System Impact Study

Interconnection Request for a Small Generating Facility

From

Cascade Community Wind Company

For Service To

Three Bar G Ranch # 1 & # 3

Kittitas County, WA

September 21, 2009
Rev 1, September 29, 2009
Rev 2, December 5, 2011

Puget Sound Energy, Inc.

Transmission Contracts Department
System Planning Department
System Protection Department

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December 5, 2011
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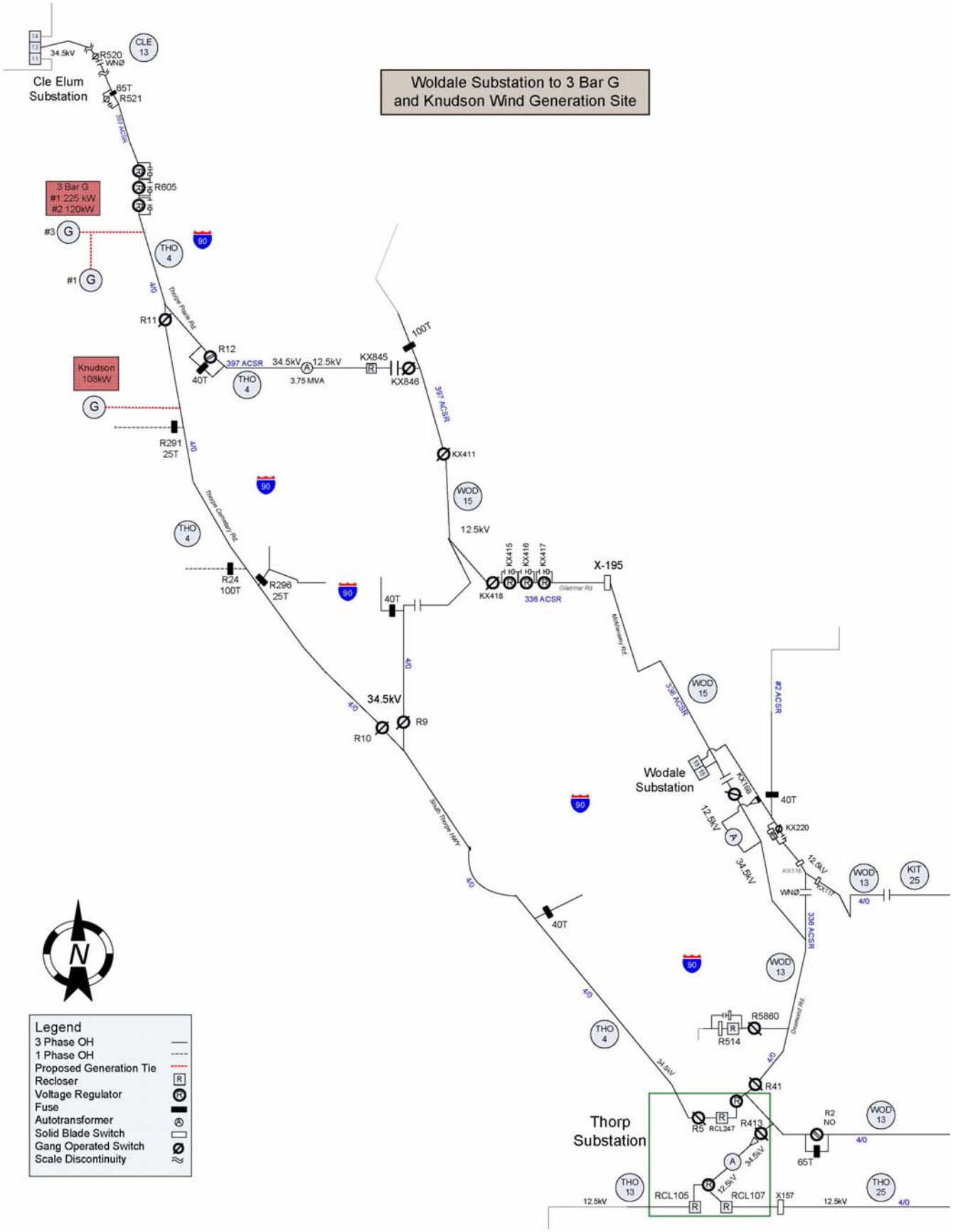
Introduction

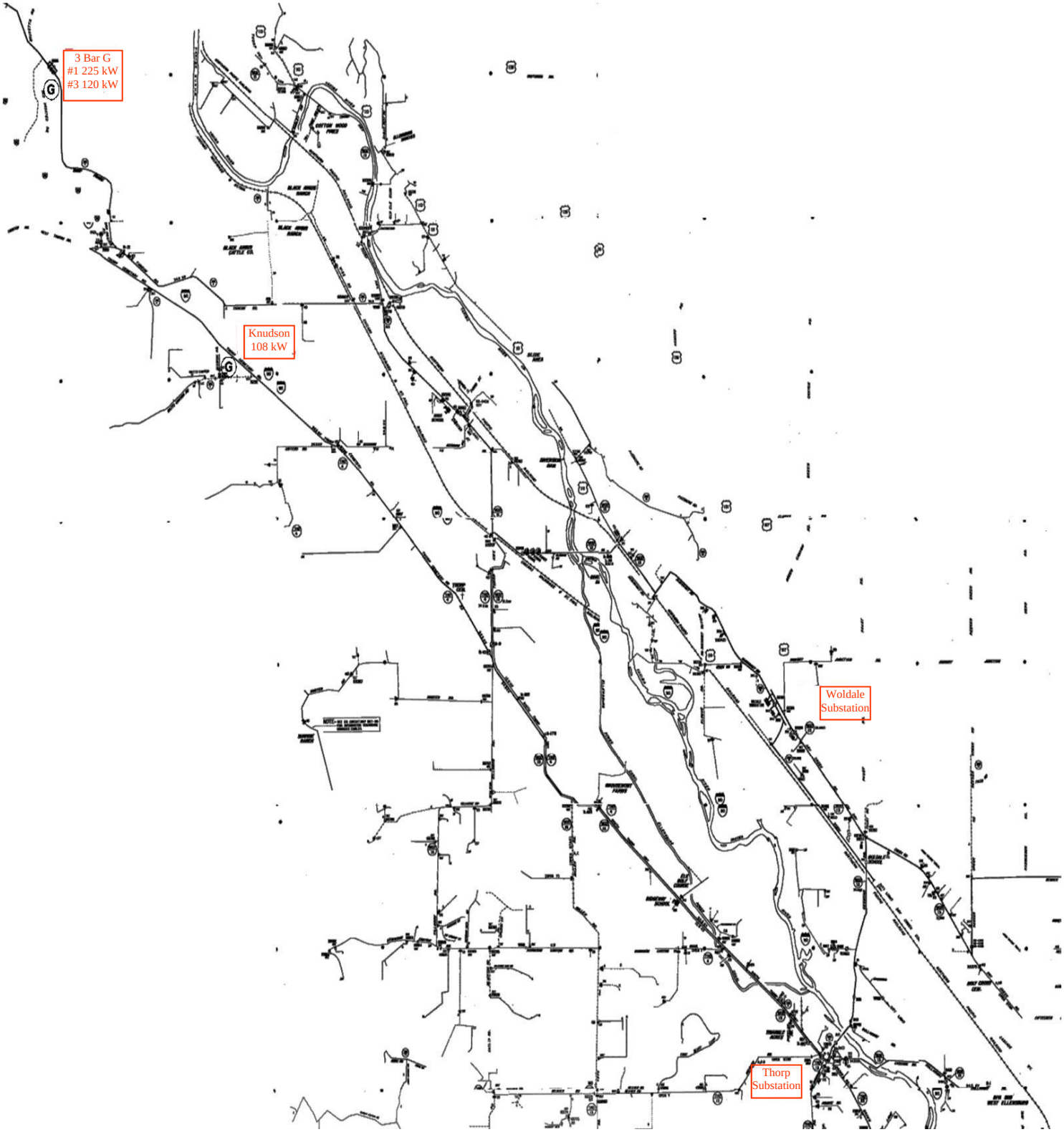
This Interconnection System Impact Study ("ISIS") is in response to a Small Generation Interconnection request received 10/24/2011 from Cascade Community Wind Company ("Interconnection Customer") of a proposed 225 KW generating facility located at 3761 Thorp Hwy South in Ellensburg, Washington (the “Project”) to interconnect to Puget Sound Energy, Inc.’s (“PSE’s”) system. A scoping meeting was originally held 6/15/2009 and an ISIS was executed on 8/10/2009. This revised ISIS summarizes the results of analyses conducted to develop reliable interconnection alternatives that integrate the proposed Project. The results of the ISIS indicate that the addition of the Project will require system improvements.

Existing Facilities

Existing electric service to the Project site is provided by PSE’s 34.5 kV distribution system originating at PSE’s Woldale Substation, located near McMahoney Road & Dry Creek (SR10 & SR131). Woldale substation has a 20 MVA 115-12.47 kV transformer and two existing distribution circuits (Circuits 13 & 15). Woldale circuit 13 (WOD-13) exits the substation and immediately branches out in two directions. One branch heads east and the other branch is stepped up to 34.5 kV by way of a 12.47/34.5kV auto-transformer. The 34.5 kV overhead line then travels south approximately 3 miles to Thorp substation. It is at this location that the circuit passes through recloser RCL247 and becomes Thorp circuit 04 (THO-04). THO-04 then travels approximately 10 miles along South Thorp Hwy (Thorp Cemetery Rd) to the project site. The 34.5 kV THO-04 circuit serves approximately 20 electric large parcel farm/ranch customers. The existing overhead distribution system at the proposed site is 3 phase construction traveling along Thorp Cemetery Rd. Figure 1 displays a simplified one-line diagram of THO-04 as it currently exists. Figure 2 displays the overhead distribution circuit map to provide a to-scale representation of THO-04.

Figure 1. Existing Facilities One Line




3 Bar G
#1 225 kW
#3 120 kW
Knudson
108 kW
Woldale
Substation
Thorp
Substation

Discussion of System Improvement

Modification to PSE's existing distribution facilities will be required in order to interconnect the proposed Project to the Thorp 04 (THO-04) distribution circuit. A three phase underground line extension from the generator to the PSE overhead distribution system will be required to interconnect the proposed 225 kW, turbine #1.

Interconnection from Thorp Hwy to 3 Bar G#1 225 kW Project Site

This option provides 480V secondary service to the Interconnection Customer via an interconnection to the THO-04 distribution circuit on the east side of Thorp Hwy and requires the construction of underground primary from the existing overhead tap line at turbine #3 south approximately 450 ft and the installation of a 34.5kV grounded-wye/480V grounded-wye PSE transformer at the proposed wind turbine generator project site #1.

The preliminary estimated cost range for distribution facility upgrades for this site is approximately $75,000 plus either Alt 1) circuit breaker (recloser, $50,000) or Alt 2) customer provided 480V breakers at each generator. The new underground line will extend south in customer provided trench approximately 450 ft to a mutually agreed upon transformer location on site.

Assumptions include:

- In customer trench, PSE to construct 450 feet of underground primary line in conduit from the existing overhead feeder on the 3 Bar G site at turbine #3 south to the transformer location.
- Included in the estimate is approximately $10,000 for a junction vault adjacent to the transformer should the Customer elect to extend the primary from this location for the addition of future generators at this site.
- Metering will be a 480V metering package located on the transformer secondary.
- Customer will provide associated connections to the POI at the meter on the transformer secondary.
- Installation of Alt 1) Recloser/circuit breaker or Alt 2) customer circuit breakers at each turbine, including second breaker at existing turbine.
- Customer will provide trench, backfill, and restoration.

The addition of this second wind generator at the 3 Bar G site requires the Interconnection Customer to install a circuit breaker for direct transfer trip (DTT). The circuit breaker will be used to trip all of the wind generators at this site from the PSE system. Two alternatives exist for this circuit breaker.

> Alt 1) Install a 34.5 kV circuit breaker at the POI. This option allows for a single point for DTT and makes future site expansion easier as the single point communications to that one recloser will trip all future generators beyond the recloser. Also, as additional generation is added, the recloser will offer a wider range of coordination w/ the upstream protection device than will the existing line fuses.
>
> Alt 2) Install dual 480V breakers at each generator site. While this option may be less costly for each breaker, the added communications to each individual site will likely result in a more costly installation.

This conceptual cost estimate is for planning purposes and may change as a result of the Interconnection Facility Study. The time required to complete this work including engineering, permitting, and construction is estimated to be approximately 2-3 months.

The interconnection Customer has described plans to add additional wind generators at this site. When an additional generator is added at this site, the interconnection will be reviewed and made consistent with requirements in effect at the time of the project expansion.

Interconnection Requirements

The Project facility shall meet all requirements identified in the PSE's "Technical Specifications and Operating Protocols and Procedures for Generation Interconnections", PSE-ET-160.70 (http://www.oatioasis.com/PSEI, under the GENERATION INTERCONNECTION tab).

Due to the size of the proposed Project and the distance from the Thorp Substation, care must be taken to ensure acceptable system voltage on the THO-04 distribution circuit. Voltage at the point of interconnection with the PSE distribution system shall not deviate more than 5% above or below the 34.5 kV standard voltage. Total voltage variation at the point of interconnection shall not exceed 8% of the standard voltage (PSE Standard 0650.2000).

Covered here are the protection considerations of interconnecting a 225 kW induction generator to the existing 120 kW generator at the 3BarG ranch. Both generators will connect to the 34.5 kV Thorp-4 (THO-04) circuit. This circuit is long and lightly loaded, with relatively low fault currents. Protection for Thorp-4 is provided by a 34.5 kV recloser with an SEL-351J recloser controller. Thorp-4 is normally fed from Woldale-13 (WOD-13), a 12.47 kV circuit which is converted to 34.5 kV by an autotransformer. The Woldale 13 circuit is protected by Westinghouse CO-11 phase and neutral overcurrent relays, and includes automatic reclosing following a relay trip.

The sites being studied can also be fed from Cle Elum 13 (CLE-13) and Woldale 15 (WOD-15) during contingency load switching for operational flexibility. CLE-13 is protected by Westinghouse CO-11 phase and neutral overcurrent relays, and includes automatic reclosing following a relay trip. WOD-15 is protected by Westinghouse CO-11 phase and neutral overcurrent relays, and includes automatic reclosing following a relay trip.

System Protection Requirements

The purpose of the protection study is to ensure that the generation will be successfully disconnected for faults on the PSE system.

Because the addition of 3BarG#1 to the existing 3BarG#3 project is above the 300 kW threshold originally identified in the technical interconnection specifications, the requirement for dual relays and breaker failure detection (shown in Attachment 2 of the interconnection technical specifications) will be required.

PSE's interconnection requirements are designed to ensure that the generation will be disconnected in the event of a fault on the PSE system. The customer is responsible for installing protective devices for their generator(s) and associated equipment. However, faults on the PSE system will likely not be detected by devices installed for the purpose of generator protection, so it is necessary to provide separate devices for protection of the interconnection. Both, the 225 kW and the 120 kW generation installations will be required to provide detection and clearing for ground faults on the PSE 34.5 kV system.

Assumptions Include:

- PSE-owned grounded-wye/grounded-wye transformer with Customer installed equipment to eliminate, or reduce to 20 A primary, zero-sequence contributions to faults on the PSE distribution system.
- PSE distribution circuits typically use automatic reclosing following a fault trip, in order to restore service to customers more quickly. Generation must be disconnected from the PSE system within five seconds following a system fault to prevent damage to customer equipment.

PSE's guideline for islanding protection requires the installation of direct transfer trip (DTT) when the aggregate generation connected to a distribution circuit is equal to or greater than half of the circuit minimum load. Because the minimum loading on the (THO-04) circuit is very low (approximately 5 Amps at 34.5 kV, or 300 kVA), it is necessary to provide a means of tripping the 3BarG#1 & #3 generation off line whenever the source breaker (WOD-13) or line recloser (THO-04) opens.

If either WOD-13 or THO-04 opens, a trip signal will be sent to the 3BarG#1 & #3 generator breakers. A trip would also be applied to the generators in the event that communications were lost between the substation and the generation site. This will require installation of a communication channel between the THO-04 recloser and Woldale substation, and between Woldale substation and the generation sites. The 3BarG#1 & #3 generation site will send back generator breaker status to Woldale sub.

In addition, control modifications of WOD-13 will be required (installation of a single-phase PT on the 12.47 kV station getaways, installation of a maintenance switch, possible installation of a microprocessor-based relay in each breaker, and logic/wiring changes).

An alternate system contingency configuration can result in service from Cle Elum 13 (CLE-13), which has a minimum load of 1.5 MVA. As long as the aggregate generation does not exceed approximately 650 kVA, it will be possible to switch the generation to this alternate source without requiring transfer trip from Cle Elum substation. Utilizing CLE-13, however, would not be a seamless switching operation. Such a source transfer would require a short outage due to the need to drop the THO-04 circuit load before picking it up by CLE-13.

Additionally, Woldale 15 (WOD-15) can serve as an alternate backup circuit to THO-04. WOD-15 would then be a system contingency configuration for service to the generators. This WOD-15 source, however, will have similar conditions as THO-04 in that the same minimum loading on the (THO-04) circuit (approximately 5 Amps or less at 34.5 kV, or less than or equal to 300 kVA) would be switched over and fed through recloser KX845 on WOD-15. With this alternative, it would be necessary to provide a means of tripping the generation off line whenever that source recloser KX845 on (WOD-15) opens, so a communication channel will also be required between recloser KX845 and Woldale substation. Customer indicated that an alternate source circuit was not of interest if additional costs were required. As a result, this option and its associated costs are not discussed in further detail.

Expanding the capacity of the 3 Bar G site installation to greater than 300 kVA, (in this case 120 kW + 225 kW) requires that the dual relay and breaker failure requirements apply for both turbines.

Protection settings for under/over frequency and over/under voltage elements are specified in the interconnection technical specifications. Settings for ground detection will be provided for coordination with PSE protective devices in advance of interconnection.

Communication Requirements

Several options were investigated for communications between Woldale substation, Thorp substation, and the 3BarG site. A valid radio path does not exist to the 3BarG site. Multiple repeater locations were reviewed, but none will work. A fiber line, however, is a viable communication alternative. The fiber line route would follow the Thorp – 04 overhead circuit route from the 3BarG site 11 miles to Thorp substation and then 3.5 miles following the Woldale – 13 circuit from Thorp substation to Woldale substation. Costs associated with the fiber line are $870,000.

A Telco option was also investigated. This assumes a 4-wire leased Telco line between Woldale and the 3BarG site. Also included are RFL Teleprotection modules for transfer trip and the use of mirrored bits spread spectrum radio between Woldale and Thorp to capture recloser status. This option has risk as confirmation has not yet been received from Telco on the availability of a 4 wire circuit into the 3BarG site. Cost associated with a 4 wire leased Telco line between Woldale and the circuit breaker alternative 1) recloser at the 3BarG site is $130,000. If the customer elects to select alternative 2) 480V breakers at each generator, then mirrored bits radios will also be required between the two breaker locations. One generator breaker will have the Telco protection with radio connection to the second generator breaker. Estimated cost for 4 wire leased Telco line to the two individual generator breakers is $145,000.

Assumptions Include:

- Fiber estimate assumes adequate communications space on existing poles. Additional costs are required if poles must be replaced for added height to accommodate fiber line.
- Permitting drives schedule for pole replacements and fiber line construction.
- Four wire leased line option assumes Telco availability which is not confirmed.
- Line of sight does exist between both turbine breaker locations so antenna towers will not be required.

Customer Responsibility:

- Alt 1a) No added costs associated with fiber option.
- Alt 1b) Provide power and enclosure for the teleprotection equipment and 4 wire leased Telco line equipment. Pay all ongoing costs of leased 4 wire line from Woldale to 3BarG site.
- Alt 2a) Provide power and enclosure at each turbine site for radios and antennas.
- Alt 2b) Provide power and enclosure for the teleprotection equipment and 4 wire leased Telco line equipment. Pay all ongoing costs of leased 4 wire line from Woldale to 3BarG site. Provide power and enclosure at each turbine site for radios and antennas.

Metering Requirements

The metering point for this facility will be on the secondary (480V) side of the PSE transformer. Current transformers (CT) and test switch, provided by PSE, will be installed and connected to a meter to meet all metering requirements. The meter, CTs, test switch and visible break disconnect switch will be installed on the H-frame structure.

Customer is responsible to provide and install H-frame structure, meter cabinet, CT enclosure and visible break disconnect switch. Metering will also require a customer provided, dedicated, analog telephone line. The phone line needs to be landed inside the meter enclosure. Customer is responsible for furnishing and installing an accessible, lockable and visible-break disconnect switch. The disconnect switch can be installed on either (line or load) side of the meter. The disconnect switch and PSE revenue meter shall be accessible 24 hours a day, 7 days a week.

Operational Requirements

PSE routinely performs switching to shift load for maintenance activities and unplanned outages. The generators may be required to be disconnected at any time to facilitate routine system operations. During emergencies, PSE may not be able to give advance warning prior to disconnecting the generators.

Any time that the generation facility is fed from a breaker other than THO-04, which has the transfer trip equipment installed, the generation must be taken off line unless equivalent capabilities are provided on the breaker used to provide alternate service to the site.

The generating facility operator is required to contact PSE System Operations to coordinate reconnection with the PSE system. The facility shall not reconnect without PSE approval. For operating requirements and Operating Log, see Section 12 of PSE-ET-160.70. For general maintenance requirements and annual demonstration, see section 11 of PSE-ET-160.70. For start-up requirements and procedures, see Sections 9 and 10 of PSE-ET-160.70.

As a requirement for Interconnection under PSE's Open Access Transmission Tariff ("OATT"), information regarding the generation facility will be required to be provided by the Interconnection Customer to PSE from time to time consistent with the requirements of PSE's OATT.

These requirements are not intended to be comprehensive and may be modified to comply with PSE policies and procedures.

Interconnection Transformer

PSE Owned Transformer:

With a PSE owned transformer, 480V secondary service is provided to the Interconnection Customer via an interconnection to the THO-04 overhead distribution circuit located on the 3 Bar G site and requires the construction of underground primary to the project site and installation of a 34.5kV grounded-wye/480V grounded-wye PSE transformer.

Assumptions include:

- Customer will install equipment to eliminate, or reduce to 20 A primary, zero-sequence contributions to fault on the PSE distribution system.
- PSE distribution circuits typically use automatic reclosing following a fault trip, in order to restore service to customer more quickly. Generation must be disconnected from the PSE system within five seconds following a system fault to prevent damage to Customer equipment.

Short Circuit Analysis

The addition of these two generators will not significantly affect equipment in the area. Because of the low fault duty in the area, no line equipment is near its rated interrupting capability, and the small contribution of the generators to the available short circuit current does not cause any ratings to be exceeded.

Load Flow Analysis

Synergee, a distribution modeling tool, was utilized to analyze any effects the generators may have on the distribution system. Both light load and system peak load conditions were reviewed.

Voltage at the primary side of the POI with the PSE distribution system shall not deviate more than 5% above or below the 120V standard voltage. Total voltage variation at the primary side of the POI shall not exceed 8% of the standards voltage (PSE Standard 0650.2000).

For the following studies, the load tap changer (LTC) at Woldale was set to regulate the low side bus to a voltage set point (band center) of 12.88 kV with a two volt bandwidth for a maximum of 12.99 kV for light loading conditions and at the maximum of operating range (13.09 kV) for peak loading conditions. The generators were modeled at the Project site with one 150 kVA, and one 225 kVA 12.47-0.48 kV interconnection transformers.

The Interconnection Customer's generating units were modeled with a total output of 345 kW. The VAr level imported or exported from the generator was varied, depending on the power factor control and the primary voltage requirements.

In order to maintain acceptable voltage along the circuit, the voltage at the POI will need to be limited to a level at or below the maximum allowable primary operating voltage of the distribution system of 36.2 kV. In simulations, this was done by manipulating the VAr output from the proposed generation resource via power factor control. The study results are outlined below.

Minimum System Load Scenario

Results without the Project

Voltage at Woldale (Low Side)	Voltage at 3 Bar G POI
12.99 kV	35.80 kV

Results with 3 Bar G Turbines #1 & #3

Set Power Factor at 3 Bar G (345 kW Output)	Voltage at Woldale (Low Side)	Voltage at 3 Bar G POI	VAr flow at 3 Bar G POI
0.95	12.99 kV	37.18 kV	103 kVAr
1.00	12.99 kV	35.86 kV	-11 kVAr
-0.95	12.99 kV	35.80 kV	-126 kVAr

As shown above, the generating units may operate within the power factor range shown without causing the high side (primary voltage) to exceed the required 36.2 kV. The reactive rating provided for the proposed machine is adequate to ensure acceptable primary voltage on the circuit in the vicinity of 3 Bar G POI during light load conditions for a 345 kW output with a power factor between 1.0 and -0.95.

Results indicate there is a negligible effect the generators have on the 34.5 kV THO-04 circuit. While the system voltage is seen as varying slightly from the cases w/o generators to the cases w/ generators, the fraction of one volt variation is well within allowed.

At unity power factor, the 3 Bar G generators will cause voltage rise on the circuit in the vicinity of the POI during light load conditions. The 3 Bar G#1 225 kW and #3 120 kW generators will be required to operate between 1.0 and 0.95 power factor with VArs being absorbed by the generator from the PSE system. By absorbing VArs, the voltage rise caused by the generator will be reduced.

Maximum System Load Scenario

Results without the Project

Voltage at Woldale (Low Side) 13.08 kV	Voltage at 3 Bar G POI 36.00 kV

Results with 3 Bar G Turbines #1 & #3

Set Power Factor at 3 Bar G (345 kW Output)	Voltage at Woldale (Low Side)	Voltage at 3 Bar G POI	VAr flow at 3 Bar G POI
0.95	13.08 kV	36.11 kV	102 kVAr
1.00	13.08 kV	36.06 kV	-10 kVAr
-0.95	13.08 kV	35.97 kV	-126 kVAr

As shown above, the generating units may operate within the power factor range shown without causing the high side (primary voltage) to exceed the required 36.2 kV. The reactive ratings provided for the proposed machines are adequate to ensure acceptable primary voltage on the circuit in the vicinity of the 3 Bar G POI during peak load conditions for a 345 kW output with power factors between 1.0 and -0.95.

Avian Requirements

This proposal has been reviewed by PSE's Avian Protection program manager, and raptor protection measures are required for any overhead primary line construction due to high bird use of the area. Protection measures include 11' crossarms (centered on the pole), covered jumpers, and bushing covers. See standards 6015.2000 for examples of construction techniques.

Future System Modifications

If the generation system is modified in any way, PSE will require a review of the interconnection to determine if further modifications are required.

If the PSE distribution system is modified to meet future system requirements, PSE may require a review of the interconnection to determine if further modifications are required.

Summary of Customer's Conceptual Estimated Interconnection Costs

Distribution System Improvement:

3 Bar G#1: $ 35,000 underground line extension
(recloser equipment costs included in Alt 1a) below)

Interconnection Transformer: $ 40,000 (PSE provided)

Transformer Cost includes approximately $10,000 for junction box vault near transformer for future line extension. If no future line extension required, deduct $10,000.

Communications equipment and installation at Customer site:

Alt 1a) $ 920,000 circuit breaker/recloser equipment for DTT & fiber line
Alt 1b) $ 180,000 circuit breaker - recloser equipment for DTT & leased Telco line
Alt 2a) $ 885,000 fiber line for DTT to 480V breakers
Alt 2b) $ 145,000 leased Telco line for DTT to 480V breakers

Protection equipment installation and testing at Thorp & Woldale Substations:

3 Bar G #1 & #3
Direct Transfer Trip: $ 80,000

Metering equipment and installation:

Secondary meter:
3 Bar G#1: $ 3,000

Commissioning demonstration of protective devices and generating system functionality:

PSE Labor cost:

Alt 1a) or Alt 1b) $ 3,000 one location – circuit breaker/recloser

Alt 2a) or Alt 2b) $ 6,000 two locations - 3BarG #1 & #3

Sub Total:

Alt 1a)	$1,081,000
Alt 1b)	$ 341,000
Alt 2a)	$1,049,000
Alt 2b)	$ 309,000

Contingency 30%

Alt 1a)	$ 325,000
Alt 1b)	$ 103,000
Alt 2a)	$ 315,000
Alt 2b)	$ 93,000

Total Estimated Cost:

Alt 1a)	**$1,406,000**
Alt 1b)	**$ 444,000**
Alt 2a)	**$1,364,000**
Alt 2b)	**$ 402,000**

SIS Assumptions

- The 3 Bar G#1 225 kW generating facility will utilize one Vestas V27 (using an ABB – HXR 355L 6/8 B3 E 225/50kW) generator with a maximum output of 225 kW.
- The existing 3 Bar G#3 120 kW facility utilizes one Vestas V20 generator with a maximum output of 120 kW.
- Soft start will be used for startup of the induction generators. The current demand when synchronizing the generators to the PSE system will be less than the maximum current output of the generator.
- The interconnection transformer will be supplied and owned by PSE.

Conclusion

The proposed Project can be interconnected to PSE's distribution system, however, the following system additions and modifications are required:

Distribution line work:	Approximately 450 ft of primary underground line construction
Interconnection Transformer:	Provided by PSE
Communicatons:	Installation of fiber or leased Telco line at Woldale, Thorp recloser and Alt 1) 3 Bar G site recloser or Alt 2) 3 Bar G individual generator sites #1 & #3
System Protection:	PTs on primary, DTT at THO-04 Recloser & Woldale Substation
Metering:	Secondary Metering required on individual H-frame structures (one at each turbine)

A transfer trip scheme is required to trip the 3 Bar G#1 225 kW and #3 120 kW generators in the event that they become electrically islanded from the PSE system grid.

At unity power factor, the proposed 3 Bar G#1 225 kW generator will cause primary voltage rise on the circuit in the vicinity of the Project during extreme light load conditions. The 3 Bar G 120 kW and 225 kW generators will need to operate between 1.0 and -0.95 power factor control reactive capability with VArs flowing from the PSE system to the Interconnection Customer facility or an external device having inductive capability will need to be included in the facility design to achieve an equivalent result.