Q194 Photovoltaic Solar Generation Project Interconnection
System Impact Study
APS Contract No. 52442

By
Arizona Public Service Company Distribution Planning
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Q194 System Impact Study

TABLE OF CONTENTS

EXECUTIVE SUMMARY ........................................................................................................................... 3
1  Construction Requirements ....................................................................................................................... 6
2  Detailed Description of the required Interconnection Facilities and Associated Costs ...................... 6
3  Detailed Description of Major System Protection Facilities required and Associated Costs .............. 8
4  Request for firm Transmission Service ................................................................................................... 9
5  Interconnection Cost and Construction Time Estimates ........................................................................ 9

LIST OF APPENDICES
Appendix A – APS Distribution Generator Interconnection Standard Diagram
Appendix B – APS Interconnection Requirements for Distributed Generation (IRDG)
EXECUTIVE SUMMARY

This section summarizes the System Impact Study (SIS) results provided in response to a Small Generator Interconnection Request under the APS Open Access Transmission Tariff (OATT) for a proposed generation interconnection totaling 5 MW in the Arizona Public Service (APS) distribution system.

The Interconnection Customer is evaluating the feasibility of interconnecting a 16 MW solar resource to the Arizona Public Service (APS) distribution system (defined to FERC as less than 69kV). The proposed project, Q194 Solar Project (Q194), would consist of solar photovoltaic arrays with inverters converting DC to AC electrical power.

The Interconnection Customer’s Commercial Operation Date for Q194 is December 15, 2012 and will be located on the northwest of Santa Fe Rd and W Curtis Ranch Rd in Yavapai County located near the Town of Paulden in Arizona. The solar photovoltaic arrays’ electrical output will be interconnected to APS’s Distribution System at APS’s Paulden Substation. This in-service date may be infeasible to meet and a new date may need to be established that accounts for the Facilities Study, design and construction requirements.

High level interconnection construction costs and timelines were estimated for Q194 based on the approximate location. This study took into account the existing electrical utility corridor between Q194 and APS’s Paulden Substation. Easements may still need to be obtained as the feeder for Q194 is proposed to be a separate structure from the existing structures.

These good faith non-binding costs are applicable only to the APS system. No protection studies were performed because protection issues are not foreseen in this case. Protection settings will be determined by APS’s Protection Engineering group during the construction phase of the project. Q194’s main breaker settings are expected to coordinate with APS’s Paulden Substation and existing upstream recloser. System impact studies were performed at a high level. These will need to be reviewed more in-depth in the future under further interconnection studies and may add unknown costs and time to the estimates presented in this SIS.

The impact to the system voltage due to 16 MW exceeds APS’s voltage deviation guidelines at Paulden Substation. APS’s voltage guidelines state that voltage deviations shall not exceed 1% differential between the solar on-line or off-line at a substation bus level. If voltage deviations exceed 1%, but are less than 2%, APS’s policy is to install feeder voltage regulators at all substations exceeding the voltage deviation criteria. In this case, Paulden Substation already has voltage regulators installed.

PLEASE NOTE: The below cost estimates exclude Interconnection Customer costs associated with obtaining permits, easements or income tax or other tax effect and the cost associated with any Interconnection Customer-owned equipment required for the interconnection of the generators. The design and construction timelines do not take into account time delays to obtain permits or easements.

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 trench and conduit this would be an additional cost and is not included in the following estimates.

Pursuant to Article 5.2.1 of the Small Generator Interconnection Agreement, Transmission Provider shall repay the Interconnection Customer the total amount paid by the Interconnection Customer for Network Upgrades, including any tax gross-up or other tax-related payments associated with the Network Upgrades, and not otherwise refunded to the Interconnection Customer, on a dollar-for-dollar basis for the non-usage sensitive portion of the transmission charges, including interest, over a twenty (20) year period from the commercial operation date. Any unpaid balance shall be repaid in-full to the Interconnection Customer at the end of the twenty (20) year period from the commercial operation date.
Repayments shall include interest calculated in accordance with Article 5.2.1. Transmission Provider reserves the right to repay any unpaid balances at any time without penalty.

Energy Resource Interconnection cost and timeline estimates are listed in the table below. If the Interconnection Customer self-certifies to FERC that the project is a Qualifying Facility (QF), there may be certain tax effects. APS does not assist in the QF certification, nor does APS offer tax advice. Should the facility be successfully certified as a QF, APS will require a copy of the certification prior to executing any Interconnection Agreement.

POWER FACTOR 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.

**Table 1: Summary of Project Interconnection Costs**

<table>
<thead>
<tr>
<th>Description</th>
<th>Q194 Cost Estimate @ 12.47kV</th>
<th>Q194 Time Line Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead Line Construction</td>
<td>$1,875,000</td>
<td>9-12 Mo</td>
</tr>
<tr>
<td>Substation Work: (12kV Feeder Breaker, Feeder Relays, UG Feeder Exit, 12kV Bus Extension)</td>
<td>$220,000</td>
<td>12 Mo</td>
</tr>
<tr>
<td>Land (Easements)</td>
<td>$300,000</td>
<td>3 Mo</td>
</tr>
<tr>
<td>Communication</td>
<td>$100,000</td>
<td>3 Mo</td>
</tr>
<tr>
<td>RTU &amp; Dual Metering</td>
<td>$200,000</td>
<td>3 Mo</td>
</tr>
<tr>
<td><strong>Grand Total as a QF</strong></td>
<td><strong>$2,695,000</strong></td>
<td><strong>12 Mo</strong></td>
</tr>
<tr>
<td>Portion of Grand Total Identified as Network Upgrades</td>
<td>$ -</td>
<td>Repaid over 20 years via transmission credits</td>
</tr>
</tbody>
</table>

* Considered Network Upgrades and required per existing APS agreement

**Disclaimer**

Nothing in this report constitutes an offer of transmission service or confers upon the Interconnection Customer, any right to receive transmission service. APS and other interconnected utilities may not have the Available Transmission Capacity to support the interconnection described in this report.
Background:
Under provisions of the Arizona Public Service Company (APS) Open Access Transmission Tariff (OATT), APS has entered into a System Impact Study Agreement with Q194, APS Contract No. 52442. The Q194 Interconnection Customer plans to install 16 MW of solar photo-voltaic generation in 2012. At the request of the Applicant this interconnection will be studied at 12.47kV as an Energy Resource Interconnection Service. Also at the request of the Applicant this interconnection was only studied utilizing a new 12kV overhead line between Paulden Substation and Q194. Figure 1 below shows a sketch of the project and an overview of the proposed underground 12.47kV line route between the OH 12kV route and Q194. The Point of Interconnection (POI) will be at Q194. Attachment (A) shows the standard Distribution Generation Interconnection that will apply to Q194.

![Figure 1. Q194 Interconnection](image)

What was studied
This System Impact Study (SIS) examined the estimated construction cost of interconnecting the proposed generation to the surrounding APS distribution system and the feasibility of such project due to equipment ratings only. Engineering analyses were performed at a high level in the SIS. An Engineering Analyses consists of computer-based power flow studies, voltage flicker analysis, network analysis, protection analysis and/or short circuit/fault duty analysis. It is expected that under standard APS requirements, the system impacts will remain minimal. Protection settings will be determined during the construction phase.

Results
Preliminary review of this project presented no obvious insurmountable system limitations in terms of line and equipment ratings when interconnected to the APS 12.47kV distribution system.

The impact to the system voltage due to 16 MW exceeds APS’s voltage deviation guidelines at Paulden Substation. APS’s voltage guidelines state that voltage deviations shall not exceed 1% differential between the solar on-line or off-line at a substation bus level. If voltage deviations exceed 1%, but are less than 2%, APS’s policy is to install feeder voltage regulators at all substations exceeding the voltage deviation criteria. Paulden Substation has currently has voltage regulators installed.

If Q194 wishes to connect to the 12.47kV system at Paulden, the customer would be required to extend a new distribution feeder from Paulden Substation. This will require a 12kV bus extension, a new 12kV
feeder breaker, a 12kV underground feeder exit (9-1100Al cable) and associated relays and equipment. A second 12kV breaker will be required at the generation site at the customer’s cost and is not included in this study. Q194 will be required to allow APS to install an RTU for remote monitoring and operation of breakers and Generating Facility parameters associated with Q194. A second RTU and meter are required for back-up purposes. Extended range CTs are required for both meters and RTUs. Q194 will be responsible for the cost of these CTs, RTUs and dual meters. Q194 would also need to extend fiber optic from the Paulden Substation to the Customer’s breaker for Q194 for transfer trip and communication purposes. A backup communication system through a dedicated VG-36 telephone line to the Prescott Service Center will be utilized for the backup RTU. APS will own and maintain this 12.47kV line extension, RTUs, meters, and associated fiber optic. A telenetic modem shelf will be required to be installed at Prescott Service Center.

1 Construction Requirements

Line route is located in the Yavapai County and the Town of Paulden and for purposes hereof Permit(s) will be required before construction can begin. The Interconnection Customer’s in-service date is infeasible due to the estimated time required for design and construction for APS facilities. Therefore, the In-service Date must be delayed to account for design and construction requirements. If APS is unable to obtain permits and/or easements for the expected line route and another line route is necessary, the good faith non-binding estimated costs and timeframes herein shall be revised.

APS expects that for the line extension route private easements will need to be obtained. As noted above, should APS be unable to obtain the necessary private easements for the line and structures, the good faith non-binding estimated costs and timeframes herein shall be revised to reflect the new design, line route and other factors impacting the facilities required to provide interconnection service to the Interconnection Customer.

Subject to Yavapai County and the Town of Paulden permitting/siting processes, it is expected that APS will extend its Distribution System by installing an overhead feeder. The proposed route is along the existing electrical utility corridor between Q194 and Paulden Substation. The final route for the design and installation of APS’s 12.47kV line extension will be determined based on final engineering and the Yavapai County and Town of Paulden Permits. Other permits may also be required including, but not limited to, State, Federal or BLM Land.

2 Detailed Description of the required Interconnection Facilities and Associated Costs

Interconnection Customer has requested interconnection of their Generating Facilities (GF) to be located at approximately 2.5 miles west of Paulden Substation in the APS Prescott District. APS will extend its Distribution System by installing a 12.47kV line extension at the Interconnection Customer’s expense. The line extension will originate at APS’s Paulden Substation and terminate at the utility metering section (Point of Interconnection, “POI”, see Appendix A) to be located at the Interconnection Customer’s photovoltaic GF. The line route assumes 12kV overhead facilities will be built between Paulden Sub and the POI in accordance with APS’s construction standards as needed. These requirements will be further refined in future FERC study phases. Additional requirements may be imposed pending future study results.

There are two types of upgrades normally associated with this project: Distribution Upgrades and Network Upgrades. There is no repayment for Distribution Upgrades. Network Upgrades only apply to some upgrades to the system at or above 69kV. Network Upgrades do not include Distribution Upgrades. These Upgrades are defined below:

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.

The following items are identified:

- The following will be required at Paulden Substation: new 12.47kV bus extension, 12.47kV breaker, relays, and an underground feeder exit. These are Distribution Upgrades.

- The line extension will require approximately 5 miles of 3-795 overhead line from Paulden Substation to Q194. These are Distribution Upgrades.

- The interconnection will also require a fiber optic line from Q194’s POI to Paulden Substation for a “transfer-trip relay scheme” that will be required between Q194’s main breaker at the GF and Paulden Substation feeder breaker to meet the provisions of IEEE 1547. The fiber optic line is a Distribution Upgrade.

- Install fiber optic terminations and communication equipment for communication with the APS Energy Control Center Energy Management System (“ECC”, “EMS) and protection of the new Interconnection Facilities. This is required for the “transfer-trip relay scheme”. This will require that the fiber optic be terminated at Paulden Substation. The communication is a Distribution Upgrade.

- APS will require bi-directional metering to be installed at the switchgear at the interconnection Customer’s GF at the Interconnection Customer’s expense. A meter at the main breaker and at the GF breaker will be required. These meters define the POI between Interconnection Customer and APS. In addition, APS will require metering and an RTU (appropriately located to which meters will be connected) to be installed at the output of the generator at Interconnection Customer’s expense. The meters and RTU will be owned and operated by APS. Details regarding access to the RTU and meters will need to be addressed in the Operating Agreement (a required separate agreement) between APS and the Interconnection Customer. The RTU will carry the metering data back to Paulden Substation using some of the fibers to be installed. Interconnection Customer is solely responsible for providing a suitable AC or DC power supply for the RTU that meets AP’s requirements. The RTUs and bi-directional meters are Distribution Upgrades.

- A duplicate RTU and bi-directional meter scheme will be required for back-up purposes. The back-up communication will be a dedicated VG-36 phone line to the Prescott Service Center. This requirement will be further refined by APS’s Energy Control Center in a future study. The RTUs and bi-directional meters are Distribution Upgrades.

- Communication to two RTUs for EMS for remote metering, monitoring and operation. Communication is a Distribution Upgrade.

- An Interconnection Customer-owned visibly-open Disconnect Device equipped with grounding provisions acceptable to APS and APS-owned bidirectional utility metering equipment. This is an Interconnection Customer Facility cost.
• A 12.47kV switch along the line extension prior to Q194. For an overhead feeder, this is an Distribution Upgrade.

• The GF shall be required to meet the APS OATT power factor of 0.95 leading to 0.95 lagging, as measured at Paulden Substation. This Power Factor may be dispatched within this designated range by the APS Energy Control Center personnel as appropriate due to system conditions and without compensation. (See “Power Factor” on page 3 for APS’s full statement.)

• **Direct Assignment Charge** – The proposed Project would be interconnected to the APS distribution system and could be engaging in wholesale energy sales beyond the APS system. Therefore this Project is a FERC jurisdictional small generator interconnection. As such, the Interconnection Customer shall be responsible for a monthly Direct Assignment Charge (“DAC”) that covers the costs of Operations and Maintenance of the line extensions and its associated equipment including the required feeder voltage regulators. This DAC is derived utilizing an APS standard methodology and is estimated during the study phase of the Project. After construction of the required line extension, the DAC will be identified and charged monthly to the Customer based on the actual costs of construction. The actual-cost-based DAC will be a fixed monthly charge for the life of the FERC Interconnection Agreement beginning on the In-Service Date. The estimated DAC if certified as QF is $6,648 per month and is subject to revision and final update after the actual construction is complete and final invoicing for construction has taken place. During the next study phase in the FERC process, this DAC estimate will be further refined for estimation to the Interconnection Customer. Replacement of failed equipment, at actual cost, is at Customer’s expense.

3 Detailed Description of Major System Protection Facilities required and Associated Costs

System Protection Facilities are to be installed by APS at the Interconnection Customer’s expense. These requirements will be further refined in future FERC study phases for Q194. Additional requirements may be imposed pending future study results.

• 12.47kV breaker and controls at Q194

• Schweitzer SEL351 with 50/51/51N feature protective relay with the Mirrored Bit option to accomplish the transfer tripping of the GF via fiber optic cable. This relay has the advantage of being able to communicate relay to relay and make the 50/51/51N elements operate in directional mode.

• An additional relay on the 12.47kV side to detect ground over-voltages on the 12.47kV system in case the 12.47kV system becomes isolated and fed from the generators.

• Devices equipped with grounding provisions acceptable to APS.

• 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. For this interconnection at the 12.47kV level, interconnection requirements are specified in the APS document titled: Interconnection Requirements for Distributed Generation (APS “IRDG” manual). The Interconnection Customer shall be required to meet the requirements in effect at the time of execution of the Small Generator Interconnection Agreement (SGIA). The IRDG version in effect at the time of publishing of this Feasibility Study is attached to this report as Attachment (B). APS publishes the current IRDG on the website located at: [http://www.oatioasis.com/azps/index.html](http://www.oatioasis.com/azps/index.html) in the Generation Interconnection folder.
The Interconnection Customer small Generating Facility shall comply with the APS safety, metering, protection, and contractual requirements specified in the relevant APS documents pertaining to the interconnection and operation of a small Generating Facility in parallel with the APS Distribution System. All relevant sections of the APS Distribution Interconnection Agreement, as referenced in the IRDG manual, will be incorporated and attached to the SGIA, of which the backbone is located in Attachment P in the APS Tariff located at: http://www.oatioasis.com/azps/index.html

Minimum control and protective devices installed at the facility’s main circuit breaker as follows:

A Schweitzer SEL351 relay that incorporated the following functions:
(a) Over / Under Frequency
(b) Over / Under Voltage
(c) 50/51/51N functions.
(d) Alarm contacts to trip off the generators in the event of relay failure.
(e) Transfer trip
(f) Sync-check

Such other equipment as shall mutually be agreed upon by the Interconnection Customer and APS from time to time during the term of this Agreement.

4 Request for firm Transmission Service

Transmission service was not studied in the Feasibility 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.

5 Interconnection Cost and Construction Time Estimates

High level interconnection construction cost estimates for each of the interconnection options are tabulated below.

12.47kV Line Assumptions:

12 kV single circuit new build is included in the estimate.
Generation feeder will be built to standard 12kV specifications.
Construction estimate based on one 8 person crew.
Terrain was not considered when estimating line route.
Existing 12kV route could be used.
Difficulty obtaining ROW or appropriate permits may extend design time and construction.
If new ROW or easements must be obtained, the costs and additional timing are not included.
Difficulty obtaining ROW or appropriate permits may extend design time and construction.
If Paulden Substation must be expanded, land costs are not included.
Environmental studies will be required on new and existing lines crossing federal lands. These costs are not included.
Access and Lay Down Yards are not included in the Estimate.
Private acquisition could be approximately 18 months if condemnation is required.
All Estimates are in 2011 dollars.
Table 6a: Line Cost Estimates as QF

<table>
<thead>
<tr>
<th>Line Section</th>
<th>New Line Length (mi)</th>
<th>Fiber Optic Cable (FOC)</th>
<th>Conductor Type</th>
<th>Design time</th>
<th>Construction time</th>
<th>Cost ($)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Paulden Sub</td>
<td>Q194</td>
<td>5 miles</td>
<td>5 miles</td>
<td>3-795</td>
<td>6-9 Mo</td>
<td>$1,875K</td>
<td>New overhead circuit.</td>
</tr>
<tr>
<td>Grand Total</td>
<td>5 miles</td>
<td>5 miles</td>
<td>6 Mo</td>
<td>6 Mo</td>
<td></td>
<td>$1,875K</td>
<td></td>
</tr>
</tbody>
</table>
Appendix A

APS Distribution Generator
Interconnection Standard Diagram
APS DISTRIBUTION GENERATOR INTERCONNECTION STANDARD

(EACH PROPOSED PROJECT IS SUBJECT TO APS CASE-BY-CASE REVIEW)

NOTES:
• ADDITIONAL RELAYS WILL BE REQUIRED AT CUSTOMER’S GENERATING FACILITY
• A RTU WILL BE REQUIRED AT CUSTOMER’S SITE TO REPORT:
  BREAKER STATUS
  KW
  KWHR
  VOLTS
  KWHR

APS OWNED FACILITIES
CUSTOMER OWNED FACILITIES
APS OPERATIONAL CONTROL/JURISDICTION
Appendix B

APS Interconnection Requirements for Distributed Generation (IDRG)

(Note that the IRDG contains its own page numbering.)