Interconnection Feasibility Study Report
Request # GI-2008-31

600 MW Wind Powered Generation Interconnecting at Weld Substation

PSCo Transmission Planning
September, 15, 2010

A. Executive Summary

On December 18, 2008 Public Service Company of Colorado (PSCo) received a generation interconnection request to determine the potential system impacts associated with interconnecting a 600 MW wind generation facility (GI-2008-31) at the Weld Substation through a Generation Provider-owned and constructed 60 mile, double circuit, 230 kV transmission line (see Figure 1). The Generation Provider requested a Commercial Operation Date[1] of January 1, 2012 and Back-Feed In-Service Date[2] of July 1, 2011. The study request indicates that the generation would be delivered to PSCo native load customers.

The Generation Provider initially requested the primary Point of Interconnection (POI) be the 345 kV bus at Ault Substation; however, this was modified by the Generation Provider to the 230 kV bus at Weld Substation so the generation facility could interconnect directly to PSCo's transmission system. No alternative POI was studied.

The purpose of this Interconnection Feasibility Study is to evaluate the potential impact of GI-2008-31 on the PSCo transmission infrastructure as well as that of neighboring entities, when injecting a total of 600 MW of generation from GI-2008-31 into Weld Substation, and delivering that additional generation to PSCo native load customers.

This request was studied as both a Network Resource (NR)[3] and as an Energy Resource (ER)[4]. These investigations included steady-state power flow and short-

[1] **Commercial Operation Date** of a unit shall mean the date on which the Generating Facility commences Commercial Operation as agreed to by the Parties pursuant to Appendix E to the Standard Large Generator Interconnection Agreement.
[2] **In-Service Date** shall mean the date upon which the Interconnection Generation Provider reasonably expects it will be ready to begin use of the Transmission Provider's Interconnection Facilities to obtain back-feed power.
[3] **Network Resource Interconnection Service** shall mean an Interconnection Service that allows the Interconnection Developer to integrate its Large Generating Facility with the Transmission Provider's Transmission System (1) in a manner comparable to that in which the Transmission Provider integrates its generating facilities to serve native load Developers; or (2) in an RTO or ISO with market based congestion management, in the same manner as all other Network Resources. Network Resource Interconnection Service in and of itself does not convey transmission service.

[4] **Energy Resource Interconnection Service (ER Interconnection Service)** shall mean an Interconnection Service that allows the Interconnection Developer to integrate its Large Generating Facility with the Transmission Provider's Transmission System in a manner comparable to that in which the Transmission Provider integrates its generating

circuit studies. The request was studied as a stand-alone project only, with no evaluations made of other potential new generation requests that may exist in the Large Generator Interconnection Request (LGIR) queue, other than the generation projects that are already approved and planned to be in service by the summer of 2012. The costs to interconnect the project with the transmission system at the Weld Substation have been evaluated by PSCo Engineering. This study considered facilities that are part of the PSCo transmission system as well as monitoring other nearby entities' regional transmission systems.

Energy Resource

The results of this feasibility study indicate that firm transmission capacity for the 600 MW wind generation facility is not available due to existing overloads and firm transmission commitments of TOT 7 and is not possible without the construction of network reinforcements. Non-firm transmission capability may be available depending on marketing activities, dispatch patterns, generation levels, demand levels, import path levels (TOT3, etc.) and the operational status of transmission facilities.

Network Resource

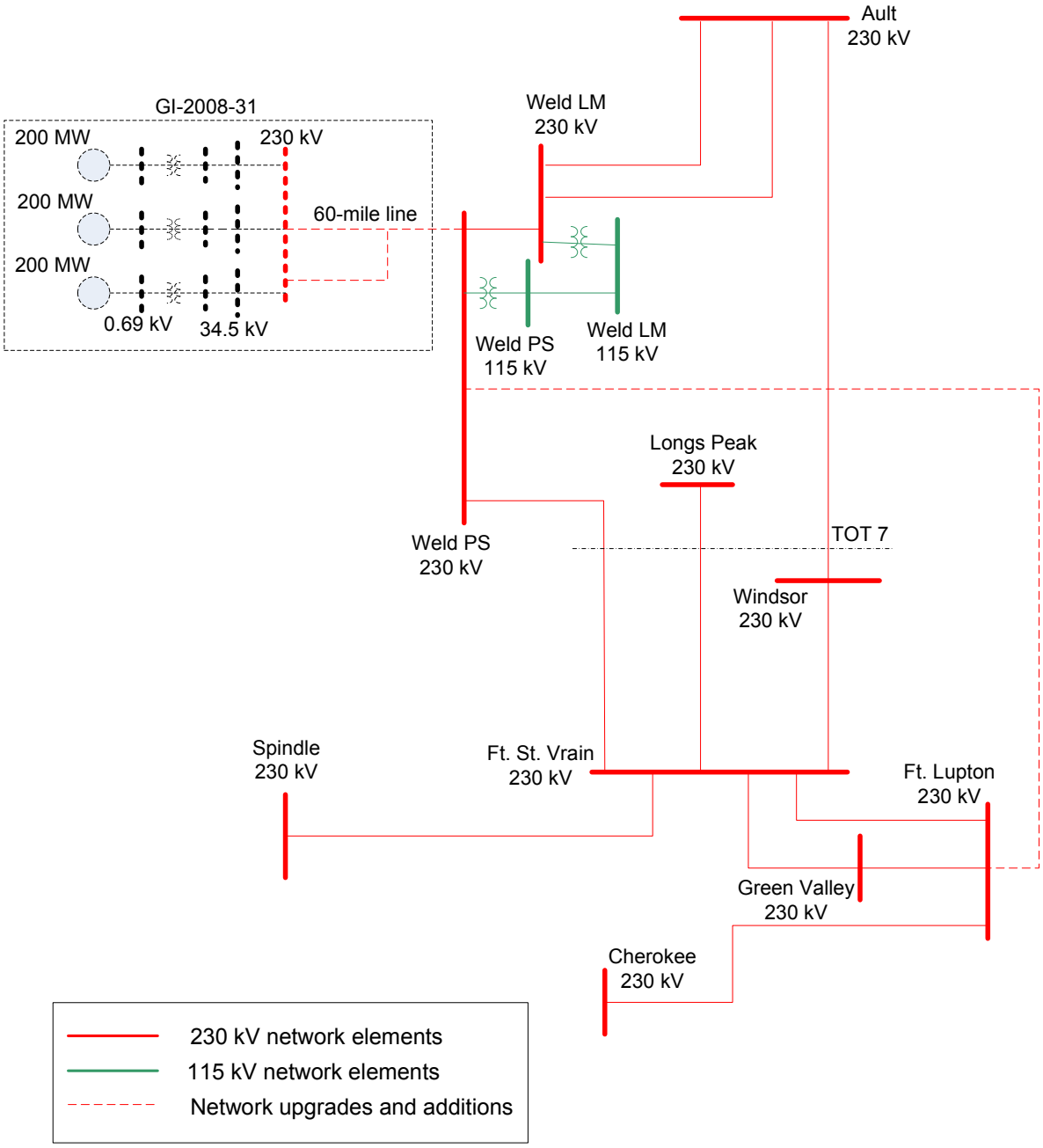
Based on the evaluation process for a Network Resource request, a contingency analysis was performed to determine if the transmission system would be adversely impacted and, if so, the upgrades that would be required to deliver the entire output of the GI-2008-31 wind facility as provided at the POI to PSCo native load customers. **Interconnection at the 230 kV bus was determined feasible.** Under that condition, the estimated cost of the recommended system upgrades to accommodate the project is approximately **$31,425,000** and includes:

- ***$0.545 million for PSCo-Owned, Developer-Funded Interconnection Facilities,***
- ***$0.970 million for PSCo-Owned, PSCo-Funded Network Upgrades for Interconnection, and***
- ***$29.910 million for PSCo Network Upgrades for Delivery. This assumes that PSCo completes the network upgrade projects that have been identified and included in the PSCo Transmission Capital Budget.***

facilities to serve native load customers. A Network Resource is any designated generating resource owned, purchased, or leased by a Network Customer under the Network Integration Transmission Service Tariff. Network Resources do not include any resource, or any portion thereof, that is committed for sale to third parties or otherwise cannot be called upon to meet the Network Customer's Network Load on a non-interruptible basis. Network Resource Interconnection Service in and of itself does not convey transmission service.

The results of the feasibility study also indicate that approximately 35 MVAR of reactors will likely be required for the Generation Developer's wind generating plant to maintain a power factor within the range of 0.95 leading to 0.95 lagging at minimal generation levels, measured at the POI. The reactors would be needed whenever the Generation Developer's generators are off-line or generating at very low levels while GI-2008-31 facilities are connected to the POI. In addition, about 120 MVAR of switched capacitors will likely be needed to meet the voltage criteria at the POI during periods of maximum generation at GI-2008-31. More detailed studies should be performed by the Generation Developer to ensure that the proposed wind generation facility will display acceptable performance during the commissioning testing. If the Generation Developer advances the request to the System Impact Study phase, the results of the stability analysis may modify the nature of the reactive power support that may be required of the Generation Developer for the project to meet relevant reliability criteria.

Figure 1. Simple One- Line Diagram Showing GI-2008-31 with the Preferred Network Upgrade



B. Introduction

Public Service Company of Colorado (PSCo) received a large generator interconnection request (GI-2008-31) on December 18, 2008 to interconnect 261 Siemens 2.3 MW wind turbines, with a total generator nameplate capacity of 600.3 MW and a commercial operation date of January 1, 2012. The proposed project would be located about 25 miles southwest of Chugwater, Wyoming. The GI-2008-31 project would be connected with a new Generation Provider-owned and constructed 60 mile, double circuit, 230 kV transmission line to PSCo's Weld Substation 230 kV bus. As per the Developer's request, the 230 kV bus at Weld would be the primary Point of Interconnection (POI). Although the Generation Provider initially requested the primary POI be the 345 kV bus at Ault Substation, this request was modified in order to allow the generation facility to connect directly to PSCo's transmission system. No alternative POI will be studied. This request would be evaluated as a stand alone project with no other higher queued projects modeled.

The Developer has requested that this project be evaluated as a Network Resource (NR) and an Energy Resource (ER), with the energy delivered to PSCo's native load customers.

C. Study Scope and Analysis

This feasibility study evaluated the feasibility of providing 600 MW of energy from GI-2008-31 through the point of interconnection at Weld Substation to PSCo native load customers. This request was studied both a NR and as an ER. This feasibility study consisted of both steady state power flow analysis and short circuit analysis. The power flow analysis provides a preliminary identification of any thermal or voltage limit violations resulting from the interconnection, and for a NR request, a preliminary identification of network upgrades required to deliver the proposed generation to PSCo native load customers. The short circuit analysis identifies any circuit breakers with short circuit capability limits exceeded as a result of the interconnection and for a NR request, the delivery of the proposed generation to PSCo native load customers.

PSCo adheres to NERC / WECC criteria as well as internal company criteria for planning studies. The following criteria were used for this study:

- For system intact conditions, transmission system bus voltages must be maintained between 0.95 and 1.05 per-unit of system nominal / normal conditions, and steady-state power flows must be maintained within 1.0 per-unit of all elements' thermal (continuous current or MVA) ratings.
- PSCo tries to maintain a transmission system voltage profile ranging from 1.02 per unit or higher at regulating buses, and 1.0 per unit or higher at transmission load buses.

- Following a single contingency element outage, transmission system steady state bus voltages must remain within 0.90 per-unit to 1.10 per-unit (and between 0.92 per-unit and 1.07 per-unit at load buses for Platte River Power Authority (PRPA)), and power flows within 1.0 per-unit of the elements' continuous thermal ratings.

For this project, the potential affected parties are Tri-State Generation and Transmission Association (TSGT), Western Area Power Administration (WAPA), and PRPA. PSCo will provide TSGT, WAPA, and PRPA with a copy of this feasibility study report and will work with them during the system impact study phase.

Interconnecting to the PSCo bulk transmission system requires the developer to adhere to certain interconnection requirements. These requirements are contained in the Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW (Guidelines). The Guidelines make reference to interconnection requirements resulting from Federal Energy Regulatory Commission (FERC) Order 661A. FERC Order 661A describes the interconnection requirements for wind generation plants. In addition, PSCo System Operations conducts commissioning tests prior to the commercial in-service date for a developer's facilities. Some of the requirements that a developer must complete include the following:

1. A wind generating plant shall maintain power factor within the range of 0.95 leading to 0.95 lagging, measured at the POI. The Transmission Provider's System Impact Study is needed to demonstrate that such a power factor requirement is necessary to ensure safety or reliability.

2. The voltage at a POI shall be maintained in the ideal voltage range for the appropriate Rocky Mountain region and bus type (regulating[5] or non-regulating) as determined in the Rocky Mountain Area Voltage Coordination Guidelines[6]. The System Impact Study will investigate pertinent demand (on-peak or off-peak), season (summer or winter), dispatch, and outage scenarios based on the defined study area that includes the proposed POI. The study will conform to the NERC Transmission System Planning Performance Requirements (TPL standards).

[5] A regulating bus is defined in the Rocky Mountain Area Voltage Coordination Guidelines as any transmission or generation bus with controllable VAR's. This implies that the bus has a voltage schedule that is being regulated by a generating facility. Generating facilities include Static VAR Compensators (SVC's), synchronous generators, or synchronous condensers that can supply fast-acting reactive power (VAR) compensation to dynamically regulate voltage at a power system bus. Switchable capacitors, switchable reactors, load tap changing transformers, etc. are not defined as generating facilities as they do not provide controllable dynamic VARs'.

[6] The Voltage Coordination Guidelines Subcommittee (VCGS) of the Colorado Coordinated Planning Group developed the guidelines. The subcommittee consisted of representatives from major Colorado utilities including Colorado Springs Utilities, Platte River Power Authority, Tri-State Generation and Transmission, Public Service Company of Colorado, and Western Area Power Administration-Rocky Mountain Region. Other major utilities outside of Colorado were also involved in the development of these guidelines.

3. The POI for a wind generating facility cannot be declared a regulating bus unless system studies demonstrate that the designation of the POI as a regulating bus is needed for system reliability or safety.

4. The impact of the wind generating facility on the reactive power schedules of nearby generating units may need to be mitigated by the Customer if system studies demonstrate that the proposed wind generating facility causes nearby generating units to generate or absorb reactive power for voltage control [7]. It is understood that sufficient reactive power reserve must be maintained on generating units to allow them to dynamically regulate voltage for extreme system conditions.

5. If a wind generating facility is interconnected to the bulk transmission system but is operating with its generation off-line and receiving power from the bulk transmission system for its station service requirements, that facility is acting as a load and will be required to maintain the power factor at the POI within 98% lagging or leading (when the station service load is greater than 85% of maximum) per the Xcel Energy document titled Interconnection Guidelines For Transmission Interconnected Developer Loads.

6. PSCo System Operations will require the developer to perform operational tests prior to commercial operation that would verify that the equipment installed by the developer meets operational requirements.

7. It is the responsibility of the developer to determine what type of equipment (DVAR, added switched capacitors, SVC, reactors, etc.), the ratings, and the locations of those facilities that may be needed for acceptable performance during the commissioning testing.

The Interconnection Agreement (IA) requires that certain conditions be met, as follows:

1. The conditions of the Large Generator Interconnection Guidelines[8] (LGIG) are met.

2. A single point of contact is given to Operations to manage the transmission system reliably for all wind projects using the transmission facilities associated

[7] The Rocky Mountain Area Voltage Coordination Guidelines (July 2006), page 8 of 34, Item 6, states that "Static VAR sources (switched shunt capacitors, reactors) should be operated to control the voltage profile before relying on LTC or generator VAR output, and should be used in such a manner to keep LTC transformers near their nominal tap range and to keep reactive margin on generating equipment. The rationale for this goal is that the generator is a dynamic reactive source that can provide high-speed reactive support to the transmission system after a disturbance that results in low voltages, or conversely are in a position to reduce voltages after a contingency that results in high voltages. Keeping transformers near their mid-tap range also allows for maximum response to either boost or reduce voltages following a disturbance".

[8] Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW, version 3.0, 12/31/06

with GI-2008-31 that deliver power to the Weld POI, as indicated in the Interconnection Guidelines.

3. PSCo will require testing of the full range of 0 MW to 600 MW of the wind project. These tests will include, but not be limited to, power factor control, and voltage control as measured at the Weld POI for various generation output levels (0 to 600 MW) of the overall wind generation facility.

4. The developer must show that the power factor at the POI is within the required +/-0.95 power factor range at all levels of generation and that the voltage levels and changes are within reliability criteria as measured at the POI for the full range of testing (including generator off-line conditions).

D. Power Flow Study Models

Western Electricity Coordinating Council (WECC) coordinates the preparation of regional power flow cases for transmission planning purposes. PSCo transmission developed a base case for the 2012 heavy summer peak load as a part of their annual five-year project identification process, from WECC approved models and modified for PSCo-approved projects and topology changes. In the 2012 case, the following generators in Area 70 (PSCo Transmission) were re-dispatched to simulate high north-to-south stressed system conditions.

- The generation at Rawhide, St. Vrain, MBPP, Spindle and Valmont was increased to maximum capacity.
- The generation at Peetz Logan was set to 12% of its maximum capacity.
- The increase in generation in Northern Colorado was accommodated by decreasing the generation at the Comanche and Front Range units.

Implementation of these changes resulted in the benchmark case used for this study. Comanche Unit 1 was designated as the slack bus for Area 70. The flow across TOT 3 in the benchmark case, without the addition of GI-2008-31, is 1364 MW.

The proposed wind generation facility consists of 261 2.3 MW Siemens units. The turbines have a terminal voltage of 0.69 kV. For this feasibility analysis, the wind facility was represented as three (3) 200 MW generators with a terminal voltage of 0.69 kV. Each composite unit was connected to a 34.5 kV feeder through a GSU. The voltage was then stepped up by three 34.5/230 kV transformers to 230 kV for transmission purposes. The Generation Developer's facility was connected to the 230 kV bus at Weld Substation through a 60 mile, double circuit line, using a single 795 ACSR conductor for this line. In the study request documents, the Generation Developer indicated that the two circuits would be tied together at a point just outside the Weld Substation and only a single circuit carrying the entire 600 MW would be connected to the Weld 230 kV bus. For the steady state analysis, it was assumed that both circuits

would be connected directly to the Weld 230 kV bus; as at least one document from the Generation Developer indicated that. This is a reasonable simplification for the steady state analysis as these are functionally equivalent. However, this inconsistency would need to be resolved for the System Impact Study. The 600 MW of new generation was accommodated by decreasing the output of the Comanche units.

E. Nearby Transmission Paths

The proposed POI for GI-2008-31 is at PSCo's Weld 230 kV bus, with power generally flowing south to the PSCo loads. While the wind turbines for the GI-2008-31 project are located north of TOT 3, the Generation Developer is proposing to construct a radial double circuit 230 kV line connecting the new generation to the transmission system only at the Weld 230 kV bus. Since the power from GI-2008-31 will be delivered to PSCo for its customers to the south, there should not be any net increase in TOT 3 flows. However, there is a power transfer path, TOT 7 (see Figure 1), south of the proposed POI, which will be affected by generation from GI-2008-31.

TOT 7 is the WECC-defined power transfer path located in the vicinity of the study area. It is comprised of the transmission lines that allow power to be transferred between northeast Colorado and the north Denver metropolitan area. This path is shared by PSCo and PRPA. TOT 7 has a maximum path rating of 890 MW; however, the real time path capability depends on the level of demand in the Foothills area and the Colorado-Big Thompson generation. The facilities that comprise TOT 7 are as follows:

Transmission Line	Metered End
Ault - Windsor 230 kV	Ault
Weld PS - Ft. St. Vrain 230 kV	Weld
Longs Peak - Ft. St. Vrain 230 kV	Ft. St. Vrain

As demand in the local Denver area increases, the TOT 7 real-time transfer limit decreases. Similarly, as Colorado - Big Thompson generation decreases, the TOT 7 real-time transfer limit decreases. Using the 2012 summer case, when the generation at Colorado-Big Thompson is at 180 MW and the demand is at 50% of summer peak, the TOT 7 transfer rating is at 890 MW. The TOT 7 real time transfer limit decreases to approximately 580 MW at the point where the demand reaches 100% of summer peak. Since a summer peak power flow case was used for this study, the TOT 7 limit was considered to be 580 MW.

In the benchmark 2012 heavy summer case, the TOT 7 flow is 463 MW. With the interconnection of GI-2008-31 and delivery of its 600 MW to PSCo loads, the flow across TOT 7 increases to 826 MW which is greater than its real time transfer limit.

F. Power Flow Study Process

Automated contingency power flow studies were completed on all power flow models using the PSS®MUST program, switching out single elements one at a time for all of the elements (lines and transformers) in control areas 70 (PSCo) and 73 (WAPA RM). Upon switching each element out, the program re-solves the power flow model with all transformer taps and switched shunt devices locked, and control area interchange adjustments disabled.

G. Power Flow Results

Stand Alone Results

The stand-alone analysis consisted of a comparative study of the system behavior with the addition of the Generation Developer's 600 MW project to the PSCo system compared with that associated with the existing PSCo system. The power flow model used in this study is a 2012 budget model with heavy summer load and moderately heavy stressed north-to-south (HSHN) flows.

From the results of the steady-state analysis performed for this feasibility study, the full 600 MW generation output of the GI-2008-31 project could be provided to PSCo after reinforcements to the PSCo transmission system have been completed and additional transformer capacity is added at Weld Substation. PSCo will complete its reinforcements through its capital budget process for transmission upgrades.

Thermal Overloads

The adverse impacts in terms of overloaded facilities resulting from the addition of GI-2008-31 and delivering 600 MW of generation to the 230 kV bus at Weld Substation are shown in Table 1. Without any reinforcements, there are several lines in Areas 70 and 73 that become overloaded with the addition of GI-2008-31.

Table 1. Thermal Overloads with 600 MW GI-2008-31 at Weld

** From bus ** ** To bus ** CKT	Branch Rating (MVA)	Branch Loading - % of Branch Rating				Contingency	FAC-009 Rating (July '10)
		Bench-mark	No Upgrade	Option 1	Option 2		
70045 BANCROFT 115 70208 GRAY ST 115 1	120	132.1	137.9	139.2	140.7	70037 ARAPAHOB 115 70401 SOUTH 1 115 1	120
70149 DENVTM 230 70177 ELATI3 230 1	440	70.9			106.3	70141 DAKOTA 230 70149 DENVTM 230 1	
70164 ELDORADO 115 70346 RALSTON2 115 1	27	187.5	216.2	211.7	189.4	70447 VALMONT 230 70543 SIMMS 230 1	
70170 ELATI2 230 70291 MONROEPS 230 1	398	<70.0			101.7	70141 DAKOTA 230 70149 DENVTM 230 1	
70191 FTLUPTON 115 70192 FTLUPTON 230 T3	280	97.6	105.0	109.8		70447 VALMONT 230 70592 SPNDLE 230 1	280
70192 FTLUPTON 230 70410 ST.VRAIN 230 1	444	108.4	138.6			70192 FTLUPTON 230 70410 ST.VRAIN 230 2	506
70192 FTLUPTON 230 70410 ST.VRAIN 230 2	444	108.4	138.6			70192 FTLUPTON 230 70410 ST.VRAIN 230 1	506
70197 GEORGETN 115 70218 HENDERPS 115 1	57	147.2	158.9			70053 BLUERIVR 230 70156 DILLON 230 1	80
70224 HOGBACK 115 70265 LOOKOUT 115 1	138	92.5	108.4	108.5	109.9	70018 SODALAKE 230 70266 LOOKOUT 230 1	
70273 MALTA 115 70274 MALTA 230 T1	100	109.3	117.7	118.0	118.3	70155 DILLON 115 70156 DILLON 230 T2	
70285 MIDWAYPS 115 70286 MIDWAYPS 230 T1	100	91.3	100.8	101.1	101.1	70030 APT PARK 115 70549 APT MEM 115 1	
70345 RALSTON1 115 70354 RIDGE 115 1	27	275.3	316.8			70447 VALMONT 230 70543 SIMMS 230 1	80
70345 RALSTON1 115 70444 VALMONT 115 1	27	349.3	397.4			70447 VALMONT 230 70543 SIMMS 230 1	
70395 SMOKYHIL 115 70416 STRASBRG 115 1	97.6	98.7	107.5			70343 QUINCY 230 70545 BRICKCTR 230 1	IREA
70395 SMOKYHIL 115 70521 PEAKVIEW 115 1	133.5	98.9	114.4	114.5	114.5	70396 SMOKYHIL 230 70551 MURPHY 230 1	IREA
70410 ST.VRAIN 230 70471 WELD PS 230 1	478	75.1	133.1	102.5*	102.5*	70474 WINDSOR 230 73011 AULT 230 1	564
70474 WINDSOR 230 73011 AULT 230 1	498	<70.0	100.5			70410 ST.VRAIN 230 70471 WELD PS 230 1	
70517 PARKERPS 115 70518 BAYOU 115 1	133.5	127.5	133.4	134.3	134.2	70138 DANIELPK 115 70139 DANIELPK 230 T1	IREA
73061 METTLER 138 73296 FRASER 115 1	100	99.2	106.3			70053 BLUERIVR 230 79033 GOREPASS 230 1	TSGT
73150 PEETZ 115 73191 STERLING 115 1	109	95.2	100.7			73143 N.YUMA 230 73579 SPRNGCAN 230 1	
73211 WELD LM 115 73212 WELD LM 230 1	150	111.7	130.6	117.0	116.7	70470 WELD PS 115 70471 WELD PS 230 T1	

Items highlighted in yellow are within PSCo acceptable limits

Items highlighted in orange are overloads on affected parties systems

Items highlighted in green are necessary reinforcements that will be completed through the PSCo capital budget process

*This overload has been eliminated based on the revised FAC-009 rating

In reviewing the results of the contingency analysis with GI-2008-31 for Area 70 (PSCo system), the following conclusions have been made:

The loading on the transformer at Ft. Lupton and at Midway is less than 115%, which is within acceptable limits for PSCo (the yellow shaded line in Table 1).

The overloading of the Malta transformer is due to a scheduling issue and will not require a network upgrade.

The 115/230 kV transformer at Weld is overloaded in the benchmark case itself and the loading increases with the addition of 600 MW at Weld. This is a known issue and the transformer either needs to be replaced or an additional transformer needs to be added at this location before this facility is interconnected.

There are significant overloads on the Weld to St. Vrain 230 kV circuit and the two St. Vrain to Ft. Lupton 230 kV circuits under contingency conditions. In addition, while not shown in Table 1, the TOT 7 flow also exceeds its real time transfer limit with the 600

MW generation from GI-2008-31 added. To address these overloads, the following two transmission circuits were studied:

Option 1: a new 230 kV circuit from Weld to Ft. Lupton

Option 2: a new 230 kV circuit from Weld to Cherokee

With the construction of a new 62-mile circuit from Weld to Cherokee (**option 2**), the 230 kV underground lines from Denver Terminal to Elati and Elati to Monroe would be overloaded under contingency conditions. Therefore, the 30-mile circuit from Weld to Ft. Lupton (**option 1**) is the preferred option, since it allows 600 MW of wind generation to be scheduled across TOT 7 without adversely impacting the nearby transmission system.

A detailed TOT 7 analysis was not conducted in this study, but should the Generation Developer continue the request to the System Impact Study phase, a more detailed TOT 7 analysis will need to be done.

Voltage Criteria Violations

Interconnecting to the PSCo bulk transmission system involves the developer adhering to certain interconnection requirements. These requirements are contained in the Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW (Guidelines). The Guidelines make reference to interconnection requirements from FERC Order 661A. FERC Order 661A describes the interconnection requirements for wind generation plants. In addition, PSCo System Operations conducts commissioning tests prior to the commercial in-service date for a developer's facilities. Some of the requirements that the developer must complete include the following:

1. A wind generating plant shall maintain a power factor within the range of 0.95 leading to 0.95 lagging, measured at the POI, if the Transmission Provider's Feasibility Study shows that such a requirement is necessary to ensure safety or reliability.
2. The Feasibility Study will investigate pertinent demand, dispatch, and outage scenarios based on the defined study area that includes the proposed POI. The study will conform to the NERC Transmission System Planning Performance Requirements (TPL standards).
3. The results of the Feasibility Study (mentioned in Item 1 and 2 above) do not absolve the developer from its responsibility to demonstrate to the satisfaction of PSCo System Operations prior to the commercial in-service date that it can safely operate within the required power factor and voltage ranges.
4. Reactive Power Control at the POI is the responsibility of the developer. Additional developer studies should be conducted by developer to ensure that

the facilities can meet the power factor control test and the voltage controller test when the facility is undergoing commissioning testing.

5. PSCo System Operations will require the developer to perform operational tests prior to commercial operation that would verify that the equipment installed by the developer meets operational requirements.
6. It is the responsibility of the developer to determine what type of equipment (DVAR, added switched capacitors, SVC, reactors, etc.), the ratings (MVAR, voltage--34.5 kV or 230 kV), and the locations of those facilities that may be needed for acceptable performance during the commissioning testing.
7. PSCo requires the developer to provide a single point of contact to coordinate compliance with the power factor and voltage regulation at the POI. The reactive flow at the end of 230 kV line near the POI will need to be controlled according to the Interconnection Guidelines.

According to WECC/NERC criteria, it is necessary to maintain voltages at all buses in the system between 0.95 per unit to 1.05 per unit under operating conditions.

In the Rocky Mountain Voltage Coordination Guidelines that were developed by the Voltage Coordination Guideline Subcommittee of the Colorado Coordinated Planning Group, the ideal voltage for a regulating bus must be greater than 1.02 per unit. The voltage at the 230 kV bus at Weld in the benchmark case is 1.026 per unit. With the interconnection of the proposed generation facility and the delivery of 600 MW from GI-2008-31, the voltage at the POI drops to 1.015 per unit. At the POI, the Developer's transmission line draws about 140 MVAR of reactive power from the PSCo system.

To keep the power factor at the POI between 0.95 leading to 0.95 lagging and keep the voltage above 1.02 per unit, about 120 MVAR of switched capacitors or other reactive power source may need to be connected to the Developer's facilities. With 120 MVAR of switched capacitors connected near the POI when GI-2008-31 is producing 600 MW, the voltage at the POI rises to 1.023 per unit.

During periods of minimal wind generation, the voltage at the 230 kV Weld bus remains at 1.026 per unit. However, the Developer's transmission line supplies 37 MVAR of reactive power to the PSCo system, and the voltage at the wind facility rises to 1.050 per unit. Therefore, in order to keep the interconnection VAR neutral, a 35 MVAR reactor may be needed close to the wind farm.

The indicated reactive requirements are potential solutions to the reactive power requirements for the transmission system. The values have not been optimized with respect to different locations or types of reactive power support. Additionally, the collector system has not been modeled for the feasibility study. In the system impact study, if such is pursued by the Developer, the detailed collector system needs to be represented to perform the stability analysis and this change will have some impact on the reactive power requirements. The voltage-tap settings on the main power

transformers that connect the 34.5 kV system to the Developer's transmission line will impact the operating voltages and related reactive power capabilities and requirements for GI-2008-31. These issues should be considered by the Developer in determining the final equipment design and parameters.

Energy Resource (ER):

The ER portion of this study indicates that the Generation Developer could provide 0 MW without the construction of new transmission lines and assuming that TOT3 and TOT 7 flows are at or above the levels studied. The limiting elements are the 230 kV lines from Ft. St. Vrain to Ft. Lupton and the 230/115 kV transformer at Weld. Once the interconnection is made, at the 230 kV POI, non-firm transmission capability may be available depending upon marketing activities, dispatch patterns, generation levels, demand levels, import path flow levels and the operational status of the transmission facilities.

Network Resource (NR):

The results of this study indicate that the 600 MW output from the GI-2008-31 generation project delivered to the Weld 230 kV POI could result in the overloading of facilities in the PSCo system and exceeding TOT 7 real time operating ratings. Therefore, the 600 MW NR value requested will require interconnection and transmission network upgrades across TOT 7 and a TOT 7 rating study. After the required upgrades are complete, the 600 MW generating facility could be considered a network resource with firm transmission capability for the entire output of the plant to be delivered to load.

H. Short Circuit Analysis

A short circuit study was conducted to determine if the fault currents (single line-to-ground or three-phase) exceed the interrupt ratings of any circuit breakers at the Weld or Ft. Lupton substations. The approximate fault currents at Weld and Ft. Lupton with the addition of the GI-2008-31 600 MW wind facility and proposed reinforcement are summarized in Table 2.

Table 2. Short Circuit Study Results With the Addition of GI-2008-31

System Condition	Location	Three-phase Fault (amps)	Single-line-to-ground Fault (amps)
System Intact	Weld 230 kV	23,800	19,100
System Intact	Ft. Lupton 230 kV	32,600	26,000

In comparing the results of the benchmark case without GI-2008-31 and the results shown in Table 2, the addition of the 600 MW wind farm does not result in a significant increase in fault current levels, and thus should not require the replacement of circuit breakers, switches or other substation equipment near the POI.

I. Cost Estimates and Assumptions

Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) have been developed by PSCo Engineering. The cost estimates are in 2010 dollars with escalation and contingencies applied (AFUDC is not included) and are based upon typical construction costs for previously performed similar construction. These estimated costs include all applicable labor and overheads associated with the siting support, engineering, design, and construction of these new PSCo facilities. This estimate does not include the cost for any other Customer owned equipment and associated design and engineering.

The estimated total cost for the required upgrades for is $31,245,000.

The following tables list the improvements required to accommodate the interconnection and the delivery of the Project generation output. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to change upon a more detailed and refined design.

This estimate does not include any network reinforcements that may be required to meet the interconnection guidelines as required by PSCo in the Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW (Guidelines). Other projects are included in the PSCo Capital Budget process and are assumed to be in-service by the commercial in-service date of the 600 MW project. Substation diagrams for Weld and Ft. Lupton are shown in the Appendix.

Figure 2 shows a conceptual one-line of the proposed interconnection at the Weld Substation, with only one circuit connected at the Weld 230 kV bus.

Figure 2. Simple One- Line Diagram For GI-2008-31 Interconnection at Weld

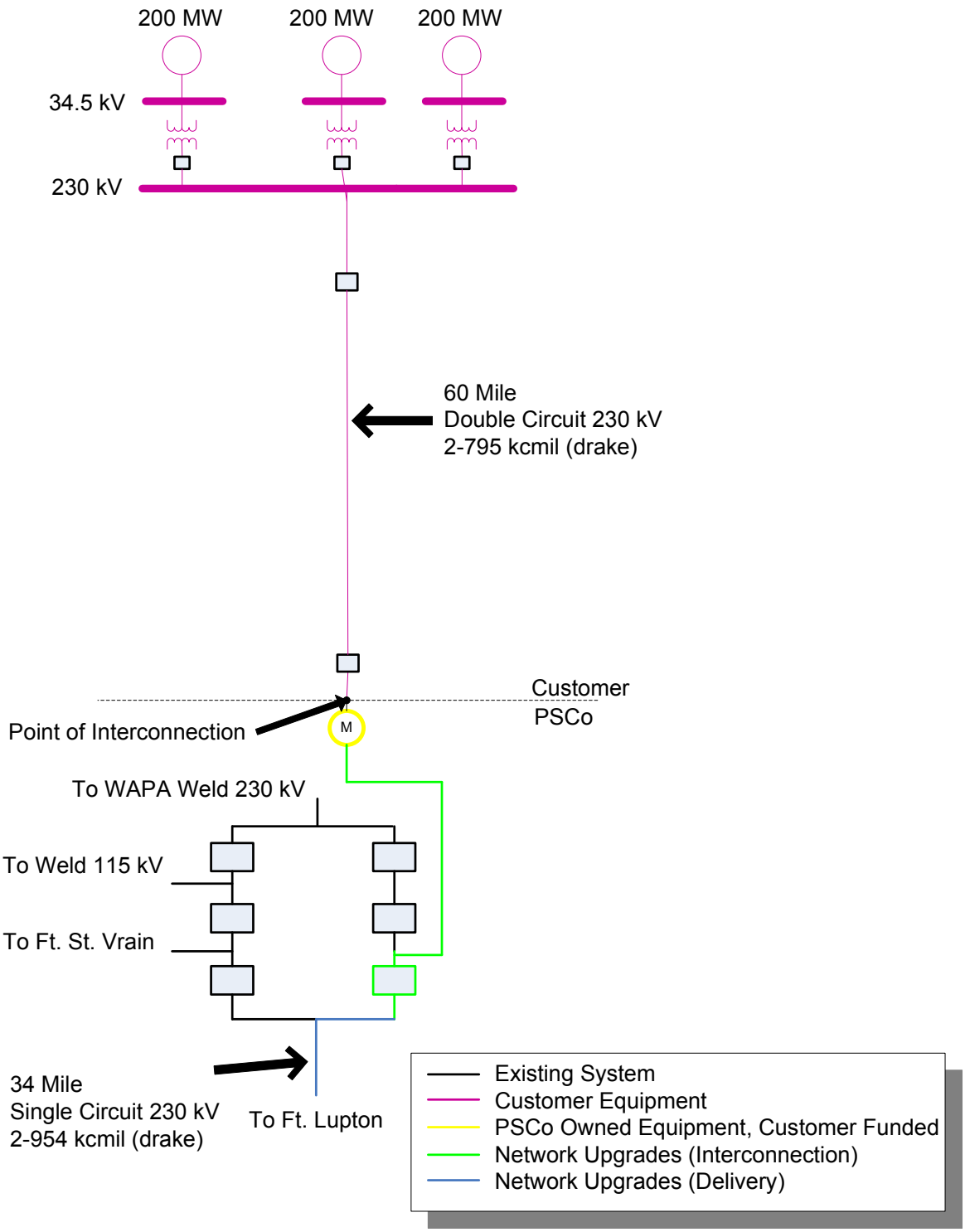


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Table 3. PSCo Owned; Developer Funded Interconnection Facilities

Element	Description	Cost Est. Millions
Weld 230 kV Substation	Interconnect Customer to tap at PSCo's Weld 230 kV Substation. The new equipment includes: • One 230 kV, 3000 amp, gang switch • Three 230 kV combination CT/PT metering units • Three 230 kV lightning arresters • One relay panel • One Jemstar metering for Load Frequency/Automated Generation Control • Associated bus, wiring and equipment • Associated foundations and structures • Associated transmission line communications, relaying and testing	**$0.445**
	Transmission line tap into substation. Structure, conductor, hardware and installation labor.	**$0.070**
	Customer Load Frequency/Automated Generation Control and Generator Witness Testing. (Customer generation telemetry equipment and witnessing the Customer generator commissioning testing).	**$0.020**
	Siting and Land Rights support for required easements, reports, permits and licenses.	**$0.010**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$0.545**
Time Frame	**Site, design, procure and construct**	**15 Months**

Table 4. PSCo Owned; PSCo Funded Interconnection Facilities

Element	Description	Cost Est. (Millions)
Weld 230 kV Substation	Interconnect Customer to tap at PSCo's Weld 230 kV Substation. The new equipment includes: • Two 230 kV, 3000 amp, 40 kA circuit breakers • Four 230 kV, 3000 amp gang switches • One 230 kV circuit switcher • Associated communications, supervisory and SCADA equipment • Line relaying and testing • Associated bus, miscellaneous electrical equipment, cabling and wiring • Associated foundations and structures • Associated yard surfacing, landscaping, fencing and grounding	**$0.960**
	Siting and Land Rights support for construction.	**$0.010**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$0.970**
Time Frame	**Site, design, procure and construct**	**15 Months**

Xcel Energy

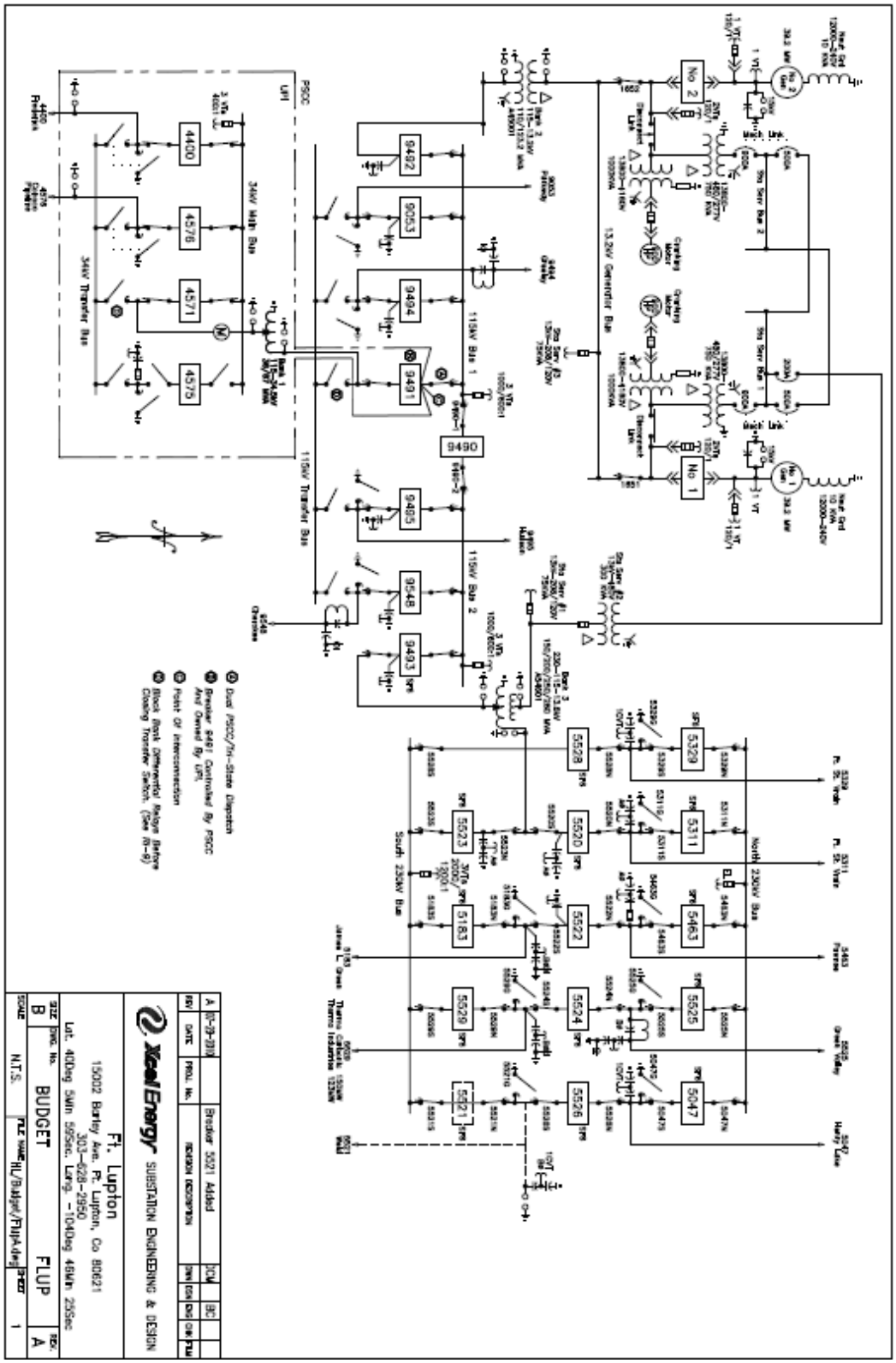
Table 5. PSCo Network Upgrades for Delivery

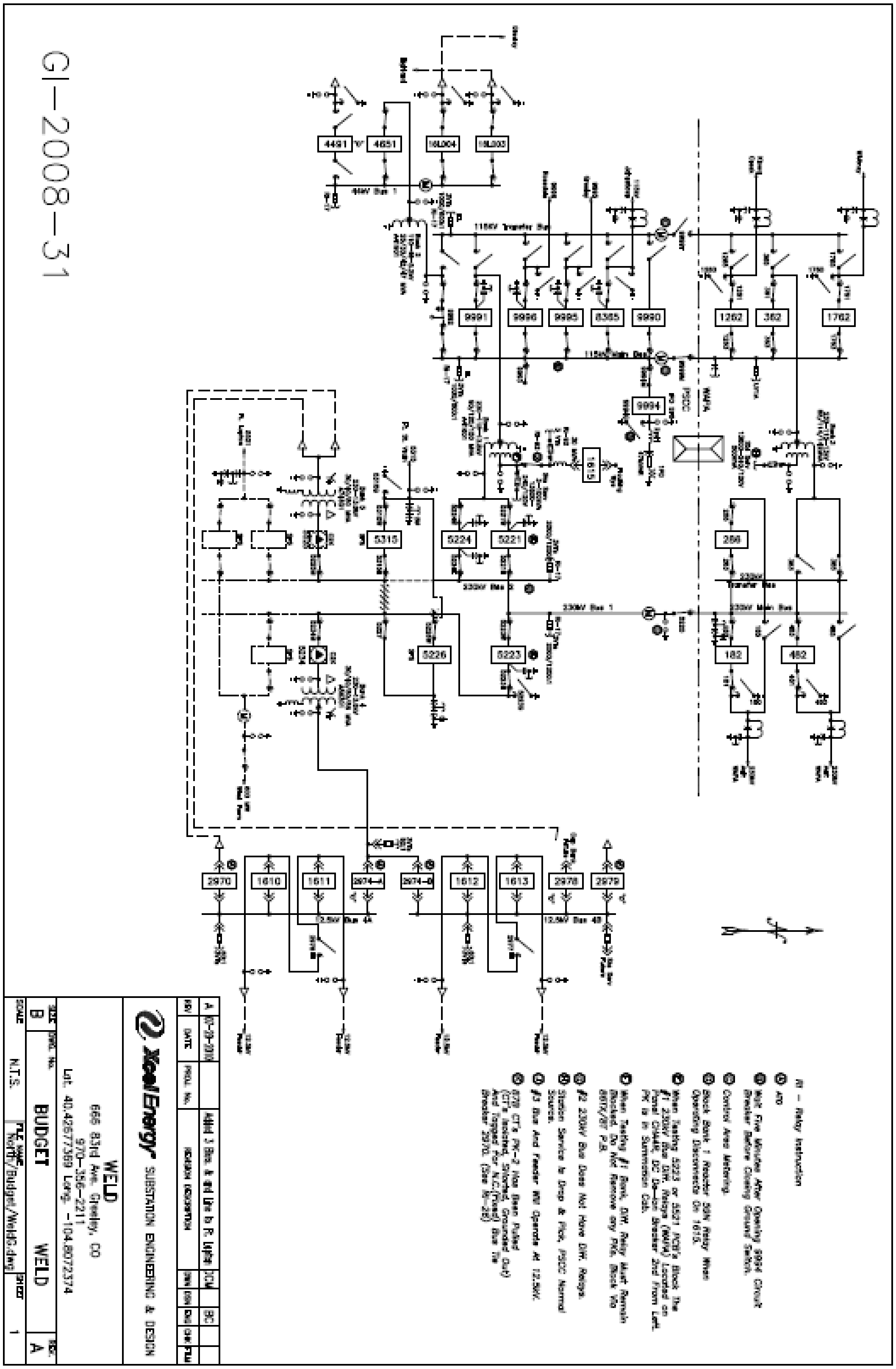
Element	Description	Cost Est. (Millions)
Weld-Ft. Lupton 230 kV OH Trans Line	Construct a new 34-mile, 230 kV single conductor, bundled 954 kcmil (Drake) overhead transmission line from Weld 230 kV Substation to Ft,. Lupton 230 kV Substation.	**$23.925**
Weld 230 kV Substation	Line termination into Weld 230 kV Substation. The new equipment includes: • One 230 kV, 3000 amp, 40 kA circuit breaker • Two 230 kV, 3000 amp gang switches • One 230 kV, 2000-1200 amp CCVT • Three 230 kV lightning arresters • One relay panel • Associated communications, supervisory and SCADA equipment • Line relaying and testing • Associated bus, miscellaneous electrical equipment, cabling and wiring • Associated foundations and structures • Associated yard surfacing, landscaping, fencing and grounding	**$0.710**
Ft. Lupton 230 kV Substation	Line termination into Ft. Lupton 230 kV Substation. The new equipment includes: • One 230 kV, 3000 amp, 40 kA circuit breaker • One 230 kV, 3000 amp gang switch • One 230 kV, 2000-1200 amp CCVT • Three 230 kV lightning arresters • One relay panel • Associated communications, supervisory and SCADA equipment • Line relaying and testing • Associated bus, miscellaneous electrical equipment, cabling and wiring • Associated foundations and structures • Associated yard surfacing, landscaping, fencing and grounding	**$0.645**
	Siting and Land Rights support for required easements, reports, permits and licenses.	**$4.630**
	Total Cost Estimate for PSCo Network Upgrades for Delivery	**$29.910**
Time Frame	**Regulatory, site, design, procure and construct**	**60 months**
	Total Cost of Project	**$31.425**

Assumptions

- Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by PSCo Engineering.
- Estimates are based on 2010 dollars (appropriate contingency and escalation applied).
- AFUDC has been excluded.
- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- The Wind Generation Facility is not in PSCo's retail service territory. Therefore, no costs for retail load metering are included in these estimates.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- The estimated time to site, design, procure and construct the interconnection facilities is at least 15 months, The estimated time to site, design, procure and construct the Network/Infrastructure Upgrades is 60 months after authorization to proceed has be obtained. This is completely independent of other queued projects and their respective in-service dates.
- A CPCN will not be required for the interconnection facilities construction.
- A CPCN will be required for the network/infrastructure upgrades for delivery.
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.
- All substation work and expansion will be completed within existing property boundaries. No new land is required.
- Substation trench and duct space is available.
- Existing bus ratings are adequate for the substation additions.
- No upgrades are required at Ft. St. Vrain 230kV Substation – all equipment is adequate and operational.

J. Appendix – Weld and Ft. Lupton Substation Diagrams with Upgrades

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WELD
666 83rd Ave. Greeley, CO
SUBSTATION ENGINEERING & DESIGN
BUDGET
WELD
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