Small Generator Interconnection
Oregon Tier 4 System Impact Study Report

Completed for

(“Interconnection Customer”)  
Q0971

A Qualifying Facility

Proposed Point of Interconnection

New breaker position at the Turkey Hill substation

March 31, 2020
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1.0 DESCRIPTION OF THE GENERATING FACILITY

(“Interconnection Customer”) proposed interconnecting 2.7 MW of new generation to PacifiCorp’s (“Public Utility”) new breaker position at the Turkey Hill substation located in Klamath County, Oregon. The project (“Project”) will consist of one (1) TMEIC PVH-L2700 GR inverter for a total nameplate output of 2.7 MVA. The requested commercial operation date was 12/15/2019.

Interconnection Customer will operate this generator as a Qualifying Facility as defined by the Public Utility Regulatory Policies Act of 1978 (PURPA).

The Public Utility has assigned the Project “Q0971.”

2.0 APPROVAL CRITERIA FOR TIER 4 INTERCONNECTION REVIEW

Pursuant to 860-082-0060(1), a public utility must use the Tier 4 interconnection review procedures for an application to interconnect a small generator facility that meets the following requirements:

(a) The small generator facility does not qualify for or failed to meet Tier 1, Tier 2, or Tier 3 interconnection review requirements; and
(b) The small generator facility must have a nameplate capacity of ten (10) megawatts or less.

3.0 SCOPE OF THE STUDY

Pursuant to 860-082-0060(7)(g) the System Impact Study Report shall consist of a short circuit analysis, a stability analysis, a power flow analysis, voltage drop and flicker studies, protection and set point coordination studies, and grounding reviews, as necessary. The System Impact Study shall state the assumptions upon which it is based, state the results of the analyses, and provide the requirement or potential impediments to providing the requested interconnection service, including a preliminary indication of the cost and length of time that would be necessary to correct any problems identified in those analyses and implement the interconnection. The System Impact Study shall provide a list of facilities that are required as a result of the Interconnection Request and non-binding good faith estimates of cost responsibility and time to construct.

Due to the small size of this interconnection, a stability analysis is not necessary.

This is a restudy due to both a service election by a higher priority interconnection request and a withdrawal of a higher priority interconnection request.

4.0 INDEPENDENT STUDY EVALUATION

Pursuant to 860-082-0060(7)(h), the application has not provided an independent system impact study that is to be addressed and evaluated along with the results from the Public Utility’s own evaluation of the interconnection of the proposed Small Generator Facility.

5.0 PROPOSED POINT OF INTERCONNECTION

The Interconnection Customer’s proposed Small Generator Facility is to be interconnected through a new breaker position at the Public Utility’s Turkey Hill substation.
6.0 **Study Assumptions**

- All active higher priority transmission service and/or generator interconnection requests will be considered in this study and are listed in Appendix 1. If any of these requests are withdrawn,
the Public Utility reserves the right to restudy this request, as the results and conclusions contained within this study could significantly change.

- For study purposes there are two separate queues:
  - Transmission Service Queue: to the extent practical, all System Upgrades that are required to accommodate active transmission service requests will be modeled in this study.
  - Generation Interconnection Queue: All relevant higher queue interconnection requests will be modeled in this study.

- The Interconnection Customer’s request for interconnection service in and of itself does not convey transmission service.

- This study assumes the Project will be integrated into Public Utility’s system at the agreed upon and/or proposed Point of Interconnection (“POI”).

- The Interconnection Customer will construct and own any facilities required between the POI and the Project unless specifically identified by the Public Utility.

- Line reconductor or fiber underbuild required on existing poles will be assumed to follow the most direct path on the Public Utility’s system. If during detailed design the path must be modified it may result in additional cost and timing delays for the Interconnection Customer’s Project.

- Generator tripping may be required for certain outages.

- All facilities will meet or exceed the minimum Western Electricity Coordinating Council (“WECC”), North American Electric Reliability Corporation (“NERC”), and Public Utility performance and design standards.

- Voltage regulation at Turkey Hill substation was modeled at 1.03 per unit with no load-drop compensation.

- Two case studies were assembled and studied in power flow simulation at the transmission level:
  1. Normal transmission configuration case no. 1: Malin substation 230-69 kV transformer supplies Turkey Hill, Merrill, Henley, Tulelake and Newell substations; 69 kV Line 5 (K4) is open between Henley and Hornet substations; 69 kV path from Tulelake to Tunnel tap is open; 69 kV path from Merrill tap to Tunnel tap is open; Line 5 (K4) is open between Newell and Clear Lake substations. In power flow simulation, the transmission system was tested for its response to the interruption of the requested Q0971 Generation.
  2. Contingency transmission configuration case no. 2: Klamath Falls substation 69 kV supplies Hornet, Dairy, Casebeer, Bonanza, Henley, Merrill and Turkey Hill substations; 69 kV Line 5 (K4) from Turkey Hill substation to Malin tap is open; Merrill Tap to Tunnel tap is open. In power flow simulation, the transmission system was tested for its response to the interruption of the requested Q0971 Generation. (Klamath Falls substation is the alternate transmission supply to Turkey Hill substation).

- Contingency transmission configuration for the Public Utility’s system is defined as any configuration other than normal transmission configuration.

- Summer peak load is defined as the highest load demand that occurs on the Public Utility’s power system during the summer season.

- Winter peak load is defined as the highest load demand that occurs on the Public Utility’s power system during the winter season.
• Light load is defined as the minimum load demand that occurs on the Public Utility’s power system at any time during the year.
• Steady state voltage is defined as the voltage after all voltage regulating devices, both electronic and mechanical, have reached a quiescent state for the power flow and voltage conditions at a specific time.
• Post transient voltage is defined as the voltage measured after high speed switching transients and the effects of generator exciter controls have settled out and before any mechanically operated load tap changing and voltage regulating devices have started to adjust to new system conditions.
• Post transient voltage step is defined as the difference between the voltage before an event and the post transient voltage after the event. The WECC limits the post transient voltage step to a maximum of 8.0 percent for infrequent switching events such as the separation of a generation facility from the transmission system. Any post transient voltage step occurring on the transmission system is imposed directly on customers in the region.
• Reactive margin is a volt-ampere measure of power system voltage stability that may be reduced in magnitude by the connection of load or generation operating at constant power factor. Greater magnitude negative reactive margin indicates greater voltage stability. Zero and positive magnitude reactive margin indicate impending voltage collapse. The measurement of reactive margin is made in a power flow simulation model.
• This report is based on information available at the time of the study. It is the Interconnection Customer’s responsibility to check the Public Utility’s web site regularly for transmission system updates (http://www.pacificorp.com/tran.html)

7.0 **REQUIREMENTS**

7.1 **SMALL GENERATOR FACILITY MODIFICATIONS**

The Small Generator Facility and Interconnection Equipment owned by the Interconnection Customer are required to operate under automatic power factor control with the power factor sensed electrically at the POI. The Small Generator Facility should have sufficient reactive capacity to enable the delivery of 100 percent of the plant output to the POI at unity power factor measured at 1.0 per unit voltage under steady state conditions.

In general, the Small Generating Facility and Interconnection Equipment should be operated so as to maintain the voltage at the POI between 1.01 pu to 1.04 pu. At the Public Utility’s discretion, these values might be adjusted depending on the operating conditions. Within this voltage range, the Small Generator Facility should operate so as to minimize the reactive interchange between the Small Generator Facility and the Public Utility’s system (delivery of power at the POI at approximately unity power factor). The power factor control settings of the Small Generator Facility must be coordinated with the Public Utility prior to energization (or interconnection). The reactive compensation must be designed such that the discreet switching of the reactive device (if required by the Interconnection Customer) does not cause step voltage changes greater than +/-3% on the Public Utility’s system.
All generators must meet applicable WECC low voltage ride-through requirements as specified in the interconnection agreement.

As per NERC standard VAR-001-1, the Public Utility is required to specify voltage or reactive power schedule at the POI. Under normal conditions, the Public Utility’s system should not supply reactive power to the Small Generating Facility.

As the Public Utility cannot submit a user written model to WECC for inclusion in base cases, a standard model from the WECC Approved Dynamic Model Library is required 180 days prior to trial operation. The list of approved generator models is continually updated and is available on the http://www.WECC.biz website.

**7.2 DISTRIBUTION/TRANSMISSION SYSTEM MODIFICATIONS**

No modifications to the Public Utility’s distribution or transmission system are required.

![System One Line Diagram](image)

**Figure 2: System One Line Diagram**

**7.3 EXISTING BREAKER MODIFICATIONS – SHORT-CIRCUIT**

The increase in the fault duty on the system as the result of the addition of the Generation Facility with photovoltaic arrays fed through 1 – 2.7 MVA inverters connected to 1 – 2.41/2.7 MVA 12 kV – 600 V transformer with 5.75 % impedance will not push the fault duty above the interrupting rating of any of the existing fault interrupting equipment.
7.4 **PROTECTION REQUIREMENTS**

A circuit breaker will need to be installed in Turkey Hill substation to provide isolation for faults on the 12 kV tie line to the Q0971 collector substation. The protective relay associated with the new breaker will have the capability to detect faults in either the Generation Facility or in the Turkey Hill substation with different sensitivities depending on the direction of the fault current. This is required due to the significant difference in the strength of the two sources. The breaker relay will also have under/over voltage and over/under frequency protection functions to disconnect the Generation Facility for out of tolerant voltage magnitude or frequency conditions.

Protective relays are in place to detect faults in the Turkey Hill substation 69 – 12 kV transformer and receive transfer trip from Malin substation for the opening of the 69 kV breaker at that substation. These relays will be configured to trip the new 12 kV breaker for faults detected in the transformer or on the 69 kV line to Malin substation.

7.5 **DATA REQUIREMENTS (RTU)**

Due to the power size of the Q0971 Project no real time data will be required for the operation of the transmission system. The feeder addition at the Turkey Hill substation will require standardized status and analog SCADA points brought back to the Monarch EMS.

7.6 **COMMUNICATION REQUIREMENTS**

7.6.1 *LINE PROTECTION*

No communication will be required for line protection.

7.6.2 *DATA DELIVERY TO THE CONTROL CENTERS*

Since no real time data will be required from this project no additional communication will be required.

7.7 **SUBSTATION REQUIREMENTS**

**Turkey Hill substation**

This substation is not designed for further expansion, therefore the low voltage side of the substation will need to be rebuilt.

The following equipment is required:

- 1 – 15 kV Self-contained circuit breaker
- 6 – 15 kV Arrester
- 27 – 15 kV Hook-stick operated disconnect switch

7.8 **METERING REQUIREMENTS**

**Interchange Metering**

The revenue metering will be located on a pole just outside the Turkey Hill substation fence. The Public Utility will procure, install, test, and own all revenue metering equipment. The revenue meter and instrument transformers will be installed overhead on a
pole at the POI. The meter instrument transformer mounting shall conform to the Public Utility’s DM construction standards.

The metering will be bi-directional to measure KWH and KVARH quantities for both generation received and retail load delivered. A cellular package will be required to remotely interrogate the meter for generation and billing data via the Public Utility’s MV-90 data acquisition system.

Station Service/Construction Power
The Project is within the Public Utility’s service territory. Please note that prior to back-feed, Interconnection Customer must arrange transmission retail meter service for electricity consumed by the Project that will be drawn from the transmission system when the Project is not generating. Interconnection Customer must call the PCCC Solution Center 1-800-625-6078 to arrange this service. Approval for back feed is contingent upon obtaining station service.

8.0 COST ESTIMATE
The following estimate represents only scopes of work that will be performed by the Public Utility. Costs for any work being performed by the Interconnection Customer are not included.

Turkey Hill substation
New 12 kV feeder position with metering
$774,000

Q0971 collector substation
Review relay settings
$16,000

Total: $790,000

*Any distribution line modifications identified in this report will require a field visit analysis in order to obtain a more thorough understanding of the specific requirements. The estimate provided above for this work could change substantially based on the results of this analysis. Until this field analysis is performed the Public Utility must develop the Project schedule using conservative assumptions. The Interconnection Customer may request that the Public Utility perform this field analysis, at the Interconnection Customer’s expense, prior to the execution of an Interconnection Agreement in order to obtain more cost and schedule certainty.

Note: Costs for any excavation, duct installation and easements shall be borne by the Interconnection Customer and are not included in this estimate. This estimate is as accurate as possibly given the level of detailed study that has been completed to date and approximates the costs incurred by Public Utility to interconnect this Small Generator Facility to Public Utility’s electrical distribution or transmission system. A more detailed estimate will be calculated during the Facilities Study. The Interconnection Customer will be responsible for all actual costs, regardless of the estimated costs communicated to or approved by the Interconnection Customer.
9.0 SCHEDULE
The Public Utility estimates it will require approximately 18-24 months to design, procure and construct the facilities described in this report following the execution of an Interconnection Agreement. The schedule will be further developed and optimized during the Facilities Study.

Please note, the time required to complete the facilities required for this interconnection request does not support the Interconnection Customer’s requested commercial operation date of December 15, 2019.

10.0 PARTICIPATION BY AFFECTED SYSTEMS
Public Utility has identified the following Affected Systems: None

Copies of this report will be shared with each Affected System.

11.0 APPENDICES
Appendix 1: Higher Priority Requests
Appendix 2: Property Requirements
Appendix 3: Distribution Study Results
Appendix 4: Transmission Study Results
11.1 **APPENDIX 1: HIGHER PRIORITY REQUESTS**

All active higher priority transmission service and/or generator interconnection requests will be considered in this study and are identified below. If any of these requests are withdrawn, the Public Utility reserves the right to restudy this request, as the results and conclusions contained within this study could significantly change.

Transmission/Generation Interconnection Queue Requests considered:
GIQ0806, 20 MW
11.2 Appendix 2: Property Requirements

Requirements for rights of way easements
Rights of way easements will be acquired by the Interconnection Customer in the Public Utility’s name for the construction, reconstruction, operation, maintenance, repair, replacement and removal of Public Utility’s Interconnection Facilities that will be owned and operated by Public Utility. Interconnection Customer will acquire all necessary permits for the project and will obtain rights of way easements for the project on Public Utility’s easement form.

Real Property Requirements for Point of Interconnection Substation
Real property for a POI substation will be acquired by an Interconnection Customer to accommodate the Interconnection Customer’s project. The real property must be acceptable to Public Utility. Interconnection Customer will acquire fee ownership for interconnection substation unless Public Utility determines that other than fee ownership is acceptable; however, the form and instrument of such rights will be at Public Utility’s sole discretion. Any land rights that Interconnection Customer is planning to retain as part of a fee property conveyance will be identified in advance to Public Utility and are subject to the Public Utility’s approval.

The Interconnection Customer must obtain all permits required by all relevant jurisdictions for the planned use including but not limited to conditional use permits, Certificates of Public Convenience and Necessity, California Environmental Quality Act, as well as all construction permits for the project.

Interconnection Customer will not be reimbursed through network upgrades for more than the market value of the property.

As a minimum, real property must be environmentally, physically, and operationally acceptable to Public Utility. The real property shall be a permitted or permittable use in all zoning districts. The Interconnection Customer shall provide Public Utility with a title report and shall transfer property without any material defects of title or other encumbrances that are not acceptable to Public Utility. Property lines shall be surveyed and show all encumbrances, encroachments, and roads.

Examples of potentially unacceptable environmental, physical, or operational conditions could include but are not limited to:

- Environmental: known contamination of site; evidence of environmental contamination by any dangerous, hazardous or toxic materials as defined by any governmental agency; violation of building, health, safety, environmental, fire, land use, zoning or other such regulation; violation of ordinances or statutes of any governmental entities having jurisdiction over the property; underground or above ground storage tanks in area; known remediation sites on property; ongoing mitigation activities or monitoring activities; asbestos; lead-based paint, etc. A phase I environmental study is required for land being acquired in fee by the Public Utility unless waived by Public Utility.
Physical: inadequate site drainage; proximity to flood zone; erosion issues; wetland overlays; threatened and endangered species; archeological or culturally sensitive areas; inadequate sub-surface elements, etc. Public Utility may require Interconnection Customer to procure various studies and surveys as determined necessary by Public Utility.

Operational: inadequate access for Public Utility’s equipment and vehicles; existing structures on land that require removal prior to building of substation; ongoing maintenance for landscaping or extensive landscape requirements; ongoing homeowner's or other requirements or restrictions (e.g., Covenants, Codes and Restrictions, deed restrictions, etc.) on property which are not acceptable to the Public Utility.
11.3  APPENDIX 3: DISTRIBUTION STUDY RESULTS

11.3.1 DISTRIBUTION STUDY RESULTS

11.3.1.1 Short Circuit Study

This Generation will interconnect at a new feeder position in Turkey Hill substation and will not require any modifications to existing protection settings at the distribution level.

11.3.1.2 Power Flow Analysis

The existing substation equipment is adequate to interconnect this Generation. A maximum current of 607 A is predicted at the Turkey Hill voltage regulator.

11.3.1.3 Voltage Drop and Flicker Study

The interconnection of this Generation is predicted to cause a 0.2% change in voltage due to sudden connection or disconnection. This is within the Public Utility standard of 2.5%.
11.4 APPENDIX 4: TRANSMISSION STUDY RESULTS

11.4.1 SUMMARY

A power flow simulation of adding the Q0971 Generation Facility (operating at 2.7 MW maximum) to the Public Utility’s substation and transmission system predicted the following:

- The Public Utility’s system has adequate thermal capacity for the flow of Q0971 Generation in normal transmission configuration no. 1 and in contingency transmission configuration no. 2.
- The Public Utility’s system voltages and voltage steps are predicted in power flow simulation to be acceptable in normal transmission configuration no. 1 and in contingency transmission configuration no. 2.
- Power flow may be accepted from Q0971 in normal transmission configuration no. 1 and in contingency transmission configuration no. 2.

11.4.2 NORMAL TRANSMISSION CONFIGURATION NO. 1

In normal transmission configuration no. 1, fully defined in Study Assumptions, Malin substation supplies Turkey Hill, Merrill, Henley, Newell and Tulelake substations. In power flow simulation, Q0971 was then separated from the distribution system.

11.4.2.1 Transmission Line Loading

The transmission equipment ratings on the supply path are adequate to accept generation from Q0971.
Table 11.4.2.1.a. Power flow during Q0971 Generation in normal transmission configuration no. 1 (Malin supplying Turkey Hill substation).

<table>
<thead>
<tr>
<th>Season</th>
<th>Real power flow at Q0971 POI, MW</th>
<th>Reactive power flow at Q0971 POI, MVAR</th>
<th>Power flow on Turkey Hill transformer, MVA</th>
<th>Rating of Turkey Hill transformer, MVA</th>
<th>Power flow at Malin 69 kV circuit breaker 3L179, MVA</th>
<th>Limiting Rating on 69 kV Line 78 (K9) at Malin Sub, MVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer Peak Load</td>
<td>2.7</td>
<td>0</td>
<td>5.3</td>
<td>11.5</td>
<td>10.6</td>
<td>73</td>
</tr>
<tr>
<td>Winter Peak Load</td>
<td>2.7</td>
<td>0</td>
<td>8.1</td>
<td>13.8</td>
<td>21.0</td>
<td>109</td>
</tr>
<tr>
<td>Light Load</td>
<td>2.7</td>
<td>0</td>
<td>10.5</td>
<td>11.5</td>
<td>29.6</td>
<td>73</td>
</tr>
</tbody>
</table>

Table 11.4.2.1.a shows that the substation and transmission equipment ratings in region are adequate to accept generation from Q0971 when operating in normal transmission configuration no. 1.

11.4.2.2 Transmission System Voltages

Voltages and post transient voltage steps are projected in power flow simulation to remain within permissible limits during the interruption of the Q0971 Generation in the Public Utility’s normal transmission configuration no. 1.

Table 11.4.2.2.a Power system voltages when Q0971 Generation interrupted during normal transmission configuration no. 1 (Malin supplying Turkey Hill substation).

<table>
<thead>
<tr>
<th>Season</th>
<th>Location</th>
<th>Q0971, MW</th>
<th>Q0971, MVAR†</th>
<th>Steady State Voltage, per unit</th>
<th>Post Transient Voltage After Q0971 Interruption, per unit</th>
<th>Post Transient Voltage Step, percent†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer Peak Load</td>
<td>Turkey Hill Sub 12.5 kV</td>
<td>2.7</td>
<td>0</td>
<td>1.025</td>
<td>1.023</td>
<td>0.2%</td>
</tr>
<tr>
<td>Winter Peak Load</td>
<td>Turkey Hill Sub 12.5 kV</td>
<td>2.7</td>
<td>0</td>
<td>1.026</td>
<td>1.025</td>
<td>0.1%</td>
</tr>
<tr>
<td>Light Load</td>
<td>Turkey Hill Sub 12.5 kV</td>
<td>2.7</td>
<td>0</td>
<td>1.026</td>
<td>1.026</td>
<td>0%</td>
</tr>
</tbody>
</table>

† Q0971 Inverter AC bus voltages set to maintain constant power factor of 1.00.
11.4.3 Contingency Transmission Configuration No. 2

In contingency transmission configuration no. 2, fully defined in Study Assumptions, Klamath Falls substation supplies Hornet, Dairy, Casebeer, Bonanza, Henley, Merrill and Turkey Hill substations, and 69 kV Line 5 is open from Turkey Hill substation to Malin Tap. The power flow simulation test began with Q0971 generating, and then Q0971 Generation was interrupted.

11.4.3.1 Transmission Line Loading

Table 11.4.3.1.a. Power flow during Q0971 Generation in contingency transmission configuration no. 2 (Klamath Falls supplying Turkey Hill substation).

<table>
<thead>
<tr>
<th>Season</th>
<th>Real power flow at Q0971 POI, MW</th>
<th>Reactive power flow at Q0971 POI, MVAR</th>
<th>Power flow on Turkey Hill transformer, MVA</th>
<th>Rating of Turkey Hill transformer, MVA</th>
<th>Power flow at Klamath Falls 69 kV circuit breaker 3L9, MVA</th>
<th>Limiting Rating on 69 kV Line 9 (K5) at Klamath Falls Sub, MVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer Peak Load</td>
<td>0</td>
<td>0</td>
<td>4.5</td>
<td>11.5</td>
<td>19.0</td>
<td>60</td>
</tr>
<tr>
<td>Summer Peak Load</td>
<td>2.7</td>
<td>0 †</td>
<td>5.3</td>
<td>11.5</td>
<td>19.0</td>
<td>60</td>
</tr>
<tr>
<td>Light Load</td>
<td>0</td>
<td>0</td>
<td>7.7</td>
<td>11.5</td>
<td>49.8</td>
<td>60</td>
</tr>
<tr>
<td>Light Load</td>
<td>2.7</td>
<td>0 †</td>
<td>10.5</td>
<td>11.5</td>
<td>52.5</td>
<td>60</td>
</tr>
</tbody>
</table>

†Q0971 Inverter AC bus voltages set to maintain constant power factor 1.00 at POI.

Table 11.4.3.1.a shows that 69 kV Line 9 (K5) rated 60 MVA between Klamath Falls and Hornet substations would not be overloaded by the addition of Q0971 in contingency transmission configuration no. 2.

Power flow may be accepted from Q0971 when the Public Utility is operating in contingency transmission configuration no. 2.

11.4.3.2 Transmission System Voltages

Voltages and voltage steps are predicted in power flow simulation to be acceptable during contingency transmission configuration no. 2.
Table 11.4.3.2.a Power system voltages when Q0971 Generation is interrupted during contingency transmission configuration no. 2 (Klamath Falls supplying Turkey Hill substation).

<table>
<thead>
<tr>
<th>Season</th>
<th>Location</th>
<th>Q0971, MW</th>
<th>Q0971, MVAR</th>
<th>Steady State Voltage, per unit</th>
<th>Post Transient Voltage After Q0971 Interruption, per unit</th>
<th>Post Transient Voltage Step, percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer Peak Load</td>
<td>Turkey Hill Sub 12 kV</td>
<td>2.7</td>
<td>0</td>
<td>1.025</td>
<td>1.023</td>
<td>0.2%</td>
</tr>
<tr>
<td>Light Load</td>
<td>Turkey Hill Sub 12 kV</td>
<td>2.7</td>
<td>0</td>
<td>1.039</td>
<td>1.038</td>
<td>0.1%</td>
</tr>
</tbody>
</table>