



## **Interconnection Facilities Study Report GI-2007-4**

**300 MW Wind Generation Expansion (600 MW Total)  
Interconnecting at Ault Substation**

**PSCo Transmission Planning  
January 6, 2011**

### **A. Executive Summary**

This Interconnection Facilities Study Report summarizes the analysis performed by Public Service Company of Colorado (PSCo) in GI-2007-4 to specify and estimate the cost of the equipment, engineering, procurement, and construction needed to interconnect a 300 MW expansion of the wind generation facility from GI-2007-3 at Ault Substation, located in Weld County, Colorado. The GI-2007-4 request was studied as a 300 MW expansion of the GI-2007-3 wind generation project for a total of a 600 MW injection at the Ault Substation. The Point of Interconnection (POI) will be the 230 kV bus at Ault Substation. Western Area Power Administration (Western) is the owner of the Ault Substation; however, PSCo has conducted the Feasibility and System Impact Studies as if it were the owner. PSCo has coordinated these study results with Western, and Western has provided initial results of their Facilities Study associated with the interconnection at Ault. For the purpose of this study, the Ault Substation (including the 230 kV yard with 15 power circuit breakers in a breaker and a half arrangement) is assumed to be part of the "existing system." Existing system means that the cost for most of the PSCo-Owned; PSCo-Funded Interconnection Facilities is not considered to be a project cost because the Generation Provider would be interconnecting its transmission line to substation facilities that will be in existence when the interconnection is accomplished.

The Generation Provider's 300 MW expansion of the GI-2007-3 wind generation facility will utilize the same 35-mile, radial 230 kV transmission line to interconnect at the POI. The Generation Provider will be responsible for construction of the transmission line from the generating facility to the POI. For cost estimating purposes it is assumed this line has not been constructed in this study. It was determined the projects anticipated Commercial Operation Date (COD) of November 1, 2014, and expected back-feed for site energization of May 1, 2014 is not possible. Instead, a new anticipated COD would be five to seven years from authorization to proceed, with an expected back-feed date of six months prior.



The GI-2007-4 System Impact Study determined the proposed 600 MW (300 MW from GI-2007-3 and 300 MW of expansion) facility could be considered a Network Resource after resolving one reliability issue:

- An increase to the TOT 7 transfer path rating under heavy summer demand conditions.

The required Network Upgrade to mitigate this reliability issue is the construction of the **Ault – Cherokee 230 kV line**.

Power flow studies demonstrate that TOT 7 capacity is fully committed by existing firm reservations, and there are current system criteria violations that reduce the use of the Total Transfer Capability (TTC) on TOT 7. Generation injection at Ault will require the Network Upgrade of the Ault – Cherokee 230 kV line.

Studies show the Ault – Cherokee 230 kV alternative allows the full 600 MW of wind generation (300 MW from GI-2007-3 and 300 MW of expansion) to be scheduled across TOT 7 without violating system criteria. For all contingencies studied, the results of the transient stability analysis indicates that the addition of a 300 MW wind generation expansion connected to the Ault 230 kV bus, along with an Ault – Cherokee 230 kV line, does not have an adverse impact on the response of the system to severe system disturbances.

The Generation Provider and PSCo contacted Western about the interconnecting of GI-2007-4 and the Network Upgrades necessary for delivery. Western has provided PSCo with their interconnection design and associated costs at the Ault Substation.

**NOTE:** Although it was specified GI-2007-3 and GI-2007-4 would interconnect at Ault Substation through the same termination, interconnection estimates provided by Western and PSCo assume this study as a new interconnection at Ault Substation. The 2014 HS base case used for the Feasibility and System Impact Studies does not include Westerns new Ault Substation 230/115 kV transformer. However, it is assumed this element does not impact the cost of interconnection or the recommended Network Upgrades necessary for delivery of GI-2007-4.

The total estimated cost of the recommended system upgrades to interconnect the project is approximately **\$ 67,350,000** and includes:

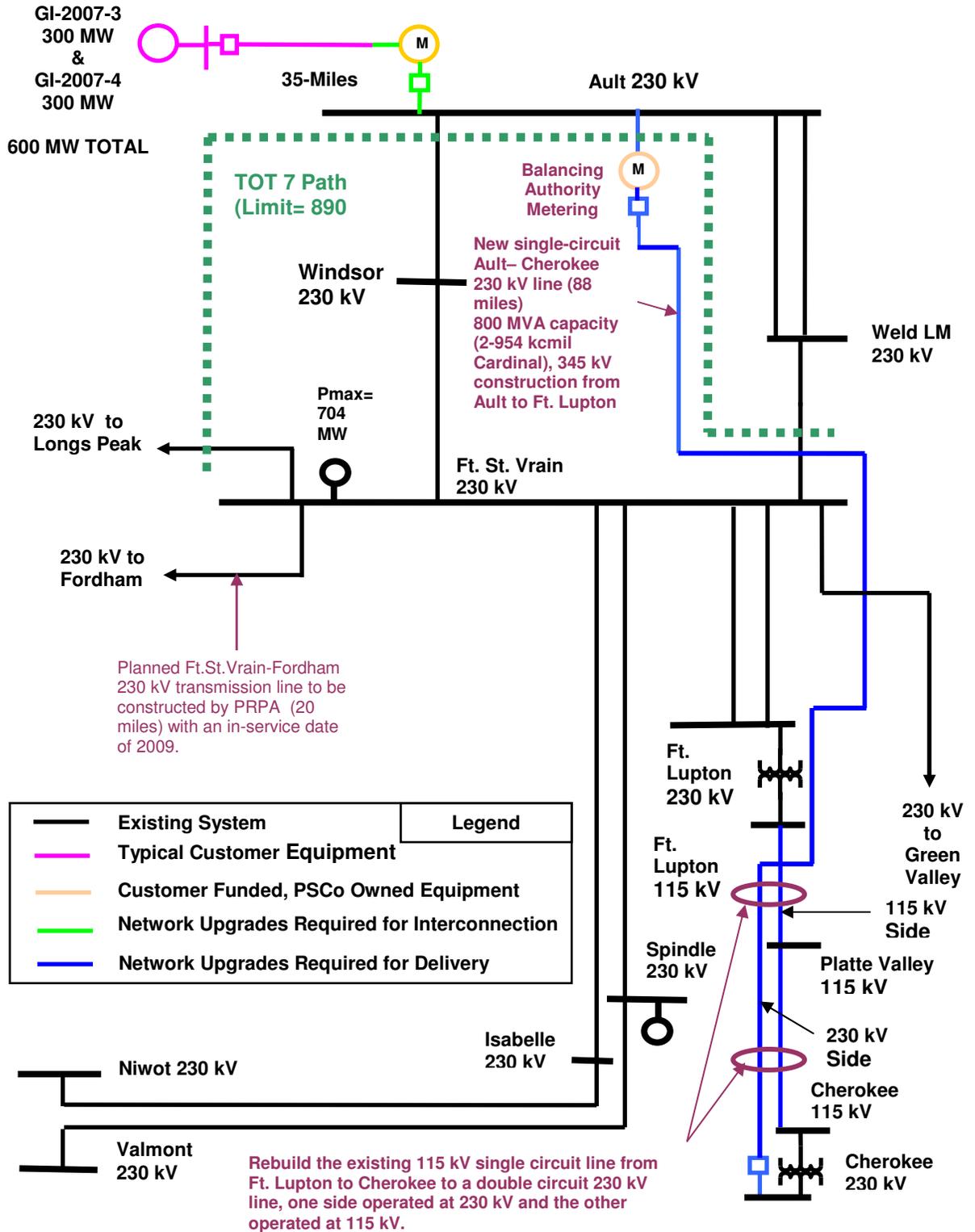
- \$0.890 million for PSCo Owned, Generation Provider Funded Interconnection Facilities. This includes a 230kV gang switch, 230kV lightning arrestors, CT/PT's, revenue metering and enclosure, foundations, structures, communications, relaying, testing, etc.



- \$1.200 million for Western Owned, PSCo Funded network upgrades for interconnection. This includes and includes substation upgrades required at Western's Ault Substation (relaying and testing).
- \$65.260 million for PSCo Network Upgrades for Delivery.

A conceptual one-line of the proposed Interconnection is shown in Figure 1 below.

**Figure 1: Diagram of the GI-2007-4 Interconnection at Ault 230 kV**





## **B. Introduction**

On May 26, 2009, Public Service Company of Colorado (PSCo) and a Generation Provider signed an Interconnection Facilities Study request to provide cost estimates, a project schedule and address the impacts of interconnecting a 300 MW wind powered expansion to GI-2007-3, as identified in the System Impact Study, at Westerns 230 kV Ault Substation. This request was studied as a 300 MW expansion of the GI-2007-3 wind generation project for a total of 600 MW (300 MW from GI-2007-3 and 300 MW of expansion). The Generation Provider proposed that the 300 MW wind generation expansion would consist of 200 Acciona Windpower AW1500 (1.5 MW) wind turbine units, and would be located in Weld County, approximately 35-miles northwest of Ft. Collins, Colorado. This facility would interconnect into the transmission system via the same Customer-owned, 35-mile, radial 230 kV transmission line from GI-2007-3, terminating at the 230 kV bus of the Ault Substation. In this study it is assumed this transmission line has not been built for cost estimating purposes.

Western's Ault Substation consists of a 345 kV yard with eight (8) power circuit breakers and a 230 kV yard with fifteen (15) power circuit breakers in a breaker and a half configuration. The most recent power circuit breaker addition to the 230 kV yard (1386) was added in order to terminate the rebuilt Ault – Cheyenne 230 kV line. The Substation also contains three (3) 345/230 kV power transformers totaling 1560 MVA of capacity. Currently, the Substation does not have sufficient room for the 230 kV breaker additions required for the interconnection of GI-2007-4 project without moving the south fence of the Substation or locating the breakers elsewhere on the property. Furthermore, Western is in the process of installing a 200 MVA, 230/115 kV Transformer and associated 115 kV and 230 kV power circuit breakers at Ault Substation, known as the Ault Stage 07 Project. The addition of the Ault Stage 07 Project will utilize the remaining space in the control building; therefore, the interconnection of GI-2007-4 would require the addition of a satellite control building for the associated power circuit breakers and switches.

The Feasibility Study was completed on August 30, 2007, subsequent to which the POI was moved from 1-mile south of the Ault Substation to the 230 kV bus at the Ault Substation. The System Impact Study was completed on March 31, 2009.

The GI-2007-4 System Impact Study determined the proposed 300 MW addition to GI-2007-3 (the full 600 MW of wind generation) could be considered a Network Resource after resolving one reliability issue:

- An increase to the TOT 7 transfer path rating under heavy summer demand conditions.

The required Network Upgrade to mitigate this reliability issue is the construction of the **Ault – Cherokee 230 kV line**.



The System Impact Study showed that the generation interconnection request impacts the power transfer path TOT 7. TOT 7 is WECC defined power transfer path located in the vicinity of the study area. TOT 7 is comprised of transmission lines that allow power to be transferred between northeast Colorado and the north Denver Metro Area. The path is shown in Figure No. 1. The path has a maximum WECC-accepted north-to-south rating of 890 MW; however, the real-time path rating is highly dependant on the level of demand in the Foothills Area, and the on-line generation in the area called the Colorado-Big Thompson (CBT) generation. The TOT 7 path owners include Platte River Power Authority (PRPA) and PSCo. The facilities for this study that comprise TOT 7 are as follows:

| <u>Transmission Line</u>      | <u>Metered End</u> |
|-------------------------------|--------------------|
| Ault-Windsor 230 kV           | Ault               |
| WeldPS-Ft.St.Vrain 230 kV     | Weld               |
| Longs Peak-Ft.St.Vrain 230 kV | Ft.St.Vrain        |

The ability to transfer power across the TOT 7 Transfer Path is impacted by the level of local demand and level of hydroelectric generation of the CBT system. As demand in the local area increases, the TOT 7 real-time transfer limit decreases. Similarly, as the CBT generation decreases, the TOT 7 real time rating decreases. These variables are considered for any study that considers transfers across the TOT 7 Transfer Path.

Power flow studies demonstrate that TOT 7 capacity is fully committed by existing firm reservations, and there are current system criteria violations that reduce the use of the Total Transfer Capability (TTC) on TOT 7. Generation injection will require the recommended Network Upgrade for Delivery of the Ault – Cherokee 230 kV line which includes the following:

Construct a new 88-mile 230 kV transmission (345 kV construction) line using a two-conductor bundle of 954 kcmil “Cardinal” conductor per phase from the Ault Substation to Cherokee Substation. The line will consist of a single 59-mile line from Ault to just outside of Ft. Lupton. From this point the line will become a 29-mile double circuit 230 kV line by rebuilding the existing 115 kV line from Ft. Lupton to Cherokee on 230 kV structures with one side operated at 115 kV for the Tri-State Generation and Transmission (TSGT) load-serving substations, and the other side operated at 230 kV completing the circuit from Ault to Cherokee. The portion of the circuit from Ft. Lupton to Cherokee could be constructed for future 345 kV operation as there is sufficient existing right-of-way; however, adding a 345 kV yard at the Cherokee Substation is not feasible.

This alternative allows the full 600 MW (300 MW from GI-2007-3 and 300 MW of expansion) wind generation output to be scheduled across TOT 7 without violating system criteria. For all contingencies studied, the results of the transient stability analysis indicates that the addition of a 300 MW wind generation expansion connected to the Ault 230 kV bus, along with an Ault – Cherokee 230 kV line, does not have an adverse impact on the response of the system to severe system disturbances.



The transient stability study determined the following:

For all contingencies that were studied, the results of the stability analysis indicate that the addition of GI-2007-4, a 300 MW expansion to the GI-2007-3 Wind Farm, connected to the Ault 230 kV bus, along with an Ault-Cherokee 230kV line, does not have an adverse impact on the response of the system to severe system disturbances. All generation remained on line, except where purposely disconnected from the system. All oscillations were positively damped and voltage deviations on nearby 115 kV and 230 kV buses were well within acceptable criteria. The contingencies consisting of delayed clearing were similarly behaved with no undamped oscillations and voltage response within criteria as well. Results of system behavior in the benchmark case were similar to those observed for the case with GI-2007-4 generation.

For the single-line-to-ground with delayed clearing faults, it was observed that the Acciona Wind Turbine voltages are marked by oscillations (choppiness) that remain throughout the duration of the fault. These oscillations are also reflected on to the 230 kV side, though not significantly. However, after the fault is cleared the voltages recover to the initial condition and the system is stable. It is recommended that further investigation into the Acciona Wind Turbine model be carried out to understand the turbine's behavior and the resulting oscillations during a fault.

The power flow studies show that the wind generation facility is within criteria when the wind farm is operating at full output (600 MW). With the wind farm generating at a 600 MW maximum output, the Ault 230kV bus (POI) bus voltage is at 1.026 pu, the customer's facilities (line plus wind generation site) absorb 31 MVAR of reactive power, and the power factor is within the required 0.95 lagging/leading range. With the Customer wind units off-line, the Ault 230kV bus (POI) voltage is at 1.021 pu, and 16 MVAR is injected into the Ault 230kV bus (POI) from Customer's 230 kV transmission line. The voltage of 1.021 pu is within the voltage range of 1.00 pu to 1.04 pu for a controlled bus; however; the power factor under these conditions is 0.9 lagging, outside the required power factor range for loads. Therefore, approximately 16 MVAR of inductors would be needed to bring the power factor within the required range.

The Generation Provider and PSCo have entered into Interconnection Facilities Study Agreement. The purpose of the Interconnection Facilities Study<sup>1</sup> is to do the following:

- Specify and estimate the cost of the equipment, engineering, procurement and construction work needed to implement the conclusions of the Interconnection System Impact Study in accordance with Good Utility Practice to physically and electrically connect the Interconnection Facility to the Transmission System.
- Identify the electrical switching configuration of the connection equipment, including the transformer, switchgear, meters, and other station equipment

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<sup>1</sup> Information for the Facilities Study is taken from Appendix B of the Standard Large Generator Interconnection Procedures (LGIP) including Standard Large Generator Interconnection Agreement (LGIA)



- Identify the nature and estimated cost of any Transmission Provider's Interconnection Facilities and Network Upgrades necessary to accomplish the interconnection
- Estimate of the time required to complete the construction and installation of the Transmission Provider's facilities.

### C. Interconnection & Network Upgrades for Interconnection

PSCo's requirements for interconnection can be found in the Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW – Version 5.0<sup>2</sup>, found on the Xcel Energy website. Xcel Energy requires the Interconnection Generation Provider to construct the Interconnection Facilities in compliance with this document. The guidelines describe the technical and protection requirements for connecting new generation to the Xcel Energy Operating Company transmission system and also requires that the Interconnection Generation Provider be in compliance with all applicable criteria, guidelines, standards, requirements, regulations, and procedures issued by the North American Electric Reliability Council, Public Utility Commission or their successor organizations.

Western's requirements for interconnection can be found in the General Requirements for interconnection<sup>3</sup>, found on Westerns website.

#### Study Results

##### a. Fault Currents

A fault study was conducted on the future system with the proposed wind generation facility interconnected at the Ault 230kV bus and the Ault – Cherokee 230 kV line Network Upgrade. The study found that for the system, the three-phase fault and the single-line-to-ground fault currents are expected to be 24,682.4 amps and 24,553.0 amps respectively at the proposed Ault 230 kV bus. These values can be found in Table 1 below.

**Table 1: Fault Current Information for the Ault 230kV Bus with GI-2007-4 Contribution Represented and the Ault – Cherokee 230 kV line**

| System Condition | Three-phase (amps)  | Thevenin System Equivalent Impedance (R,X) in ohms  | Single-line-to-ground (amps)   | Thevenin System Equivalent Impedance (R,X) in ohms  |
|------------------|---|---|--|---|
| System Intact    | $I_1=24,682.4$<br>$I_2=I_0=0.0$<br>$I_A=I_B=I_C=24,682.4$ | $Z_1(\text{pos})=$<br>0.44479,5.36155<br>$Z_2(\text{neg})=$<br>0.45032,5.36313<br>$Z_0(\text{zero})=$ | $I_1=I_2=8,184.33$<br>$3I_0=24,553.0$<br>$I_A=24,553.0$<br>$I_B=I_C=0.0$ | $Z_1(\text{pos})=$<br>0.44479,5.36155<br>$Z_2(\text{neg})=$<br>0.45032,5.36313<br>$Z_0(\text{zero})=$ |

<sup>2</sup> Guidelines can be found at

[http://www.xcelenergy.com/Colorado/Company/Transmission/Pages/Transmission\\_Services\\_Interconnection\\_Guidelines.aspx](http://www.xcelenergy.com/Colorado/Company/Transmission/Pages/Transmission_Services_Interconnection_Guidelines.aspx)

<sup>3</sup> <http://www.wapa.gov/transmission/interconn.htm>



|  |  |                 |  |                 |
|--|--|-----------------|--|-----------------|
|  |  | 0.69030,5.42267 |  | 0.69030,5.42267 |
|--|--|-----------------|--|-----------------|

The fault current values listed in Table 1 may increase as additional generators and transmission lines are added to the system.

**b. Contracts**

Western and PSCo will enter into a separate agreement to construct the required facilities for the interconnected transmission lines.

**c. Description of Interconnection Facility**

Western is in the process of installing a 200 MVA, 230/115 kV transformer at Ault Substation, referred to previously as the Ault Stage 07 Project. With the addition of the Ault Stage 07 Project, the Substation does not have sufficient room for the 230 kV breaker additions required for the interconnection of GI-2007-4 project without a relocation of the south fence or locating the breakers elsewhere on the property. Furthermore, the addition of the Ault Stage 07 Project will utilize the remaining space in the control building; therefore, the interconnection of GI-2007-4 would require the addition of a satellite control building for the associated power circuit breakers and switches.

The 2014 HS base case used for the Feasibility and System Impact Studies does not include the Ault Stage 07 Project. However, it is assumed this element does not impact the cost of interconnection or the recommended Network Upgrades necessary for delivery of GI-2007-4.

Western will need to install three (3) 230 kV power circuit breakers, six (6) 230 kV disconnect switches and two inside take-off structures for the 600 MW (300 MW from GI-2007-3 and 300 MW of expansion) wind generation interconnection. Western understands that any reactor(s) needed would be installed in the Interconnection Customers generation yard. The estimated cost for Western work at Ault Substation is \$ 4,485,000. **NOTE:** Interconnection estimates provided by Western assume this study as a new interconnection at Ault Substation and not part of the interconnection for GI-2007-3.

**d. Network Improvements**

Western will install one breaker-and-a-half bay at Ault Substation to allow the termination of the transmission line for GI-2007-3 and GI-2007-4, and the Ault – Cherokee 230 kV transmission line at the Ault Substation 230 kV bus.



### **Ault – Cherokee 230 kV Line:**

Ault-Ft. Lupton

Notes and Assumptions:

- Assume siting, permitting and acquisition for approximately 59 miles of new 100' wide 230 kV transmission line Right of Way (ROW).
- Assume no additional land at Ault Substation is required.
- Local land use permitting costs through Weld County are included.
- Anticipate 20 months to complete siting study (including public involvement), local land use permitting and ROW acquisition after project authorization.

Ft. Lupton-Cherokee

Notes and Assumptions:

- Assume minimal additional ROW required and available (5 miles X 25' wide) for rebuild and trans.
- Engineering will design within existing ROW.
- Assume no new land needed for substations.
- Assume land use permitting in Weld, and Adams Counties, Ft. Lupton, Thornton, Commerce City and Brighton.
- Very difficult permitting with much public involvement due to adjacent development.
- Assume 24 months for permitting and minor acquisition (appeals to PUC possible).

### **e. Operations Requirements**

Western will own, operate and have operational control of the equipment installed under this project at the Ault substation.

### **f. Schedule**

Western's draft schedule of major activities is found in the Appendix.

### **g. Assumptions for Generation Provider's Site**

The Generation Provider will provide reactive support equipment to meet voltage tolerances and power factor at the Point of Interconnection as required by Xcel Energy's and Western's interconnection guidelines.



The System Impact Study determined that 16 MVAR of inductors are needed to meet the reactive power requirements at the Ault Substation 230 kV POI. The Generation Provider is responsible for conducting a facilities design to determine the optimal arrangement and size of devices to meet reliability criteria and conform to Xcel Energy's and Western's interconnection requirements.

The Generation Provider will engineer, procure, and construct all equipment up to and including the last transmission structure outside Western's Ault Substation. This is the point of ownership demarcation. The Generation Provider is responsible for transmission line relaying at their end of the line, and will coordinate protection design and settings with both PSCo's and Western's Substation Engineering.

The Generation Provider will need to arrange for station service power through the local utility/service provider, as the Generation Provider's site is not within the PSCo service territory.

PSCo needs approximately four to six weeks to test requirements of Interconnection Guidelines For Transmission Interconnected Producer-Owned Generation Greater Than 20 MW. Much of the testing can be performed in parallel with the construction schedule. A typical testing and commissioning procedure can be provided upon request.

Western may also require time to test the requirements of their General Requirements for Interconnection.

The Generation Provider must comply with FERC Order 661-A and guidelines for Low Voltage Ride Through (LVRT) capability.

The Generation Provider is responsible for providing the following information, subject to change, to the PSCo Lookout Control Center via a DNP-3 communication protocol.

- MW, & MVAR for each breaker in the Generation Provider's substation(s)
- Breaker Status for all breakers in the Generation Provider's substation(s).
- Wind speed.
- Wind direction.
- High wind cutout/cutoff.
- Generating generation.
- Available generation.



Via this same link, PSCo will supply raise and lower pulses to control the load on the wind generators, if generation curtailment is required by the PSCo Lookout Control Center.

Because the wind generation facility falls within the PSCo balancing authority, the Generation Provider is also responsible for providing the following information, subject to change, to the PSCo Lookout Control Center in order to allow for Automatic Generation Control (AGC) of the wind generation facility.

- PF set point (or Var set point)
- MW set point
- Feedback of MW set point
- Voltage set point
- Feedback of voltage set point
- Max +Var output available
- Max -Var output available
- Overall MW output
- Overall MVar output
- Slew rate MW change per second

#### **h. Communications**

The Generation Provider will need to supply a communication circuit from their site to the PSCo lookout Control Center, as well as to the Western Control Center in Loveland, for the information mentioned in the section above. **NOTE:** Interconnection estimates provided by Western and PSCo for the communications assume this study as a new interconnection at Ault Substation and not part of the interconnection for GI-2007-3.

#### **D. Costs Estimates and Assumptions**

Appropriation level cost estimates for Interconnection (+/- 20% accuracy) and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by Western and 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 Western and PSCo facilities. This estimate does not include the cost for any other Customer owned equipment and associated design and engineering. **NOTE:** Interconnection estimates provided by Western and PSCo assume this study as a new interconnection at Ault Substation.



The estimated total cost for the required upgrades is **\$67,350,000**. These estimates do not include costs for any other Customer owned equipment and associated design and engineering. 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.



**Table 2 – PSCO Owned; Customer Funded Interconnection Facilities**

| Element                                | Description  | Cost Est. Millions |
|--|--|--------------------|
| <b>Western's Ault 230kV Substation</b> | Interconnect Customer at Western's Ault 230kV Substation. The new equipment includes 230 kV bi-directional metering, control area boundary metering, relaying and associated equipment and material. | <b>\$0.482</b>     |
|  | Transmission tie line into substation.   | <b>\$0.232</b>     |
|  | Customer Generator Communication to Lookout.   | <b>\$0.032</b>     |
|  | Customer LF/AGC and Generator Witness Testing.   | <b>\$0.134</b>     |
|  | Siting and Land Rights for required easements, reports, permits and licenses.  | <b>\$0.010</b>     |
|  | <b>Total Cost Estimate for Customer Interconnection Facilities</b>   | <b>\$0.890*</b>    |
| <b>Time Frame</b>                      | <b>Site, design, procure and construct</b>   | <b>30 Months</b>   |

\*Cost provided from the Western Cost Estimates found in the Appendix

**Table 3 - Western Owned; Customer Funded Network Upgrades for Interconnection**

| Element                                | Description   | Cost             |
|--|---|------------------|
| <b>Western's Ault 230kV Substation</b> | Interconnect Customer at Western's Ault 230kV Substation. New 230kV line termination requiring the following equipment: <ul style="list-style-type: none"> <li>• one 230kV 40 kA, 3000 amp, circuit breaker</li> <li>• two 230kV, 3000 amp gang switches</li> <li>• electrical bus work</li> <li>• required steel and foundations</li> <li>• minor site work (station wiring, grounding)</li> </ul> | <b>\$1.200*</b>  |
| <b>Time Frame</b>                      | <b>Design, procure and construct</b>  | <b>30 Months</b> |

\*Cost provided from the Western Cost Estimates found in the Appendix

**Table 4 – Network Upgrades for Delivery (Infrastructure Upgrades)**

| Element                                | Description  | Cost Est. Millions |
|--|--|--------------------|
| <b>Western's Ault 230kV Substation</b> | New 230kV line termination requiring the following equipment: <ul style="list-style-type: none"> <li>• two 230kV 40 kA, 3000 amp, circuit breakers</li> <li>• four 230kV, 3000 amp gang switches</li> <li>• electrical bus work</li> <li>• metering, control, relaying and testing</li> <li>• required steel and foundations</li> <li>• minor site work (grading, fencing, grounding)</li> </ul> | <b>\$2.400*</b>    |



| Element  | Description  | Cost Est. Millions |
|--|--|--------------------|
| <b>PSCo's Cherokee 230kV Switching Station</b> | New 230kV line termination requiring the following equipment: <ul style="list-style-type: none"> <li>• one 230kV, 50 kA, 3000 amp circuit breaker</li> <li>• two 230kV 2000 amp gang switches</li> <li>• electrical bus work</li> <li>• metering, control, relaying and testing</li> <li>• required steel and foundations</li> </ul> | <b>\$0.560</b>     |
| <b>230kV Transmission Line Construction</b>    | New single circuit Ault –Ft. Lupton 230kV line (59 miles) 800 MVA capacity, bundled 954 kcmil (Cardinal) conductor.  | <b>\$27.630</b>    |
|  | Convert the existing 115kV line from Ft. Lupton to Cherokee to double circuit 230kV operation with 800 MVA capacity. One circuit will connect to the new Ault 230kV line just outside of Ft. Lupton where as the other will be operated at 115kV to serve the 115 kV stations along the way to Cherokee (29-miles).                  | <b>\$27.480</b>    |
| <b>Siting and Permitting</b>                   | Obtain necessary siting, permits, easements and ROW as required.   | <b>\$7.190</b>     |
|  | <b>Total Cost Estimate for PSCo Network Upgrades for Delivery</b>  | <b>\$65.260</b>    |
|  | <b>Total Cost of Project</b>   | <b>\$67.350</b>    |
| <b>Time Frame</b>                              | <b>Site, design, procure and construct</b>   | <b>60 Months</b>   |

\*Cost provided from the Western Cost Estimates found in the Appendix

### Cost Estimate Assumptions

- Appropriation level cost estimates for Interconnection (+/- 20%) and scoping level estimates for Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by Western and 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.
- Western, PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for Western or PSCo owned and maintained facilities.
- The estimated time to design, procure and construct the interconnection facilities is approximately 30 months after authorization to proceed has been obtained.
- This project is completely independent of other queued projects and their respective ISD's.

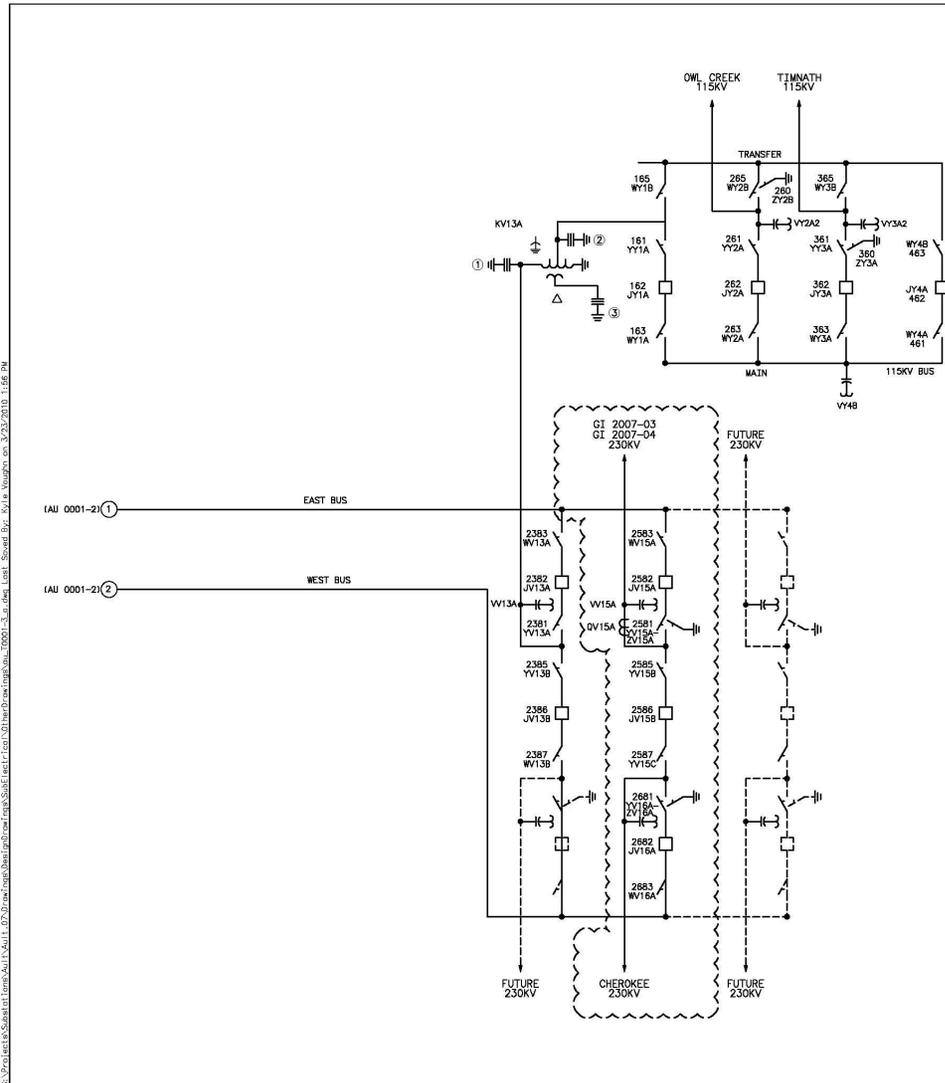


- A CPCN will not be required for the interconnection facilities construction.
- A CPCN will be required for the Network Upgrades for Delivery
- Western may require the Customer will string OPGW fiber into substation as part of the transmission line construction scope.
- All necessary substation expansions will be determined by Western.
- Implementation of the recommended infrastructure for delivery will require that existing facilities be taken out of service for sustained periods. In most cases, these outages cannot be taken during peak load periods due to operational constraints. As a result, the estimated time frame for implementation could be increased by 3-6 months.
- A siting study will be required if network upgrades for delivery. Extensive public involvement is anticipated. Permit applications and possible minor right-of-way acquisition will be required. Land use permits will be required from multiple local jurisdictions.

## Appendix



# A. Project One-Line of the Ault Substation



| TRANSFORMERS |     |         |                   |
|--------------|-----|---------|-------------------|
| DESIGNATION  | KV  | MAX MVA | SPEC OR STAGE NO. |
| KV13A        | 230 | 200     | AF65-10WJ85711    |

| SURGE ARRESTERS |      |         |                   |
|-----------------|------|---------|-------------------|
| DESIGNATION     | KV   | CLASS   | SPEC OR STAGE NO. |
| (1)             | 230  | STATION | STAGE 07          |
| (2)             | 115  | STATION | STAGE 07          |
| (3)             | 12.7 | STATION | STAGE 07          |

| CURRENT TRANSFORMERS |     |       |                   |
|----------------------|-----|-------|-------------------|
| DESIGNATION          | KV  | RATIO | SPEC OR STAGE NO. |
| DV15A                | 230 | 500:5 | STAGE 08          |

| SWITCHES   |     |          |                   |
|--|-----|----------|-------------------|
| DESIGNATION  | KV  | CONT AMP | SPEC OR STAGE NO. |
| WY2B-ZY2B  | 115 | 1600     | STAGE 05          |
| WY3A, YY3A-ZY2A                                      | 115 | 1600     | STAGE 05          |
| WY1A, YY1A, WY1B, WY2A, YY2A, WY4A, WY4B             | 115 | 1600     | STAGE 07          |
| WV13A, YV13A, YV13B, WY43B                           | 230 | 2000     | STAGE 07          |
| WV15A, YV15B, YV15C, WY15A, YV15A-ZV15A, YV15A-ZV15A | 230 | 2000     | STAGE 08          |

| COUPLING CAPACITOR VOLTAGE TRANSFORMERS |     |             |                   |
|---|-----|-------------|-------------------|
| DESIGNATION                             | KV  | RATIO       | SPEC OR STAGE NO. |
| YV4B                                    | 115 | 600/1000:1  | STAGE 05          |
| YV2A2_3A2                               | 115 | 600/1000:1  | STAGE 05          |
| YV13A                                   | 230 | 1200/2000:1 | STAGE 07          |
| WV15A, WY15A                            | 230 | 1200/2000:1 | STAGE 08          |

| POWER CIRCUIT BREAKERS |     |          |                    |                   |
|------------------------|-----|----------|--------------------|-------------------|
| DESIGNATION            | KV  | CONT AMP | INTERRUPT CAPACITY | SPEC OR STAGE NO. |
| JY3A                   | 115 | 1600     | 40KA               | STAGE 05          |
| JY1A, JY2A             | 115 | 1600     | 40KA               | STAGE 07          |
| JY4A                   | 115 | 1600     | 40KA               | STAGE 07          |
| JV13A, JV13B           | 230 | 2000     | 40KA               | STAGE 07          |
| JV15A, JV15B           | 230 | 2000     | 40KA               | STAGE 08          |
| JV15A                  | 230 | 2000     | 40KA               | STAGE 08          |

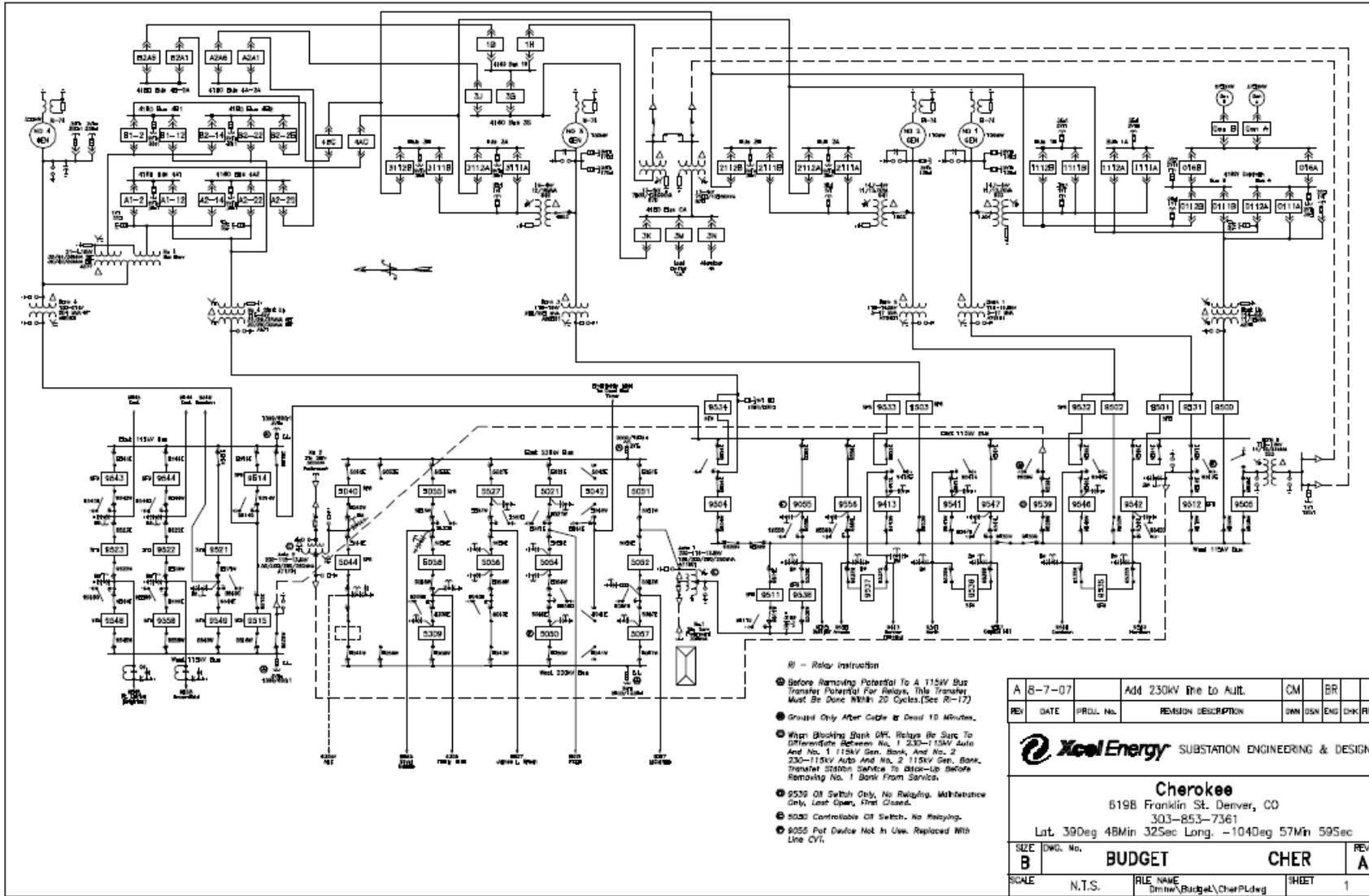
**EXPLANATION**  
 INDICATES STAGE WORK

|  |                   |  |
|--|-------------------|--|
| A  | 3-23-10<br>AT-KV  | STAGE 08 ADDITIONS                         |
| SUPERSEDES DWG NO. AU 0001 (IN PART)   |                   |  |
| UNITED STATES DEPARTMENT OF ENERGY<br>WESTERN AREA POWER ADMINISTRATION<br>COLORADO DIVISION |                   |  |
| AULT SUBSTATION<br>COLORADO<br>115KV AREA<br>SWITCHING DIAGRAM (SHEET 3 OF 3)                |                   |  |
| DESIGNED   | KENNETH E. BREWER | APPROVED                                   |
|  |                   | LYNN BREWER                                |
|  |                   | ASSISTANT ADMINISTRATOR<br>FOR ENGINEERING |
| DATE   | MAY 1, 2000       | AU 10001-3                                 |

Plotted By: vvaughn, Mar 23, 2010 - 1:57pm  
 S:\Projects\Substation\AULT\115KV\Drawings\Sheet\115KV\115KV\_Switching\_Diagram\_10001-3.dwg, Local, Sheet: 3 of 3, Vaughn on 3/23/2010 1:56 PM



## B. Project One-Line of the Cherokee Substation

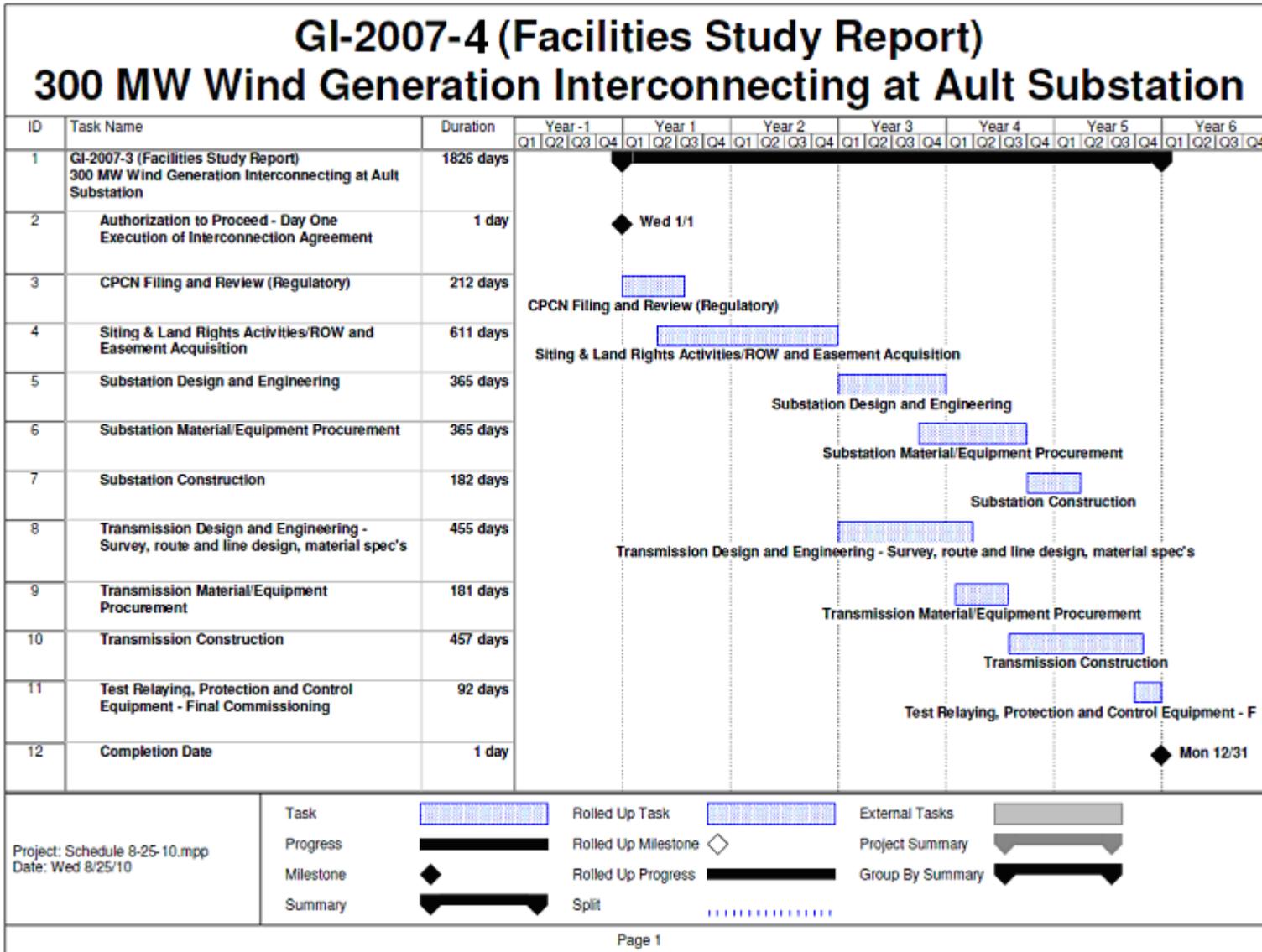


- Ⓢ - Relay instruction
- Before Removing Potential To A 115kV Bus Transfer Potential For Relays, This Transfer Must Be Done Within 20 Cycles.(See R-17)
  - Ground Only After Cable is Dead 10 Minutes.
  - When Blocking Bank OFF, Relays Be Sure To Differentiate Between No. 1 230-115kV Auto And No. 1 115kV Gen. Bank, And No. 2 230-115kV Auto And No. 2 115kV Gen. Bank. Transfer Station Service To Block-Up Before Removing No. 1 Bank From Service.
  - 9539 CB Switch Only, No Relaying, Maintenance Only, Lock Open, After Closed.
  - 9505 Controllable CB Switch, No Relaying.
  - 9505 Pad Device Not In Use, Replaced With Line CVT.

|   |          |                         |                      |                           |     |         |
|---|----------|-------------------------|----------------------|---------------------------|-----|---------|
| A   | 8-7-07   | Add 230kV line to AJLT. | CM                   | BR                        |     |         |
| REV   | DATE     | PROJ. NO.               | REVISION DESCRIPTION | DWN                       | DSN | ENG     |
| SUBSTATION ENGINEERING & DESIGN   |          |                         |                      |                           |     |         |
| <b>Cherokee</b><br>6198 Franklin St. Denver, CO<br>303-853-7361<br>Lat. 39Deg 48Min 32Sec Long. -104Deg 57Min 59Sec |          |                         |                      |                           |     |         |
| SIZE  | Dwg. No. |                         | BUDGET               | CHER                      |     | REV. A  |
| SCALE   | N.T.S.   |                         | FILE NAME            | D:\new\Budget\Cher\PLtdwg |     | SHEET 1 |



C. Project Schedule PSCo





## D. Project Schedule Western

| Activity                                 | Start     | Completion |
|--|-----------|------------|
| Planning                                 | 0 months  | 4 months   |
| Field Data                               | 1 month   | 2 months   |
| Environmental                            | 1 month   | 4 months   |
| Design                                   | 4 months  | 13 months  |
| Equipment Purchase                       | 9 months  | 11 months  |
| Construction Contract Procurement        | 13 months | 16 months  |
| Award Of Construction Contract           | 16 months | 16 months  |
| Construction Contract Performance Period | 17 months | 28 months  |
| Commissioning                            | 27 months | 30 months  |
| In-service Date                          |           | 30 months  |

## E. Cost Estimates Western

**300 MW Interconnect at Ault 230-kV  
Design and Construction Budgetary Cost  
Estimates  
May 11, 2010**

| <u>Description</u>                   | <u>Cost</u>      |
|--------------------------------------|------------------|
| Construction Contract                | \$ 2,500,000     |
| Control Building Expansion           | \$ 175,000       |
| Government Furnished Equipment (GFE) | \$ 700,000       |
| Western Labor Costs                  |                  |
| Planning/Field Data                  | \$ 30,000        |
| Environment                          | \$ 5,000         |
| Lands                                | \$ 3,000         |
| Design                               | \$ 450,000       |
| Construction Supervision             | \$ 260,000       |
| Commissioning                        | \$ 250,000       |
| Communication Work                   | \$ 50,000        |
| Project Management                   | \$ 50,000        |
| Procurement/Contract Administration  | \$ 12,000        |
| <br>TOTAL                            | <br>\$ 4,485,000 |

Notes:

1. The above is a budgetary level estimate intended to be accurate to +/-30%



## F. Generic Testing Procedures

### TESTING PROCEDURES

*NOTE\*\* Performance test period begins upon 1) successful commissioning of all turbines and other major electrical equipment to be connected to the Point of Interconnection, 2) SCADA in place, with all points available and active, and 3) Notification to PSCo by owner of readiness to start. Test Period ends upon successful completion of all tests. Additionally, test requirements are subject to change based on changes to the Facilities and System Impact Studies.*

| Line | Requirement                                     | Criteria   | Test   | Pass/Fail  | Conditions   | Other  |
|------|---|--|--|--|--|--|
| 1.   | Reactive Control over generating range          | Demonstrate ability to maintain VAR neutrality at the POI per the System Impact Study (SIS). | Maintain 0 MVAR reactive flow at the POI within a deadband of $\pm 25$ MVAR and a system voltage within $\pm 5\%$ of nominal at the POI.   | Allowed bandwidth not exceeded, except in the case of performing the capacitor test below                | Two ramp-ups and ramp-downs between zero and $>85\%$ output      | Demonstrates normal plant operation over the full range using reactive power control.<br><br>4-second telemetered values charted at Lookout Center will be used for evaluation, and provided to Interconnection Customer for review. |
| 2.   | Acceptable operation of all installed equipment | Demonstrate proper operation of capacitors installed at the POI.                             | All generator-operated capacitors installed near the POI ( $\sim 40$ MVAR) online, either automatically to maintain MVAR bandwidth, or due to manual change to MVAR/voltage setpoint to deliver reactive power to Transmission System. | All capacitors online for at least five minutes.   | $>85\%$ output, at a time approved by System Operator (Lookout). | Interconnection Customer's representative, Mr. Kerry Franklin, will be on standby at Lookout Control Center waiting for wind conditions suitable for testing.  |
| 3.   | Reactive Control at zero or less net MW output  | Demonstrate ability to maintain VAR compensation at the POI per the SIS.                     | Maintain $\leq 10$ MVAR reactive flow into the PSCo system.  | Plant always net inductive when appearing as a net load (MW delivered to plant).                         | All generators off-line  | Demonstrates automatic operation of shunt reactors adequate to offset transmission line charging.  |
| 4.   | Communication                                   | Series of reasonable requests, i.e. "Report # turbines online", "Curtail to XX MW."          | Respond professionally and promptly to reasonable requests.  | Professional, prompt (within one minute) response, accurate and complete. 99.9% compliance for one week. | 0-250 MW, full range at least once during test period            | Requests may come in via phone call or via EMS   |
|      |   | Dedicated phone circuit  | Have a tested phone line to Lookout Center from Wind Op. Center  | Documentation and testing prior to operational testing   | No operational requirement                                       |  |
|      |   | Provide EMS/SCADA points from plant to Lookout   | Have points verified to and from PSCo SCADA  | Provide points via EMS, including MW/MVAR output at POI  | No operational requirement                                       | Other points may be requested  |



## **Customer Questions and Comments**



## **GWH – GI-2007-3 & 4 Interconnection Facilities Studies:**

### **600 MW at WAPA’s Ault 345/230 kV Substation**

#### **Comments:**

1. Why is 345 kV construction specified on the proposed Ault – Cherokee 230 kV?, Is it necessary?
  - a. 345kV construction is specified in Figure 1 to be consistent with the outlined Ault – Cherokee project scope that was submitted under the Senate Bill – 07 – 100 filing. This scope will be further clarified in the CPCN filing with the Colorado PUC. In order for the Customer to interconnect at the Ault substation, the Ault – Cherokee 230 kV line will still be a necessary Network Upgrade, and the tower construction should have no direct impact on the Ault – Cherokee 230kV line itself. The customer will not be paying for the Ault – Cherokee 230 kV line if PSCo completes the line as a SB – 07 – 100 project.
2. Verify that studies have been completed that show the resulting transfer capability on TOT 7 after the Ault-Cherokee 230 kV line is built can accommodate 600 MW of proposed wind generation.
  - a. The System Impact Study (SIS) verified that 600 MW could be accommodated and the transmission system could be operated within the reliability limits. Affected parties (Platte River Power Authority (PRPA), Western Area Power Administration (Western) and Tri-State Generation & Transmission (TSGT)) were invited to participate in the SIS review. The SIS was reviewed by the affected parties (PRPA and Western), TOT 7 is currently a constrained path. Detailed studies that validate the TOT 7 limits are performed between the owners of TOT 7 annually, and are not part of the scope of the Facilities Study, and are not a requirement of the Generation Interconnection studies. The future of TOT 7 due to additional lines is a complex contractual issue that will be determined by the Transmission Providers in the area, and is not needed to complete the Facility study for this request.
3. Verify that for GI-2007-3, 26MVAR of inductors are required in addition to the existing 100 MVAR inductors at Ault; verify that the inductive requirement is reduced to 16 MVAR with the addition of GI-2007-4.
  - a. The System Impact Study (SIS) for GI-2007-3 states that
    - i. “With the wind farm generating at a 300 MW maximum output, the Ault 230kV bus (POI) bus voltage is at 1.024 pu, the customer’s facilities (line plus wind generation site) absorb 41.1 MVAR of reactive power, and the power factor is within the required 0.95 lagging/leading range. With the Customer wind units off-



line, the Ault 230kV bus (POI) voltage is at 1.018 pu, and 26.3 MVAR is injected into the Ault 230kV bus (POI) from Customer's 230 kV transmission line. The voltage of 1.018 pu is within the voltage range of 1.00 pu to 1.04 pu for a controlled bus. However, the power factor under these conditions is 0.9 lagging, outside the required power factor range for loads. Therefore, approximately 26 MVAR of inductors would be needed to bring the power factor within the required range." (p.19)

- b. The System Impact Study (SIS) for GI-2007-4 states that
  - i. "With the wind farm generating at a 600 MW maximum output, the customer's facilities (line plus wind generation site) absorb 31 MVAR of reactive power and the power factor is within the required 0.95 lagging/leading range. Based on the scenarios considered, the wind generating facility appears to operate within the 0.95 lagging and 0.95 leading power factor range with the voltages at the POI remaining within criteria at full output. (p.10)
  - ii. "With the Customer wind units off-line, 16 MVAR is injected into the POI from the Customer's 230 kV transmission line (at an Ault 230 kV bus voltage of 1.021 p.u., that is within the voltage range of 1.00 p.u. to 1.04 p.u. for a controlled bus. However, the power factor under these conditions is 0.9 lagging, outside the required power factor range for loads; therefore, approximately 16 MVAR of inductors could be needed to bring the power factor within the required range." (p.11)
4. Correct typo on Page 6, paragraph 2 of GI 2007-3 – should read "26.3 MVAR".
  - a. Corrected
5. Verify all short circuit duty ratings of Power Circuit Breakers and current ratings for switches are correct in order to accommodate the termination of the Generation Tie Line and the proposed Ault-Cherokee 230 kV line to Ault Substation.
  - a. Verified in the Feasibility Study.
6. Verify that duty ratings of existing power circuit breakers at Ault Substation are not exceeded.
  - a. Verified in the Feasibility Study GI-2007-3 (p.8) and GI-2007-4 (p.7).
7. On Page 11 of GI-2007-3, explain "slew rate".
  - a. Slew Rate, as used in this context, is the gathered data of the generator speed sent from the RTU to the Control Center.
8. Clarify that the proposed Xcel Ault-Cherokee 230 kV line is included in Xcel's approved 5 year capital budget plan. Delineate expected schedule for filing of CPCN and engineering and construction schedule. What happens if the CPCN is denied?



- a. Please refer to the SB – 07 – 100 biennial filings at the PUC on October of odd number years. This information is also available via the web at <http://sb100transmission.com/>.
9. Delineate Customer options if Ault-Cherokee 230 kV line is not constructed.
  - a. The wind project can only interconnect to sell wind energy to PSCo if the Ault – Cherokee 230 kV line is built. Please refer to the SIS documents.
10. With interconnection of potential 600 MW of wind generation, does the proposed interconnection project trigger the 50 MW EIS threshold requirement for WAPA? If so what is the schedule impact?
  - a. The customer will need to talk with WAPA about this question, however WAPA has already indicated that an EA or EIS will be required.
11. Interconnection and Network Upgrade estimates are given in 2010 dollars and escalated. How much escalation and to when?
  - a. This is not a requirement of the Facility study. The cost estimates are plus or minus 30%. Actual costs for Network Upgrades will be PSCo costs, the customer's actual costs are outlined on pages 2-3 of the Facility study report.
12. Delineate and clarify Customer's posted security requirements for direct interconnection facilities and Network Upgrades, if any. Will security be required for the proposed Ault-Cherokee 230 kV line?
  - a. Security may be required for direct interconnection costs as outlined in the OATT and LGIP. No security is required for the Ault – Cherokee 230 kV line Network Upgrade, as the project is currently in the PSCo 10 year transmission plan under the SB – 07 – 100 mandate.

**SJN: 12/10/10**