillespie 69-kV Line	658	7.5								118	105	105	100	
Rudd-White Tank Line	Seargant-Orme RS 69-kV Line	1,100	n/a	116	116	117	117	117	117	117	117	117	117	117	117
Jojoba Transformer	Gila Bend-Butterfield Tap 69-kV Line	658	6.0		103		100	99			117	105	105	101	
	Butterfield Tap-Cotton Center 69-kV Line	658	5.0		103		100	99			116	105	105	101	
	Cotton Center-Gillespie 69-kV Line	658	7.5								107				
TS 1 Transformer	Wilhoit-Kirk Junction 69-kV Line	142	n/a	121	121	121	120	120	120	120	119	119	119	120	120
White Tanks #1 Transformer.	Seargant-Orme RS 69-kV Line	1,100	n/a	118	118	119	118	118	118	118	118	119	119	118	118
	White Tanks 230/69-kV #3 Transformer	318		110	110	110	110	110	110	110	110	110	110	110	110

			Pre 1	Pre 2	Solana 1	Solana 2	Solana 3	Solana 4	Both 1	Both 2	Both 3	Both 4	Both 5
Impacted 69-kV Lines (Miles)			11.0	0.0	58.0	11.0	11.0	0.0	18.5	18.5	58.0	11.0	0.0
Required Generation Curtailments (MW) Without System Reinforcements													
For Gila Bend-Panda Line Outage	Solana		-----	-----	110	0	0	0	0	0	110	0	0
For Panda-Jojoba 230-kV Outage	APS Queue #31		25	0	-----	-----	-----	-----	25	25	0	0	0
	Solana		-----	-----	70	60	15	0	250	140	150	125	0
	Total		25	0	70	60	15	0	275	165	150	125	0
For Jojoba Transformer Outage	APS Queue #31		0	0	-----	-----	-----	-----	25	25	0	0	0
	Solana		-----	-----	0	0	0	0	250	70	80	0	0
	Total		0	0	0	0	0	0	275	95	80	0	0

1/ In Amps for lines; MVA for transformers

2/ Per APS studies, overloads on these two lines can be mitigated by opening the Gillespie-Gillespie West 69-kV line. However, doing so for post-Solana Case 1 results in voltage collapse; therefore the overloaded lines must be upgraded

3/ Line lengths are estimated

TABLE 4
SOLANA 1 PROJECT - SUMMARY OF STUDY RESULTS - COMPARISON OF CATEGORY C OVERLOADS

				APS 2011 Case	Pre-Solana Cases ("11hs_pre_case_ ")		Solana Project Cases ("11hs_solana_case_ ")				Cases With Solana Project & Q31 Project ("11hs_both_case_ ")				
					1	2	1	2	3	4	1	2	3	4	5
	Gila Bend Area Generation (MW)	APS Queue # 31		0	110	110	0	0	0	0	110	110	110	110	110
		Solana		0	0	0	250	250	250	250	250	250	250	250	250
		Total		0	110	110	250	250	250	250	360	360	360	360	360
	Generation Interconnection Points	APS Queue #31		n/a	G. B. 69	Panda	n/a	n/a	n/a	n/a	G. B. 69	G. Bend	Panda	Panda	Panda
		Solana		n/a	n/a	n/a	G. Bend	G. Bend	Panda	New Sub	G. Bend	G. Bend	G. Bend	Panda	New Sub
	No. of Gila Bend-Panda 230-kV Lines ?			1	1	1	1	2	1	1	2	2	1	1	1
230-kV Outage	Impacted Facility	Rating	Length	Post-Outage Loading (%)											
Cactus-Ocotillo and Cactus Pinnacle Peak	McCormick-Camelback 69-kV Line	900		109	109	109	109	109	109	109	109	109	109	109	109
Pinnacle Peak-Reach & Pinn. Peak-Lone Peak	Meadowbrook-Sunnyslope 230-kV line	1,231		100	100	100	101	101	101	101	101	101	101	101	101
Deer Valley-Westwing & Deer Valley-Pinn. Peak	Seargant-Orme RS 69-kV Line	1,100		99	99	99	99	99	99	99	99	99	99	99	99
Surprise-El Sol and Surprise-Westwing	Wilhoit-Kirk Junction 69-kV Line	142		141	140	140	139	139	139	140	139	139	139	139	139
	Dysart-Marin Tap 69-kV Line	900		125	125	125	124	124	124	124	124	125	125	124	124
	Marin Tap-El Sol 69-kV Line	900		125	125	125	124	124	124	124	124	124	124	124	124
	Rio Viste-Westwing 69-kV Line	1,000		116	115	115	115	115	115	115	115	115	115	115	115
	Whitspar-Wilhoit 69-kV Line	187		111	110	110	110	110	110	110	109	109	109	109	109
	Rio Viste-Surprise 69-kV Line	900		105	105	105	104	104	104	105	104	104	104	104	105
	TS 1 230/69-kV Transformer	235		102	102	102	102	102	102	102	102	102	102	102	102
	Yarnell-Kirk Junction 69-kV Line	184		101	100	100	99	99	99	100	99	99	99	99	99
Agua Fria-Westwing & Liberty-Westwing	Seargant-Orme RS 69-kV Line	1,100		99	99	99	99	99	99	99	99	99	99	99	99
Gila Bend-Panda #1 & #2	Jojoba-Patterson 69-kV Line	532	4.2	n/a	n/a	n/a	n/a	158	n/a	n/a	Diverged	Diverged	n/a	n/a	n/a
	Gillespie-Patterson 69-kV Line	532	3.8					160							
	Gila Bend-Butterfield Tap 69-kV Line	658	6.0					225							
	Butterfield Tap-Cotton Center 69-kV Line	658	5.0					225							
	Cotton Center-Gillespie 69-kV Line	658	7.5					215							
	Bunyan-Agua C Tap 69-kV Line	388	20.0					110							
	Agua C Tap-Hy 1 69-kV Line	388	11.0					108							
	Gila Bend 230/69-kV #2 Transformer	120	-----					102							
	Generation Curtailments (via RAS) Required to Mitigate Impacts of Gila Bend-Panda DLO (MW)	APS Queue # 31		-----	-----	-----	-----	-----	-----	-----	30	30	-----	-----	-----
		Solana		-----	-----	-----	-----	110	-----	-----	250	250	-----	-----	-----
		Total		-----	-----	-----	-----	110	-----	-----	280	280	-----	-----	-----

TABLE 5
SOLANA 1 PROJECT - SUMMARY OF STUDY RESULTS
69-KV BUS VOLTAGES

Critical Outages	Impacted 69-kV Busses	Post-Contingency Voltages							Voltage Deviations						
		APS 2011 Case	Solana Project Only Case 1		Solana Project Only Case 2		Solana Project and Senior Queued Project Case 6		APS 2011 Case	Solana Project Only Case 1		Solana Project Only Case 2		Solana Project and Senior Queued Project Case 6	
		Voltage (PU)	Voltage (PU)	Change (PU)	Voltage (PU)	Change (PU)	Voltage (PU)	Change (PU)	Delta V	Delta V	Change	Delta V	Change	Delta V	Change
Gila Bend-Panda 230-kV Line	Why	0.891	0.858	(0.033)					(3.71)	(7.27)	3.56				
	Twenty-four Other Busses		0.833 to 0.935	(0.140) to (0.040)						(15.71) to (7.37)	14.05 to 4.41				
Jojoba 230/69-kV Transformer	GY3	0.953	0.949	(0.004)	0.949	(0.004)	0.946	(0.007)	(5.21)	(5.30)	0.09	(5.30)	0.09	(5.39)	0.18
	Jojoba	0.955	0.951	(0.004)	0.952	(0.003)	0.949	(0.006)	(5.18)	(5.27)	0.09	(5.27)	0.09	(5.36)	0.18
Palm Valley 230/69-kV Transformer	Pima	0.941	0.940	(0.001)	0.941	(0.000)	0.940	(0.001)	(6.21)	(6.24)	0.03	(6.23)	0.02	(6.27)	0.06
	Pima S	0.942	0.940	(0.002)	0.941	(0.001)	0.940	(0.002)	(6.23)	(6.25)	0.02	(6.25)	0.02	(6.29)	0.06
	WS 2	0.944	0.943	(0.001)	0.943	(0.001)	0.942	(0.002)	(7.04)	(7.07)	0.03	(7.06)	0.02	(7.11)	0.07
	WS 1	0.944	0.943	(0.001)	0.943	(0.001)	0.942	(0.002)	(7.04)	(7.07)	0.03	(7.06)	0.02	(7.11)	0.07
	Palm Valley	0.944	0.943	(0.001)	0.943	(0.001)	0.942	(0.002)	(7.04)	(7.07)	0.03	(7.06)	0.02	(7.11)	0.07
	WS 3	0.946	0.945	(0.001)	0.945	(0.001)	0.944	(0.002)	(6.20)	(6.23)	0.03	(6.22)	0.02	(6.26)	0.06
	Peb Creek W	0.946	0.945	(0.000)	0.946	(0.000)	0.945	(0.001)	(5.25)	(5.27)	0.02	(5.26)	0.01	(5.29)	0.04
	Peb Creek E	0.946	0.946	(0.000)	0.946	(0.000)	0.945	(0.001)	(5.24)	(5.26)	0.02	(5.25)	0.01	(5.28)	0.04
TS 1 230/69-kV	SV 7	0.923	0.924	0.001	0.924	0.001	0.924	0.001	(7.54)	(7.51)	(0.03)	(7.51)	(0.03)	(7.49)	(0.05)
	W1	0.924	0.927	0.003	0.927	0.003	0.928	0.004	(5.53)	(5.50)	(0.03)	(5.50)	(0.03)	(5.49)	(0.04)
	SV8	0.925	0.926	0.001	0.926	0.001	0.926	0.001	(7.51)	(7.48)	(0.03)	(7.48)	(0.03)	(7.46)	(0.05)
	SNVLY	0.926	0.927	0.001	0.927	0.001	0.928	0.002	(7.49)	(7.45)	(0.04)	(7.46)	(0.03)	(7.44)	(0.05)
	FRT	0.936	0.937	0.001	0.937	0.001	0.938	0.002	(7.34)	(7.31)	(0.03)	(7.31)	(0.03)	(7.29)	(0.05)
	Wickenburg	0.937	0.940	0.003	0.940	0.003	0.941	0.004	(5.36)	(5.34)	(0.02)	(5.34)	(0.02)	(5.33)	(0.03)
	FLYINGE	0.940	0.942	0.002	0.942	0.002	0.943	0.003	(5.41)	(5.38)	(0.03)	(5.38)	(0.03)	(5.37)	(0.04)
	SV15	0.946	0.947	0.001	0.947	0.001	0.947	0.001	(7.20)	(7.17)	(0.03)	(7.17)	(0.03)	(7.15)	(0.05)
	TS1	0.955	0.956	0.001	0.956	0.001	0.956	0.001	(7.08)	(7.05)	(0.03)	(7.05)	(0.03)	(7.03)	(0.05)
	NW1	0.959	0.959	0.001	0.959	0.001	0.960	0.001	(5.21)	(5.18)	(0.03)	(5.18)	(0.03)	(5.17)	(0.04)
	NW2	0.960	0.961	0.001	0.961	0.001	0.961	0.001	(5.66)	(5.63)	(0.03)	(5.63)	(0.03)	(5.62)	(0.04)

SOLANA 1 PROJECT - TRANSIENT STABILITY ANALYSIS

Study Methodology
Transient stability studies involving 500-kV facilities were performed on the following pre- and post-Project cases to assess the impact of the addition of the Solana 1 Project on the transmission system in Arizona:

- Case "11hs_pre_case_2" – the pre-Project case in which the Q31 project was interconnected at the Panda 230-kV bus
- Case "11hs_solana_case_3" – a post-Project case with the Solana Project interconnected at the Panda 230-kV bus and the Q31 project not in-service
- Case "11hs_both_case_5" – a post-Project case with the Solana Project interconnected at the Watermelon 230-kV bus and the Q31 project interconnected at the Panda 230-kV bus)[8].

The following contingencies were simulated on each of the above cases:

<u>Category "B" – Single Contingency Outages</u>

- Three-phase fault at the Hassayampa 500-kV bus with outage of the Hassayampa-North Gila 500-kV line.
- Three-phase fault at the Palo Verde 500-kV bus with outage of the Palo Verde–Devers 500-kV line
- Three-phase fault at the Palo Verde 500-kV bus with outage of the Palo Verde–Westwing 500-kV line.
- Three-phase fault at the Palo Verde 500-kV bus with outage of the Palo Verde–Rudd 500-kV line.
- Three-phase fault at the Hassayampa 500-kV bus with outage of one Hassayampa-Jojoba 500-kV line.
- Three-phase fault at the Jojoba 500-kV bus with outage of the Jojoba-Kyrene 500-kV line.

<u>Category "C" – Single Contingency Outages</u>

- Single-line-to-ground fault at the Palo Verde 500-kV bus and outage of both Palo Verde-Westwing 500-kV lines.
- Single-line-to-ground fault at the Palo Verde 500-kV bus and outage of the Palo Verde-Westwing #1 and Palo Verde-Rudd 500-kV lines.

[8] The version of this case used for the stability analysis also included a 300 MW queued project interconnected at Watermelon; this project has withdrawn from the queue since the stability studies were done.

- Three-phase fault at the Gila River 500-kV bus with outage of the Gila River-Jojoba 500-kV lines. (For post-Project Case 4 this outage included one Gila River-Jojoba 500-kV line and the Gila River–Watermelon 500-kV line).
- Three-phase fault at the Jojoba 500-kV bus with outage of the Jojoba–Gila River #2 and the Jojoba–Watermelon 500-kV lines (this outage was only performed on post-Project Case 4).

In addition, transient stability studies involving 230-kV facilities in the Gila Bend area were performed on the following post-Project cases to assess the impact of the addition of the Solana 1 Project on the transmission system in Arizona:

- Case "11hs_solana_case_3" – a post-Project case with the Solana Project interconnected at the Panda 230-kV bus and the Q31 project not in-service
- Case "11hs_both_case_4" – a post-Project case with the Solana Project and the Q31 project interconnected at the Panda 230-kV bus)[9].

The following Category B contingencies were simulated on each of the above cases:

- Three-phase fault at the Gila River 230-kV bus with outage of the Gila River-Jojoba 230-kV line.
- Three-phase fault at the TS4 230-kV bus with outage of the TS4-Jojoba 230-kV line
- Three-phase fault at the TS4 230-kV bus with outage of the TS4-Palm Valley 230-kV line
- Three-phase fault at the Jojoba 230-kV bus with outage of the Jojoba 230/69-kV transformer
- Three-phase fault at the Gila River 500-kV bus with outage of the Gila River 500/230-kV transformer

Each contingency was simulated for 10 seconds so as to comply with NERC/WECC Planning criteria. Other criteria applied in these studies were as follows:

- All machines in the system will remain in synchronism as demonstrated by their relative rotor angles.
- System stability is evaluated based on the damping of the relative rotor angles and the damping of the voltage magnitude swings.
- Transient voltage dips and frequency dips must meet the WECC Reliability Criteria shown in Table 6.

[9] The version of this case used for the stability analysis also included a 300 MW queued project interconnected at Watermelon; this project has withdrawn from the queue since the stability studies were done.

TABLE 6 WECC RELIABILITY CRITERIA				
Performance Level	**Disturbance**	**Transient Voltage Dip Criteria**	**Transient Frequency Dip Criteria**	**Post Transient Voltage Deviation**
B	N-1 (Single Contingency)	Max V Dip at Load Buses-25% Max Duration of V Dip > 20% - 20 cycles	Duration of Frequency Below 59.6 Hz - 6 cycles	Not to exceed 5%
C	N-2 (Double Contingency)	Max V Dip – 30% Max Duration of V Dip > 20% - 40 cycles	Duration of Frequency Below 59.4 Hz - 6 cycles	Not to exceed 10%

Results of Transient Stability Studies

The transient stability simulations of the Category B and C contingencies discussed above resulted in stable and damped oscillations with one exception – the double-line outage involving the two 500-kV lines between the Gila River and Jojoba substations resulted in voltage and frequency dip violations throughout the Arizona system and ultimately resulted in undamped oscillations. This occurs due to the large amount of generation (over 1,950 MW) that becomes isolated on the 230-kV system at Gila River after loss of both the 500-kV lines. Tripping the Gila River units (a total of 1,950 MW) eliminated all voltage and frequency dip violations and resulted in a stable, damped system for all cases studied. For the purposes of this study generators were tripped at the same time the lines were (4 cycles).

Table 7 summarizes the results for outages that resulted in voltage dip violations and the results after tripping local generation. Refer to Appendix D for plots associated with the outages listed in Table 7 and for the 230-kV outages discussed above.

TABLE 7 TRANSIENT VOLTAGE AND FREQUENCY DIP VIOLATIONS; INCLUDING SOLUTION OF TRIPPING LOCAL GENERATION					
Base Case	**Outage**	**Generation Tripping**	**Category C Violations**	**# of Buses Violations**	**Oscillations**
"11hs_pre_ Case_2"	Three Phase Fault @ Gila River and loss of Gila River - Jojoba 500-kV lines	None	Max V dip 30%	82	Undamped
			20% V dip for 40 cycles	8	
			Duration of Frequency Below 59.4 Hz - 6 cycles	694	
		All Gila River Units - 1950 MW	Max V dip 30%	0	Damped
			20% V dip for 40 cycles	0	
			Duration of Frequency Below 59.4 Hz - 6 cycles	0	
"11hs_solana_ case_3"	Three Phase Fault @ Gila River and loss of Gila River - Jojoba 500-kV lines	None	Max V dip 30%	86	Undamped
			20% V dip for 40 cycles	0	
			Duration of Frequency Below 59.4 Hz - 6 cycles	370	
		All Gila River Units - 1950 MW	Max V dip 30%	0	Damped
			20% V dip for 40 cycles	0	
			Duration of Frequency Below 59.4 Hz - 6 cycles	0	
"11hs_both_ case_5"	Three Phase Fault @ Gila River and loss of Gila River-Jojoba 500-kV line and Gila River-Watermelon 500-kV line	None	Max V dip 30%	82	Undamped
			20% V dip for 40 cycles	0	
			Duration of Frequency Below 59.4 Hz - 6 cycles	464	
		All Gila River Units - 1950 MW	Max V dip 30%	0	Damped
			20% V dip for 40 cycles	0	
			Duration of Frequency Below 59.4 Hz - 6 cycles	0	

SOLANA 1 PROJECT - FACILITY REQUIREMENTS

The information presented above was used to develop information relative to the facilities that would be required to interconnect the Solana 1 Project with the existing grid and to allow the Project output to be delivered under all studied conditions. This information is summarized in Table 8 (simplified one-line diagrams for the pertinent 230-kV facilities are contained in Figures 2 through 10).

TABLE 8
SUMMARY OF FACILITY ADDITIONS – SOLANA 1 PROJECT

	Proposed Projects	Without Q31 project				With Q31 project					
		1	2	3	4	1	2	3a	3b	4	5
Installed Capacity (MW)	Solana	250	250	250	250	250	250	250	250	250	250
	Queue #31	0	0	0	0	110	110	110	110	110	110
	Total	250	250	250	250	360	360	360	360	360	360
Interconnection Point	Solana	Gila Bend	Gila Bend	Panda	Watermelon	Gila Bend	Gila Bend	Gila Bend	Gila Bend	Panda	Watermelon
	Queue #31	n/a	n/a	n/a	n/a	G. Bend 69	Gila Bend	Panda	Panda	Panda	Panda
Reference Figure		2	3	4	5	6	7	2	8	9	10
Facilities Required for Project Interconnection											
Miles of New 230-kV line		14	14	22	23	14	14	14	14	22	23
New Gila Bend 230-kV switchyard		Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No
• No. of circuit breakers required		3	3	-----	-----	3	4	3	3	-----	-----
230-kV additions at Panda		No	No	Yes	No	No	No	No	No	Yes	No
• No. of circuit breakers required		-----	-----	1	-----	-----	-----	-----	-----	4[6]	-----
Watermelon 500/230-kV substation		No	No	No	Yes	No	No	No	No	No	Yes
• No. of 500-kV breakers required		----	----	----	3	-----	-----	-----	-----	----	3
• No. of transformers required		----	----	----	1	-----	-----	-----	-----	----	1
• No. of 230-kV breakers required		----	----	----	1	-----	-----	-----	-----	----	1
Facilities Required for 100% Deliverability (For Main Grid Category A and B Conditions)											
• Miles of Upgraded 69-kV line		58	11	11	0	19	19	58	19	11	0
• Miles of New 230-kV line		-----	7	-----	-----	7	7	-----	7	-----	-----
• 230-kV Breakers at Gila Bend		-----	1	-----	-----	1	4[10]	-----	1	-----	-----
• 230-kV Breakers at Panda		-----	1	-----	-----	1	1	-----	4[6]	-----	-----

[10] Includes breaker(s) required for interconnection of Q31 project.

FIGURE 2
Solana 1 Project - Case 1 - 230-kV Additions

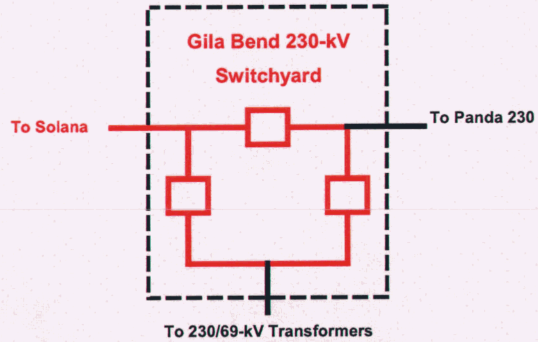


FIGURE 3
Solana 1 Project - Case 2 - 230-kV Additions

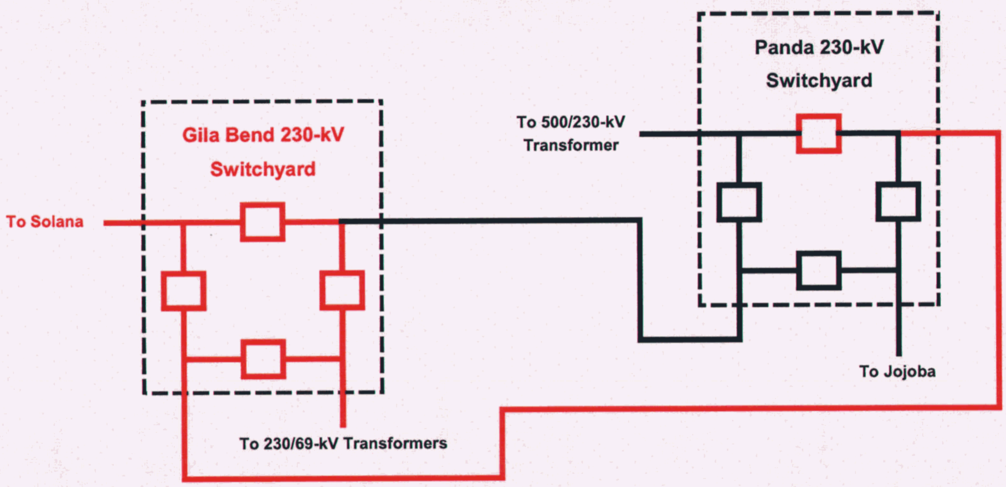


FIGURE 4
Solana 1 - Case 3 - 230-kV Additions

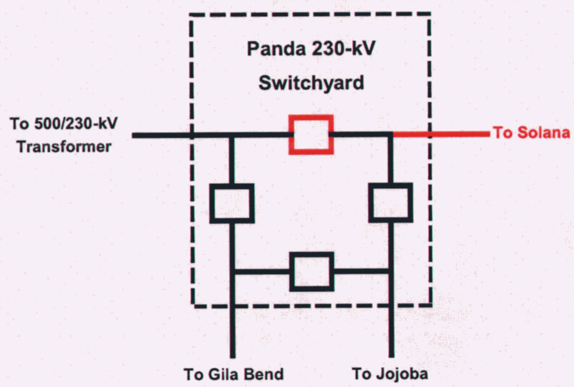


FIGURE 5
Solana 1 - Case 4 - 500-kV and 230-kV Additions

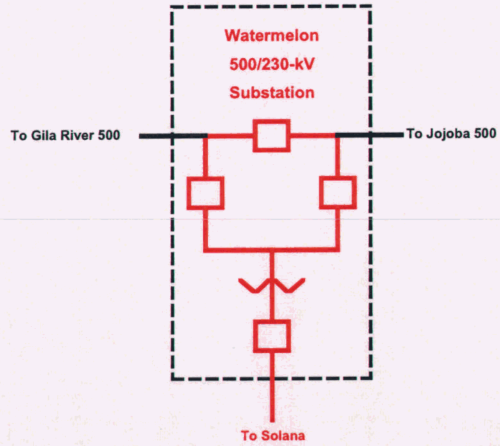


FIGURE 6
Solana 1 and Q31 Projects - Case 1 - 230-kV Additions

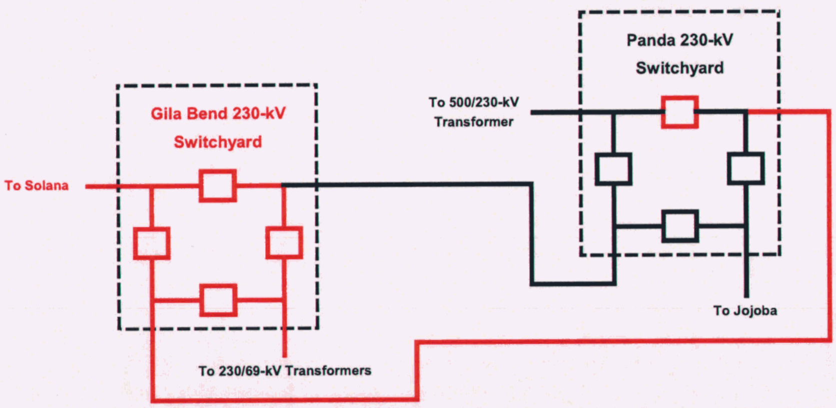


FIGURE 7
Solana 1 and Q31 Projects - Case 2 - 230-kV Additions

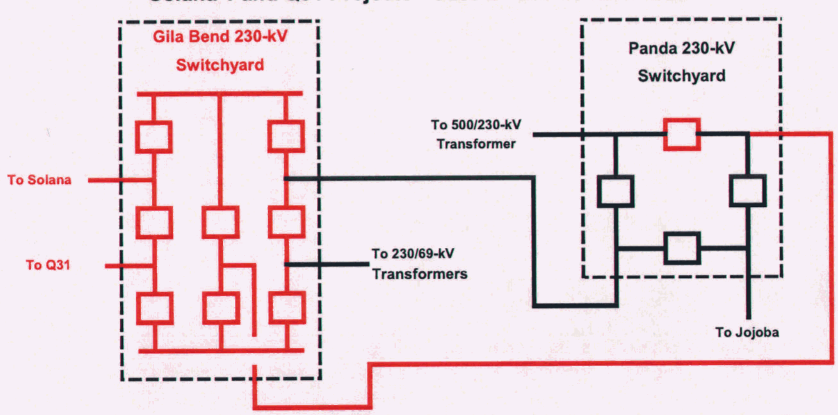


FIGURE 8

Solana 1 and Q31 Projects - Case 3 - 230-kV Additions

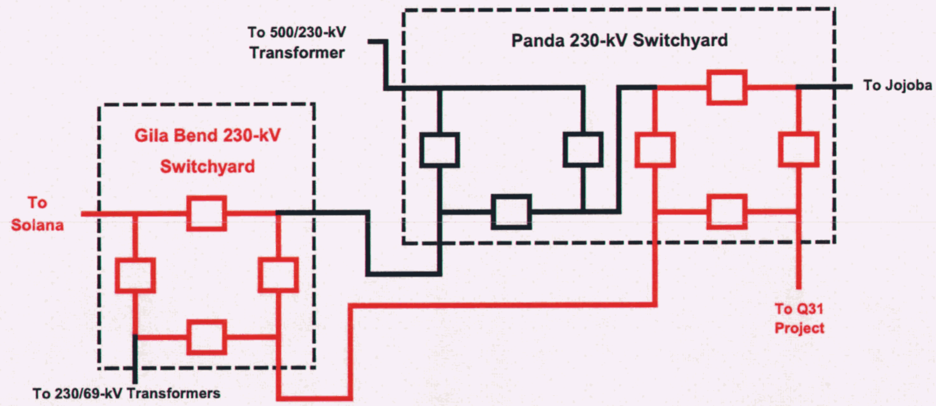


FIGURE 9

Solana 1 and Q31 Projects - Case 4 - 230-kV Additions

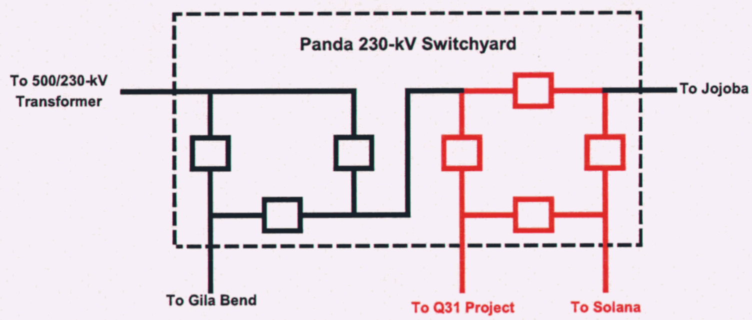
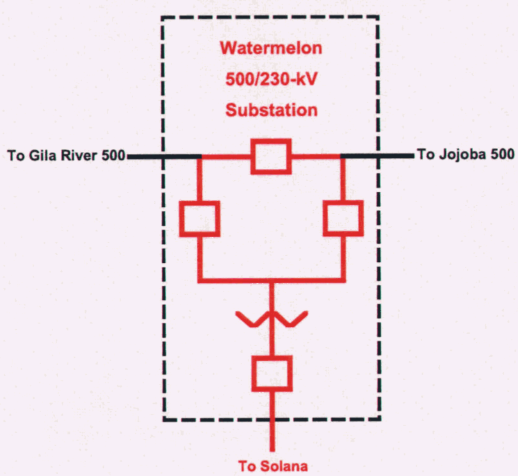


FIGURE 10

Solana 1 and Q31 Projects - Case 5
500-kV and 230-kV Additions



SOLANA 1 AND 2 PROJECTS - POWER FLOW ANALYSIS

Thermal Loading Results

The result of studies on three scenarios with the Solana 1 and 2 Projects and the Q31 project in-service are summarized in Table 9. Review of the information in Table 9 indicates that:

- If the Q31 project and the Solana 1 and 2 Projects were interconnected at the Gila Bend 230-kV bus and a second Gila Bend-Panda 230-kV line was built, approximately 19 miles of 69-kV line would have to be upgraded to allow the full 500 MW output of the Solana Projects to be delivered under all Category A and B conditions. Without such upgrades:
  - A total of 415 MW of new generation at the Gila Bend 230-kV bus would have to be curtailed to mitigate the impacts of an outage of the Panda-Jojoba 230-kV line, and
  - A total of 340 MW of new generation at the Gila Bend 230-kV bus would have to be curtailed to mitigate the impacts of an outage of the Jojoba 230/69-kv transformer.
- If the Q31 project and the Solana 1 and 2 Projects were interconnected at the Gila Bend 230-kV bus and a second Gila Bend-Panda 230-kV line was built, it would be necessary to curtail approximately 530 MW of the new generation at Gila Bend to mitigate the impacts of a Category C outage of both Gila Bend-Panda 230-kV lines.
- If all three projects were interconnected at the Panda 230-kV bus, approximately 19 miles of 69-kV line would have to be upgraded to allow the full 500 MW output of the Solana Projects to be delivered under all conditions. If these 69-kV lines were not upgraded:
  - A total of 375 MW of new generation at the Panda 230-kV bus would have to be curtailed to mitigate the impacts of an outage of the Panda-Jojoba 230-kV line, and
  - A total of 265 MW of new generation at the Panda 230-kV bus would have to be curtailed to mitigate the impacts of an outage of the Jojoba 230/69-kv transformer.
- Interconnection of the Solana Projects at the new Watermelon 500/230-kV Substation would allow for full deliverability of the Projects for all conditions studied.

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TABLE 9
SOLANA 1 & 2 PROJECTS - SUMMARY OF STUDY RESULTS
COMPARISON OF CATEGORY B & C OVERLOADS

			APS 2011 Case	Cases With Solana & Q31 Projects ("11hs_three_project_case_")		
				1	2	3
Gila Bend Area Generation (MW)	APS Queue # 31		0	110	110	110
	Solana		0	500	500	500
	Total		0	610	610	610
Generation Interconnection Points	APS Queue #31		n/a	G. Bend	Panda	Panda
	Solana		n/a	G. Bend	Panda	New Sub
# of Gila Bend-Panda 230-kV Lines ?				1	2	1	1

230-kV Category B Outage	Impacted Facility	Rating [1]	Length	Post-Outage Loading (%) APS 2011 Case	1	2	3
Gila Bend-Panda	Jojoba-Patterson 69-kV Line [2]	532	4.2	121		128	123
	Gillespie-Patterson 69-kV Line [2]	532	3.8	109		116	111
Liberty-Buckeye	Gila Bend-Butterfield Tap 69-kV Line	532	4.2		100		
	Butterfield Tap-Cotton Center 69-kV Line	532	3.8		100		
Panda-Jojoba Line.	Gila Bend-Butterfield Tap 69-kV Line	658	6.0		136	129	
	Butterfield Tap-Cotton Center 69-kV Line	658	5.0		136	129	
	Cotton Center-Gillespie 69-kV Line	658	7.5		127	119	
Rudd-White Tank Line	Seargant-Orme RS 69-kV Line	1,100	n/a	116	117	117	117
Jojoba Transformer	Gila Bend-Butterfield Tap 69-kV Line	658	6.0		118	112	
	Butterfield Tap-Cotton Center 69-kV Line	658	5.0		118	111	
	Cotton Center-Gillespie 69-kV Line	658	7.5		108	102	
TS 1 Transformer	Wilhoit-Kirk Junction 69-kV Line	142	n/a	121	118	118	118
White Tanks #1 Transformer.	Seargant-Orme RS 69-kV Line	1,100	n/a	118	119	119	119
	White Tanks 230/69-kV #3 Trans.	318		110	110	110	109

		APS 2011 Case	1	2	3
Impacted 69-kV Lines (Miles)			18.5	18.5	0.0
Required Generation Curtailments (MW) Without System Reinforcements					
For Panda-Jojoba 230-kV Line Outage	APS Queue #31		25	0	0
	Solana		390	375	0
	Total		415	375	0
For Jojoba 230/69-kV Transformer Outage	Solana		340	265	0

230-kV Category C Outage	Impacted Facility	Rating [1]	Length	Post-Outage Loading (%) APS 2011 Case	1	2	3
Cactus-Ocotillo 230 and Cactus Pinnacle Peak 230	McCormick-Camelback 69-kV Line	900		109	109	109	109
Pinnacle Peak-Reach 230 and Pinnacle Peak-Lone Peak 230	Meadowbrook-Sunnyslope 230-kV line	1,231		100	102	102	101
Deer Valley-Westwing 230 and Deer Valley-Pinnacle Peak 230	Seargant-Orme RS 69-kV Line	1,100		99	99	99	99
Surprise-El Sol 230 and Surprise-Westwing 230	Wilhoit-Kirk Junction 69-kV Line	142		141	137	137	138
	Dysart-Marin Tap 69-kV Line	900		125	125	125	124
	Marin Tap-El Sol 69-kV Line	900		125	125	125	124
	Rio Viste-Westwing 69-kV Line	1,000		116	114	114	115
	Whitspar-Wilhoit 69-kV Line	187		111	108	108	108
	Rio Viste-Surprise 69-kV Line	900		105	104	104	104
	TS 1 230/69-kV Transformer	235		102	103	103	102
Agua Fria-Westwing 230 and Liberty-Westwing 230	Seargant-Orme RS 69-kV Line	1,100		99	99	99	99
Gila Bend-Panda #1 and #2 230				n/a	Diverged	n/a	n/a

		APS 2011 Case	1	2	3
Generation Curtailments (via RAS) Required to Mitigate Impacts of Gila Bend-Panda DLO (MW)	APS Queue # 31	-----	85	-----	-----
	Solana	-----	445	-----	-----
	Total	-----	530	-----	-----

1/ In Amps for lines; MVA for transformers

2/ Per APS studies, overloads on these lines can be mitigated by opening the Gillespie-Gillespie West 69-kV line

Impacts on System Voltages

Review of post-contingency 69-kV bus voltages for the pre-Project case and the post-Project Scenarios showing the largest post-contingency system impacts (Scenarios 1 and 3) indicated that there would be no significant voltage impacts for the post-Project scenarios. Table 10 summarizes the noted voltage impacts.

SOLANA 1 AND 2 PROJECTS - TRANSIENT STABILITY ANALYSIS

Study Methodology

Transient stability studies involving the 500-kV Category B and C contingencies list on Pages 14 and 15 were performed on the "11hs_three_project_case_3" base case (in which the Solana 1 and 2 Projects were interconnected at Watermelon and the Q31 was project interconnected at the Panda 230-kV bus)[11]. In addition, transient stability studies involving the 230-kV Category B contingencies listed on Page 15 were performed on this case. The same criteria were applied in these studies as in the studies for the Solana 1 Project.

Results of Transient Stability Studies

As was the situation with the Solana 1 Project studies, the transient stability simulations of the Category B and C contingencies resulted in stable and damped oscillations with one exception – the double-line outage involving the two 500-kV lines between Gila River and Jojoba lines resulted in voltage and frequency dip violations throughout the Arizona system and ultimately resulted in undamped oscillations. As shown in Table 11 tripping the Gila River units (a total of 1,950 MW and 250 MW of Solana generation) eliminated all voltage and frequency dip violations and resulted in a stable, damped system for all cases studied. For the purposes of this study generators were tripped at the same time the lines were (4 cycles). Appendix D contains the pertinent stability plots for the outage listed in Table 11 and for the pertinent 230-kV outages.

[11] The version of this case used for the stability analysis also included a 300 MW queued project interconnected at Watermelon; this project has withdrawn from the queue since the stability studies were done.

TABLE 10
SOLANA 1 AND 2 PROJECTS - SUMMARY OF STUDY RESULTS
69-KV BUS VOLTAGES

Critical Outages	Impacted 69-kV Bus	Post-Contingency Voltages							Voltage Deviations						
		APS 2011 Case	Cases with Solana 1 and 2 Projects & Senior Queued Project						APS 2011 Case	Cases with Solana 1 and 2 Projects & Senior Queued Project					
			1		2		3			1		2		3	
		Voltage (PU)	Voltage (PU)	Change (PU)	Voltage (PU)	Change (PU)	Voltage (PU)	Change (PU)	Delta V	Delta V	Change	Delta V	Change	Delta V	Change
Gila Bend-Panda Line	WHY	0.891			0.876	(0.015)	0.889	(0.003)	(3.70)			(4.280)	0.58	(3.62)	(0.08)
	AJO	0.913			0.898	(0.015)	0.910	(0.003)	(0.03)			(4.040)	4.01	(0.03)	(0.00)
Jojoba 230/69-kV Transformer	GY3	0.953	0.939	(0.014)	0.941	(0.012)	0.950	(0.003)	(5.17)	(5.48)	0.31	(5.390)	0.22	(5.21)	0.04
	JOJOBA	0.955	0.942	(0.014)	0.943	(0.012)	0.953	(0.003)	(5.14)	(5.45)	0.31	(5.360)	0.22	(5.18)	0.04
Palm Valley 230/69-kV Transformer	PIMA	0.941	0.936	(0.005)	0.937	(0.005)	0.941	(0.000)	(6.20)	(6.38)	0.18	(6.360)	0.16	(6.22)	0.02
	PIMA S	0.942	0.936	(0.005)	0.937	(0.005)	0.941	(0.000)	(6.21)	(6.40)	0.19	(6.370)	0.16	(6.23)	0.02
	WS2	0.944	0.938	(0.005)	0.939	(0.005)	0.943	(0.001)	(7.02)	(7.23)	0.21	(7.210)	0.19	(7.05)	0.03
	WS1	0.944	0.939	(0.005)	0.939	(0.005)	0.943	(0.001)	(7.02)	(7.23)	0.21	(7.210)	0.19	(7.04)	0.02
	PLMVLY	0.944	0.939	(0.005)	0.939	(0.005)	0.944	(0.001)	(7.02)	(7.23)	0.21	(7.200)	0.18	(7.04)	0.02
	PEBCRK W	0.946	0.942	(0.005)	0.942	(0.004)	0.946	(0.000)	(5.24)	(5.38)	0.14	(5.360)	0.12	(5.25)	0.01
	PEBCRK E	0.946	0.942	(0.005)	0.942	(0.004)	0.946	(0.000)	(5.23)	(5.37)	0.14	(5.360)	0.13	(5.24)	0.01
	WS3	0.946	0.941	(0.006)	0.941	(0.005)	0.946	(0.001)	(6.18)	(6.37)	0.19	(6.350)	0.17	(6.20)	0.02
TS1 230/69-kV Transformer	SV7	0.923	0.924	0.001	0.924	0.001	0.925	0.002	(7.56)	(7.43)	(0.13)	(7.430)	(0.13)	(7.45)	(0.11)
	W1	0.924	0.930	0.006	0.930	0.006	0.930	0.007	(5.54)	(5.46)	(0.08)	(5.460)	(0.08)	(5.45)	(0.09)
	SV8	0.925	0.926	0.001	0.926	0.001	0.927	0.002	(7.53)	(7.41)	(0.12)	(7.400)	(0.13)	(7.42)	(0.11)
	SNVLY	0.926	0.928	0.001	0.928	0.001	0.928	0.002	(7.51)	(7.38)	(0.13)	(7.380)	(0.13)	(7.40)	(0.11)
	FRT	0.936	0.938	0.001	0.938	0.001	0.938	0.002	(7.36)	(7.24)	(0.12)	(7.230)	(0.13)	(7.25)	(0.11)
	WICKNBRG	0.937	0.943	0.005	0.943	0.005	0.943	0.006	(5.38)	(5.30)	(0.08)	(5.300)	(0.08)	(5.29)	(0.09)
	FLYINGE	0.940	0.945	0.005	0.945	0.005	0.946	0.006	(5.42)	(5.34)	(0.08)	(5.340)	(0.08)	(5.33)	(0.09)
	SV15	0.946	0.947	0.001	0.947	0.001	0.948	0.002	(7.22)	(7.10)	(0.12)	(7.100)	(0.12)	(7.12)	(0.10)
	TS1	0.955	0.956	0.001	0.956	0.001	0.957	0.002	(7.10)	(6.98)	(0.12)	(6.970)	(0.13)	(6.99)	(0.11)
	NW1	0.959	0.960	0.001	0.960	0.001	0.960	0.002	(5.22)	(5.13)	(0.09)	(5.130)	(0.09)	(5.14)	(0.08)
	NW2	0.960	0.961	0.001	0.962	0.001	0.962	0.002	(5.67)	(5.58)	(0.09)	(5.570)	(0.10)	(5.59)	(0.08)

TABLE 11 TRANSIENT VOLTAGE AND FREQUENCY DIP VIOLATIONS; INCLUDING SOLUTION OF TRIPPING LOCAL GENERATION SOLANA 1 AND 2 PROJECT STUDIES					
Base Case	**Outage**	**Generation Tripping**	**Category C Violations**	**# of Buses Violations**	**Oscillations**
Post-Project Case 5	Three Phase Fault @ Gila River and loss of Gila River-Jojoba 500-kV line and Gila River-Watermelon 500-kV line	All Gila River units (1950 MW)	Max V dip 30%	70	Undamped
			20% V dip for 40 cycles	0	
			Duration of Frequency Below 59.4 Hz - 6 cycles	50	
		All Gila River units (1950 MW) and two Solana units (250 MW)	Max V dip 30%	0	Damped
			20% V dip for 40 cycles	0	
			Duration of Frequency Below 59.4 Hz - 6 cycles	0	

SOLANA 1 AND 2 PROJECTS - FACILITY REQUIREMENTS

The study results discussed above were compared to those with only the Solana 1 Project in-service to identify any incremental upgrades required to support the Solana 2 Project. This comparison indicated that:

- If the Solana 1 and 2 Projects were interconnected at Gila Bend, a second Gila Bend-Panda 230-kV line would be required so as to avoid Category A (N-0) overloads on the existing Gila Bend-Panda line.
- The upgrades required for the impacted 69-kV lines would have to be sized approximately 20% larger than those when only the Solana 1 Project was in-service. For example, the required rating for the Gila Bend-Cotton Center 69-kV line with only the Solana 1 Project in-service would be at least 750 amps. The addition of the Solana 2 Project increases the minimum required rating to approximately 900 amps.