Q51 Generation Interconnection

Interconnection Facilities Study Results

APS Contract No. 52395

By

Arizona Public Service Company
Transmission Planning

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[Version 1.0]

Q51 FACILITIES STUDY

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List of Acronyms

ACC	Arizona Corporation Commission
ACSS	Aluminum Conductor Steel Supported
ANPP	Arizona Nuclear Power Project
APS	Arizona Public Service
ATC	Available Transfer Capability
CAISO	California Independent System Operator Corporation
CAWCD	Central Arizona Water Conservation District
CCVT	Coupling Capacitor Voltage Transformer
COD	Commercial Operation Date
CSP	Concentrated Solar Power
CT	Combustion Turbine or Current Transformer
EPE	El Paso Electric
ER	Energy Resource
ERIS	Energy Resource Interconnection Service
FaS	Facilities Study
FERC	Federal Energy Regulatory Commission
FeS	Feasibility Study
GT	Gas Turbine
IC	Interconnection Customer
IID	Imperial Irrigation District
IR	Interconnection Request
LADWP	Los Angeles Department of Water and Power
LGIA	Large Generator Interconnection Agreement
NEC	Navopache Electric Cooperative
NERC	North American Electric Reliability Corporation
NR	Network Resource
NRIS	Network Resource Interconnection Service
NTUA	Navajo Tribal Utility Authority
OASIS	Open Access Same Time Information System
OATT	Open Access Transmission Tariff
PG&E	Pacific Gas & Electric
PNM	Public Service Company of New Mexico
POI	Point Of Interconnection
PPA	Purchase Power Agreement
PSLF/PSDS/SCSC	Positive Sequence Load Flow/Positive Sequence Dynamic Simulation/Short-Circuit Saturation Curve
PST	Phase-Shifting Transformer
PV	Photovoltaic
RAS	Remedial Action Scheme (also known as SPS)
RFP	Request for Proposal
SCE	Southern California Edison Company
SDG&E	San Diego Gas & Electric Company
SIS	System Impact Study
SLG fault	Single Line-to-Ground fault
SPS	Special Protection System (also known as RAS)
SRP	Salt River Project
SSVEC	Sulphur Springs Valley Electric Cooperative, Inc.
SVC	Static VAR Compensator
SVD	Static VAR Device
SWTC	Southwest Transmission Cooperative
TEP	Tucson Electric Power
TPIF	Transmission Provider's Interconnection Facilities
WAPA	Western Area Power Administration
WECC	Western Electricity Coordinating Council

1. Introduction

Arizona Public Service Company (APS) performed this Generator Interconnection Facilities Study (FaS) in response to a 120 MW solar interconnection request by the Interconnection Customer (IC). The Customer is listed in APS's Active Generator Interconnection Queue as queue number 51(Q51). The purpose of the study is to provide cost and construction schedule estimates for the facilities needed to interconnect the IC's proposed 120 MW solar generation facility located near Hyder, Arizona in Yuma County.

The Interconnection Customer submitted an interconnection request to APS, which was accepted on September 23, 2008 and has already completed a System Impact Study. This Project is a FERC jurisdictional large generator interconnection request. The IC's requested Commercial Operation Date for Q51 is Q4 2015. The IC's requested date to have the interconnection initially energized in order to take back feed power is Q4 2014. **Please note that the In-Service Date must be within the seven (7) years of the APS acceptance of the Interconnection Customer's Interconnection Request.** All reasonable efforts will be used by APS to meet the Interconnection Customer's proposed project dates.

The Interconnection Customer's requested Commercial Operation Date for Q51 is Q4 2015. Therefore, the desired In-Service Date cannot be met due to the construction time requirements to construct the interconnection facilities. The new proposed In-Service Date should be Q3 or Q4 of 2016.

The IC has requested interconnection into the jointly owned Hassayampa – North Gila 500 kV line. The Point of Interconnection (POI) for this project would be at the proposed future Qx 500 kV switchyard; and the Point of Change of Ownership (POCO) would be the first structure outside the new Qx switchyard fence.

The IC has chosen to interconnect as an Energy Resource. Delivery of the Q51 output beyond the POI would be on an "as-available" basis only. The delivery of the Q51 output would be subject to the firm or non-firm transmission capacity that may be available when a Transmission Service Request is made. **Figure 1.1** shows a general location of Q51.

The Q51 interconnection request was originally for a concentrated solar project. The IC requested to change the project to utilize Photo Voltaic technology. APS has retained Utility System Efficiencies (USE) to perform the technical analysis portion of this FaS to determine if the requested change would constitute a material modification.. [Note: APS normally retains USE if IC is connecting at or above 69 kV].

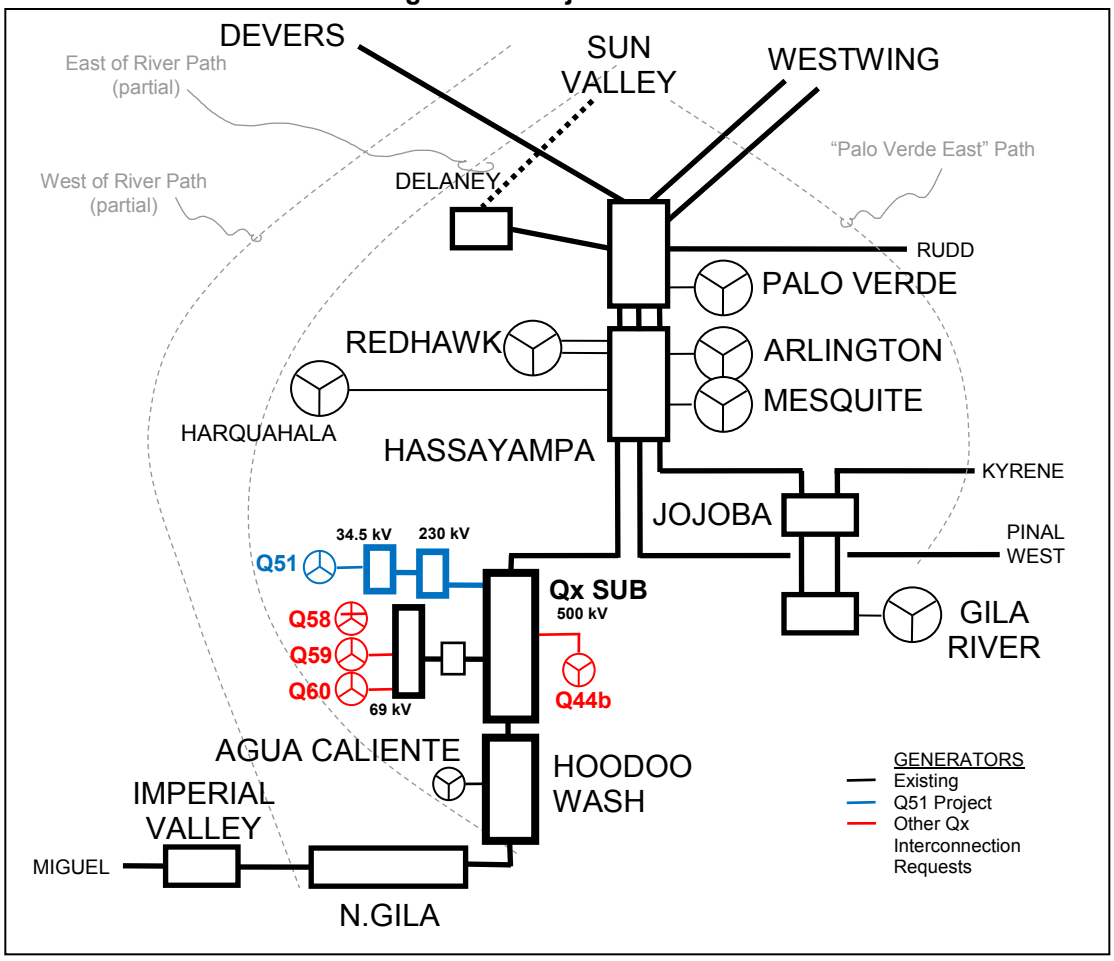
Disclaimer

Nothing in this report constitutes an offer of transmsission service or confers upon the IC, any right to receive transmission service. APS and other interconnected utilities may not have the Available Transfer Capacity ("ATC") to support the Transmission Service for the Interconnection described in this report. It should also be noted that all results for the FAS are highly dependent upon the assumed topology and timing of new projects in the vicinity of the interconnection, which are subject to change.

POI Requirements

The APS Open Access Transmission Tariff (OATT) policy regarding power factor requires <u>all</u> Interconnection Customers, with the exception of wind generators, to maintain an acceptable power factor (typically near unity) at the Point of Interconnectoin (POI), subject to system conditions. The APS OATT also requires Interconnection Customers to be able to achieve +/- 0.95 power factor at the POI, with the maximum "full-output" VAr capability available at <u>all</u> outputs. Furthermore, APS requires Interconnection Customers to have <u>dynamic</u> voltage control and maintain the voltage as specified by the transmission operator within the limitation of a +/- 0.95 power factor, as long a the Project is online and generating. If the Project's equipment is not capable of this type of response, a dynamic reactive device will be required. APS has the right to disconnect the Project if system conditions dictate the need to do so in order to maintain system reliability.

Figure 1.1. Project Location



2. 500 kV INTERCONNECTION AT PROPOSED Qx SWITCHYARD

The IC has requested Interconnection into the jointly owned Hassayampa – North Gila 500 kV line. Although this project is within approximately 10 miles of the Hoodoo Wash 500 kV switchyard this project, along with other generator interconnection requests, have been studied with an interconnection into a new 500 kV switchyard; the Qx 500 kV switchyard. It was determined that the Qx switchyard was needed due to the number of interconnection requests in the general vicinity. In evaluating the location of all of the Interconnection requests, the Hoodoo Wash switchyard will not have the physical room to be expanded to interconnect all of the projects. Therefore, a second 500 kV switchyard was determined to be needed in the area.

Through a high level analysis, APS determined that the proposed location of the Qx switchyard demonstrated the best opportunities for a new 500 kV switchyard. The Qx switchyard is proposed to be a 40 acre site that is adjacent to, on the south side of, the existing Hassayampa – North Gila 500 kV line and north of the Union Pacific Railroad tracks. The proposed site would allow Qx to be cut into the existing 500 kV line without having to cross the railroad tracks. It is also adjacent to an existing APS 69 kV substation and near existing 69 kV lines. This allows for the co-location of electrical facilities and aides in mitigating the impact to the area. This location also allows for future expansion of the Qx substation as more generators and/or transmission lines are located in the area.

3. Q51 INTERCONNECTION FACILITIES - if First to Interconnect to Qx

Figure 3.1 is a one-line diagram of the proposed configuration and interconnection of Q51's Project if Q51 is the first interconnection in the Qx switchyard. **Figure 3.1** depicts the Transmission Provider's Interconnection Facilities (TPIF) which are shown in green to include the 500 kV gen-tie line that is within the Qx substation fence. ATS will own, operate, and maintain the portion of that line from the 500kV bus up to the first structure outside of the substation fence, at which point the IC would pick-up ownership and responsibility for the line. In **Figure 3.1**, the facilities shown in blue are Network Upgrades.

If Q51, the Interconnection Customer, is first to interconnect into the new Qx switchyard, the Network upgrades will consist of the new Qx switchyard, the communications needed for the new yard, the cut-in of the Hassayampa-Hoodoo Wash 500 kV line, changing the relays at the Hoodoo Wash switchyard, changing the relays at Hassayampa, and updating the EMS system for the new Qx switchyard. The new Qx switchyard will consist of approximately 40 acres of land, three new 500 kV breakers, the associated switches and miscellaneous substation equipment, and all of the below grade and above ground construction. Along with the construction costs, there will also be costs associated with Transmission siting efforts for obtaining a Certificate of Environmental Compatibility (CEC) for the Qx switchyard from the Arizona Corporation Commission.

Figure 3.1. One-Line Diagram

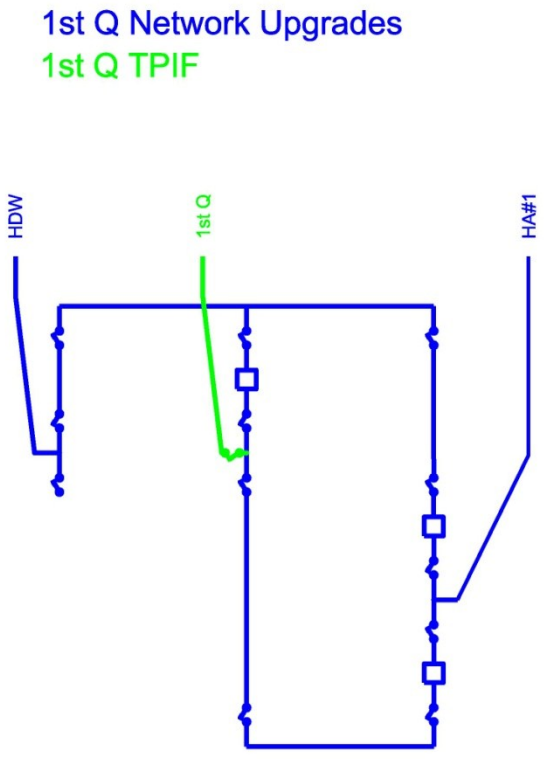


Table 3.1: Cost Estimate if First to Interconnect to Qx (2013 dollars)

Equipment Description	Network Upgrades	Transmission Provider's Interconnection Facilities	System Protection Facilities	Distribution Upgrades
Qx Switchyard	$13,441,000			
Line Work	$1,900,000			
Communications	$1,000,000	$50,000		
Hoodoo Wash Relays	$189,000			
Hassayampa Relays	$145,000			
Qx CEC Siting	$300,000			
Q51 500 kV gen-tie exit; 2 A-frames, 1 switch		$1,381,266		
Subtotal	$16,975,000	$1,431,266		
Grand Total	$18,406,266			

The estimated cost of the Q51 interconnection, connecting in the first position, is allocated into several categories, Network Upgrades, Transmission Provider's Interconnection Facilities, System Protection Facilities and Distribution Facilities and is summarized in **Table 3.1** above.

Interconnection construction costs and timelines were estimated for Q51 based on the approximate location described above. These good faith non-binding cost estimates are applicable only to the APS system and may be different if the final location of the Qx switchyard is different then assumed in this report. This study reviewed all capacity, construction, flicker, protection and communications requirements to interconnect this "FERC" generation project. NERC (North American Reliability Corporation) requires that generation facilities provide a primary and secondary (back-up) communications path for data and control.

This study does not specifically address any requirements for the Interconnection Customer Generating Facilities. However, the Interconnection Customer shall comply with all APS requirements for a generator operating in parallel with APS's electrical system.

4. Q51 INTERCONNECTION FACILITIES - if Second to Interconnect to Qx

Figure 3 is a one-line diagram of the proposed configuration and interconnection of Q51's Project if Q51 is the second interconnection in the Qx switchyard. **Figure 4.1** depicts the Customer's Interconnection Facilities which are shown in green to include the 500 kV gen-tie line that is within the Qx substation fence. APS will own, operate, and maintain the portion of that line from the 500kV bus up to the first structure outside of the substation fence, at which point the IC would pick-up ownership and responsibility for the line. In **Figure 4.1**, the facilities shown in red are Network Upgrades.

If Q51, the Interconnection Customer, is second to interconnect into the new Qx switchyard, the Network upgrades will consist of an expansion of the ring bus at Qx which includes a single 500 kV breaker and two switches.

Figure 4.1. One-Line Diagram

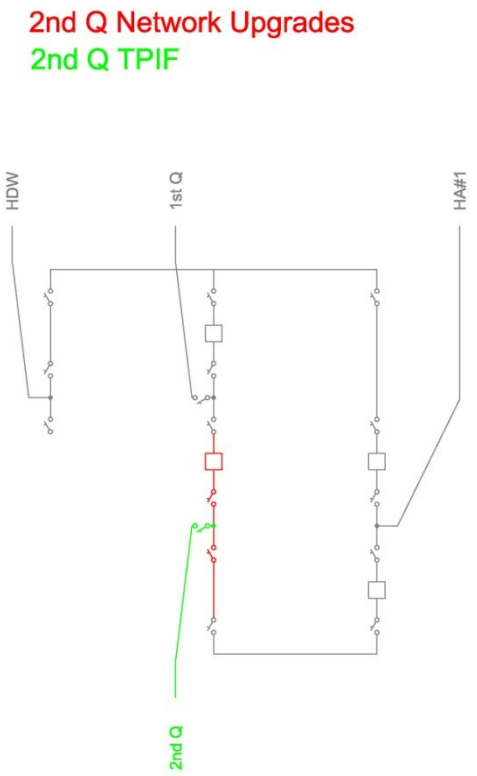


Table 4.1: Cost Estimate if Second to Interconnect to Qx (2013 dollars)

Equipment Description	Network Upgrades	Transmission Provider's Interconnection Facilities	System Protection Facilities	Distribution Upgrades
Qx switchyard expansion: 1 500 kV breaker, 2 switches	$1,302,274			
Communications		$50,000		
Q51 500 kV gen-tie exit; 2 A-frames, 1 switch		$1,381,266		
Subtotal	$1,302,274	$1,431,266		
Grand Total	$2,733,540			

The estimated cost of the Q51 interconnection, if interconnecting in the second position, is allocated into several categories, Network Upgrades, Transmission Provider's Interconnection Facilities, System Protection Facilities and Distribution Facilities and is summarized in **Table 4.1** above.

Interconnection construction costs and timelines were estimated for Q51 based on the approximate location described above. These good faith non-binding cost estimates are applicable only to the APS system and may be different if the final location of the Qx switchyard is different then assumed in this report. This study reviewed all capacity, construction, flicker, protection and communications requirements to interconnect this "FERC" generation project. NERC (North American Reliability Corporation) requires that generation facilities provide a primary and secondary (back-up) communications path for data and control.

This study does not specifically address any requirements for the Interconnection Customer Generating Facilities. However, the Interconnection Customer shall comply with all APS requirements for a generator operating in parallel with APS's electrical system.

5. Q51 INTERCONNECTION FACILITIES - if Third to Interconnect to Qx

Figure 4 is a one-line diagram of the proposed configuration and interconnection of Q51's Project if Q51 is the third interconnection in the Qx switchyard. **Figure 5.1** depicts the Customer's Interconnection Facilities which are shown in green to include the 500 kV gen-tie line that is within the Qx substation fence. APS will own, operate, and maintain the portion of that line from the 500kV bus up to the first structure outside of the substation fence, at which point the IC would pick-up ownership and responsibility for the line.
In **Figure 5.1**, the facilities shown in red are Network Upgrades.

If Q51, the Interconnection Customer, is second to interconnect into the new Qx switchyard, the Network upgrades will consist of a 500 kV breaker and a half buildout including new bay line for Q51; 2 A-frames; extended range CT's; CCVT's; disconnect switch; line relays and meters.

Figure 5.1. One-Line Diagram

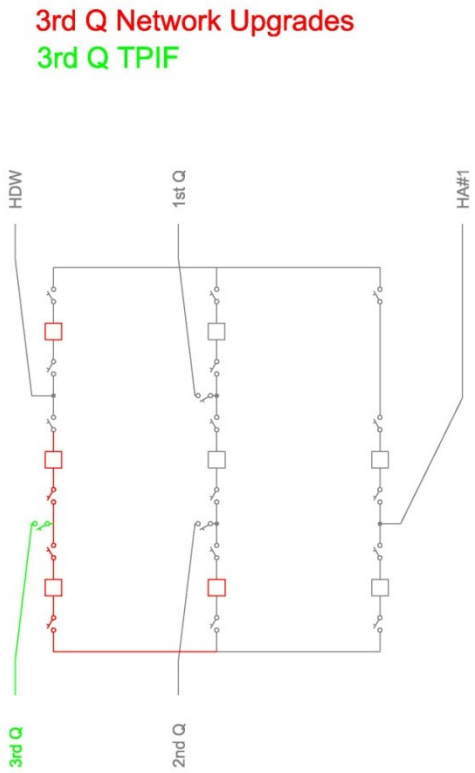


Table 5.1: Cost Estimate if Third to Interconnect to Qx (2013 dollars)

Equipment Description	Network Upgrades	Transmission Provider's Interconnection Facilities	System Protection Facilities	Distribution Upgrades
Qx Substation Work	$3,832,727			
Line Work				
Communications		$50,000		
Q51 500 kV gen-tie exit; 2 A-frames, 1 switch		$1,381,266		
Subtotal	$3,832,727	$1,431,266		
Grand Total	$5,263,993			

The estimated cost of the Q51 interconnection, if interconnecting in the third position, is allocated into several categories, Network Upgrades, Transmission Provider's Interconnection Facilities, System Protection Facilities and Distribution Facilities and is summarized in **Table 5.1** above.

Interconnection construction costs and timelines were estimated for Q51 based on the approximate location described above. These good faith non-binding cost estimates are applicable only to the APS system and may be different if the final location of the Qx switchyard is different then assumed in this report. This study reviewed all capacity, construction, flicker, protection and communications requirements to interconnect this "FERC" generation project. NERC (North American Reliability Corporation) requires that generation facilities provide a primary and secondary (back-up) communications path for data and control.

This study does not specifically address any requirements for the Interconnection Customer Generating Facilities. However, the Interconnection Customer shall comply with all APS requirements for a generator operating in parallel with APS's electrical system.

There is one type of upgrades associated with this Project: Network Upgrades. Network Upgrades only apply to some upgrades to the system at or above 69kV. Network Upgrades do not include Distribution Upgrades. Theses upgrades are defined by FERC as:

> **Distribution Upgrades**—The additions, modifications, and upgrades to the Transmission Provider's Distribution System required at or beyond the Point of Interconnection to facilitate interconnection of the Small Generating Facility and render the transmission service necessary to effect the Interconnection Customer's wholesale sale of electricity in interstate commerce. Distribution Upgrades do not include Interconnection Facilities.
>
> **Network Upgrades**—The additions, modifications, and upgrades to the Transmission Provider's Transmission System required at or beyond the point at which the Small Generating Facility Interconnects with the Transmission Provider's Transmission System to accommodate the interconnection with the Small Generating Facility to the Transmission Provider's Transmission System. Network Upgrades do not include Distribution Upgrades.
>
> **Stand Alone Network Upgrades**—The Network Upgrades that an Interconnection Customer may construct without affecting day-to-day operations of the Transmission System during their construction. Both the Transmission Provider and the Interconnection Customer must agree as to what constitutes Stand Along Network Upgrades and identify them in Appendix A to the Standard Large Generator Interconnection Agreement.

Network Upgrades are typically repaid by APS via transmission service credits over a twenty year period. Any amount remaining at the end of the twenty years, if any, are repaid to the Interconnection Customer, including such interest as defined by FERC.

6. CONSTRUCTION TIME ESTIMATES

PLEASE NOTE: The cost estimates contained herein exclude Interconnection Customer costs associated with obtaining permits, easements or income tax or other tax effect and and the cost associated with any Interconnection Customer-owned equipment required for the interconnection of the generators, including protective relaying and a visible open utility disconnect switch.

ALSO NOTE: That all trench and conduit required shall be supplied by the Interconnection Customer and is excluded from the above costs. Should the Interconnection Customer require APS provide trench and conduit, this would be an additional cost and is not included in the following estimates.

6.1. Summary of Construction Time Estimates at the POI

The IC's requested date to energize the interconnection facilities to receive back feed power is Q4 2014. **Table 6.1** is a preliminary design and construction timeline. **Table 6.1** estimates that it will take approximately 18-24 months in order to site, certificate, design, permit, procure, and construct the required facilities to interconnect the Q51 project; putting the earliest possible date for the IC's project to be energized at approximately 18-24 months from the date all the appropriate agreements are signed and funded. Given this timeline, the IC's requested in-service date of Q4 2015 is not feasible. For the LGIA, a new in-service date will need to be determined.

High level interconnection construction time estimates for the facility interconnection are tabulated below. Construction schedule estimates are from the date the Interconnection Customer provides written authorization to proceed, provided all interconnection agreements and funding arrangements are in place.

Table 6.1: Q51 Construction Time Estimates at POI

LGIA
Milestones

This Milestone table represents APS's best effort at targeting a high level construction and In-Service schedule per Interconnection Customer's requested In-Service Date. This Schedule and its projected In-Service Date are subject to change due to potential issues with weather, permitting and other required criteria and activities which may cause unforeseen timing delays. Upon commencement of Project, a construction schedule will be negotiated and adjusted accordingly. This Milestone Table represents APS's Standard Option as defined in 5.1.1 of the LGIA.

MILESTONE	RESPONSIBLE PARTY	DATE
LGIA Signed & Filed at FERC: Generator interconnect agreement signed and filed at FERC subject to Federal Regulatory requirements.	Both Parties	4/15/13
LGIA Funded: Customer's Submittal of Provision of Security (Article 5.5.3 and Article 5.6.4).	Interconnection Customer	5/15/13
Kick-off Meeting	Both Parties	6/15/13
Notice to Proceed: Customer to provide APS with written authorization to proceed with design and procurement of materials (Article 5.5.2).	Interconnection Customer	7/1/13
APS Engineering: APS begin engineering activities.	APS	8/1/13
ROW Acquisition: APS to secure Right Of Way for Overhead Line Route	APS	10/1/14
Materials: APS begin procurement of materials.	APS	10/1/13
Site Information: Substation site Topo, Geotech, and Soil Resistivity sent to APS.	Interconnection Customer	NA
Civil Information: Civil grading/drainage and site access plan submittal to APS	Interconnection Customer	NA
APS acceptance of Civil Submittal: APS acceptance of civil grading/drainage site plan submittal after final civil site plan submittal (APS requires unrestricted and adequate site access)	APS	NA
Environmental Compliance: Interconnection Customer complete all required Environmental and Archaeological Surveys and provide copy to APS.	Interconnection Customer	NA
Civil Construction: Interconnection Customer begin site below grade construction of APS and IC interconnection substation ("site prep")	Interconnection Customer	NA
Site Acceptance of Civil Construction: Interconnection Customer submit certified site as-built drawings of below grade construction and certified documents showing that site was built to APS Specifications	Interconnection Customer	NA
Land Transfer: Interconnect Customer ensures land transfer and easements are complete (if applicable)	Interconnection Customer	NA
Notice to Proceed with Construction: Customer to provide APS with written authorization to proceed with construction of facilities (Article 5.6.3).	Interconnection Customer	7/1/13
APS Overhead Line Construction: APS to begin construction of Overhead Line	APS	8/1/15
APS Substation Construction: APS begin interconnection substation construction	APS	8/1/15

APS Communications Construction: Complete communications and other activities required for APS Substation	APS	12/1/15
Operating Letter: APS and Interconnection Customer establish project specific Operating Letter	Both Parties	10/1/15
Outage Window: APS outage for substation cut-in (Subject to change based on System Conditions)	APS	10/1/15 – 11/1/15
Installation and Proving Relays: Complete line/relay work for substation cut-in	APS	1/1516
Metering: Metering installed, tested and released for use	Both Parties	2/15/16
In-Service/Back Feed: APS substation cut-in complete and released to APS Operations for IC to obtain back feed power	APS	2/15/16
Initial synchronization: The date upon which the Generating Facility is initially synchronized and upon which Trial Operation begins.	Both Parties	
Commercial Operation: Interconnection Customer Commercial Operation Date (C.O.D.)	Interconnection Customer	

7. REQUEST FOR TRANSMISSION SERVICE

Transmission service was not studied in the Facilities Study. Such a request is required to be made through the APS OASIS site to the APS Transmission Services Trading Group and is outside the scope of the generator Interconnection Request study process.

8. POWER FACTOR REQUIREMENTS

The APS Open Access Transmission Tariff (OATT) policy regarding power factor requires all Interconnection Customers, with the exception of wind generators, to maintain an acceptable power factor (typically near unity) at the Point of Interconnection (POI), subject to system conditions. The APS OATT also requires Interconnection Customers to be able to achieve +/- 0.95 power factor at the POI, with the maximum "full-output" VAr capability available at all outputs. Furthermore, APS requires Interconnection Customers to have dynamic voltage control and maintain the voltage as specified by the transmission operator within the limitation of +/- 0.95 power factor, as long as the Project is online and generating. If the Project's equipment is not capable of this type of response, a dynamic reactive device will be required. APS has the right to disconnect the Project if system conditions dictate the need to do so in order to maintain system reliability.

The method for determining whether or not the generator meets these requirements is to first record the pre-project POI bus voltage. Next, model the generator with zero reactive capabilities at full output. Any shunt devices are turned off. Two synchronous condensers are added to the model with infinite reactive capability. One is at the terminal bus of the unit regulating the bus voltage to 1.0 pu. The other is one bus into the plant from the POI regulating the POI to the pre-project voltage level. The amount of plant losses can be determined by recording the MVAR flow at the POI and adding that to the sum of the synchronous condenser output. Based on the maximum output of the plant, determine the minimum reactive capabilities required to meet the +/-0.95 power factor range. The sum of the two numbers determines the maximum amount of reactive support the project must provide.

As discussed in more details in Appendix A: Material Modification Report, the model provided by the IC was not sufficient to meet the APS power factor requirements. The customer needs to provide an additional 43.13 MVARs of reactive support to compensate for plant losses and meet the +/- 0.95 power factor requirements.

9. SYSTEM REINFORCEMENTS

As determined by the SIS study and the Material Modification Study, as an Energy Resouce Interconnection project this interconnection does not require any system reinforcements.