# Interconnection Feasibility Study Report
# Request # GI-2013-7

140 MW Wind Generation Facility South of Spring Canyon

PSCo Transmission Planning
**November 8, 2013**

## Executive Summary

On September 12, 2013, Public Service Company of Colorado (PSCo) Transmission received a generation request to determine the feasibility of interconnecting a new 140 MW wind generation facility located approximately 29 miles south of the PSCo owned Spring Canyon Substation located in Logan County, Colorado. Generation from the new facility will be supplied to the Western Area Power Administration (WAPA) Balancing Authority (BA). The Customer requested a primary Point of Interconnection (POI) on the Spring Canyon – North Yuma 230 kV line near transmission structure 40.2, approximately 29 miles south of the Spring Canyon Substation. The Customer has decided not to study the initially requested alternative POI. Additionally, in order to accelerate the Feasibility Study, the Customer has agreed with the recommendation to forego the short-circuit analysis and project schedule as a part of the Feasibility Study; however, these will be studied by Tri-State Generation and Transmission (TSGT) in a future System Impact Study (SIS). The Customer has proposed a commercial operation date of December 15, 2014 with an assumed back-feed (for site energization) date of June 15, 2014. TSGT will confirm if the proposed dates are feasible in the SIS.

This request was studied as both an Energy Resource (ER)[1] and a Network Resource (NR)[2]. The study included steady-state power flow analysis only, and did not include short-circuit or transient dynamic stability analysis. 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, with the exception of generation in the region of study which is expected to be in service at the

[1] **Energy Resource Interconnection Service (ER Interconnection Service)** shall mean an Interconnection Service that allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's Transmission System to be eligible to deliver the Generating Facility's electric output using the existing firm or non-firm capacity of the Transmission Provider's Transmission System on an as available basis. Energy Resource Interconnection Service in and of itself does not convey transmission service.

[2] **Network Resource Interconnection Service** shall mean an Interconnection Service that allows the Interconnection Customer 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 customers; 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.

time the new facility will be in service. This generation includes the existing Spring Canyon 60 MW wind generation facility and an additional 60 MW expansion at Spring Canyon designated under GI-2012-03, which is modeled on line and at or near maximum output. The main purpose of this Feasibility Study was to evaluate the potential impact on the PSCo transmission infrastructure as well as that of neighboring utilities, when injecting the new 140 MW of generation into the new POI Bus on the Spring Canyon – North Yuma 230 kV transmission line, and delivering the additional generation to the WAPA BA. Affects on other entities' nearby transmission systems will need to be analyzed by the affected parties.

A 2013 Heavy Summer (HS) Western Electricity Coordinating Council (WECC) case was used to conduct the study. This benchmark case scenario was used to analyze the impacts when adding GI-2013-7 to the existing transmission system. The generation dispatch for this benchmark case was adjusted to simulate high north-to-south flow levels across the TOT3 transfer path (1,340 MW). Wind generation at the existing Spring Canyon was modeled at 100%. In addition, the GI-2012-3 wind project at the Spring Canyon Substation was modeled in the benchmark base case. Single and double contingencies were applied.

Loss of the North Yuma - POI 230 kV line results in the Sidney 230/115 kV transformer overloading to 141.7% of its emergency thermal rating of 203 MVA. Currently there is an agreement which indicates the existing Spring Canyon facility must curtail its wind generation to 0 MW at Spring Canyon in the event either end of the North Yuma – Spring Canyon 230 kV line unintentionally opens. TSGT has indicated it will not permit curtailment of generation to be a mitigation solution to an N-1 overload of a TSGT transmission element. Therefore, when adding GI-2013-7 wind generation (140 MW), an operating procedure will not be allowed to mitigate overloads above the Sidney transformer's 203 MVA (continuous and emergency) rating. As a result, a new Sidney 230/115 transformer is required for this interconnection.

Furthermore, with addition of GI-2013-7, the Peetz - Sidney 115 kV and Peetz - Sterling 115 kV lines exceed their emergency thermal limit of 109 MVA by 105.1% and 106.6%, respectively with the Loss of the North Yuma - POI 230 kV line. These thermal overloads are a result of the GI-2013-7 project generation. As a result, both transmission lines will need to be upgraded (reconductored) to handle the additional power flow.

For the N-2 contingency and bus outage analysis, the North Yuma 230/115 kV transformer exceeded its emergency thermal limit by 107.5% for loss of the North Yuma - Story 345 kV line and North Yuma - Wray 230 kV line. As a result, an operating procedure is required for either reduction in generation, load or both. If an operating procedure is not possible, a new North Yuma 230/115 transformer is required for this interconnection.

Loss of Craig - Ault 345 kV line and North Park - Terry Ranch 230 kV line, the McKenzie - Marys Lake 69 kV line exceeds its thermal limit of 33 MVA by 100.6%. In addition, the Mary's Lake 115/69 kV transformer exceeds its emergency thermal limit of 25 MVA by 136.7%. These thermal overloads are a result of replacing Craig generation with the project generation. As a result, these thermal overloads will not be mitigated by the project.

Low voltage violations (below 0.90 per unit) were observed for N-1 and N-2 contingencies. However, they were negligible with addition of the Project.

Energy Resource (ER)

ER = 0 MW

Network Resource (NR)

NR = 0 MW

Interconnection to the PSCo network is feasible however, firm capacity is not available due to existing firm transmission commitments, 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 (TOT 3, etc.) and the operational status of transmission facilities.

The cost for the transmission interconnection (in 2013 dollars):
The total estimated cost of the recommended system upgrades to interconnect the project is approximately **$ 25,500,000** and includes:

- $ 5,000,000 for PSCo-Owned, Customer-Funded Interconnection Facilities
- $ 0 for PSCo-Owned, PSCo-Funded Network Upgrades for Interconnection
- $ 20,500,000 for Non-PSCo Network Upgrades for Delivery

A partial one-line of the new GI-2013-7 POI Substation detailing the Interconnection and Delivery is shown in Figure 1.

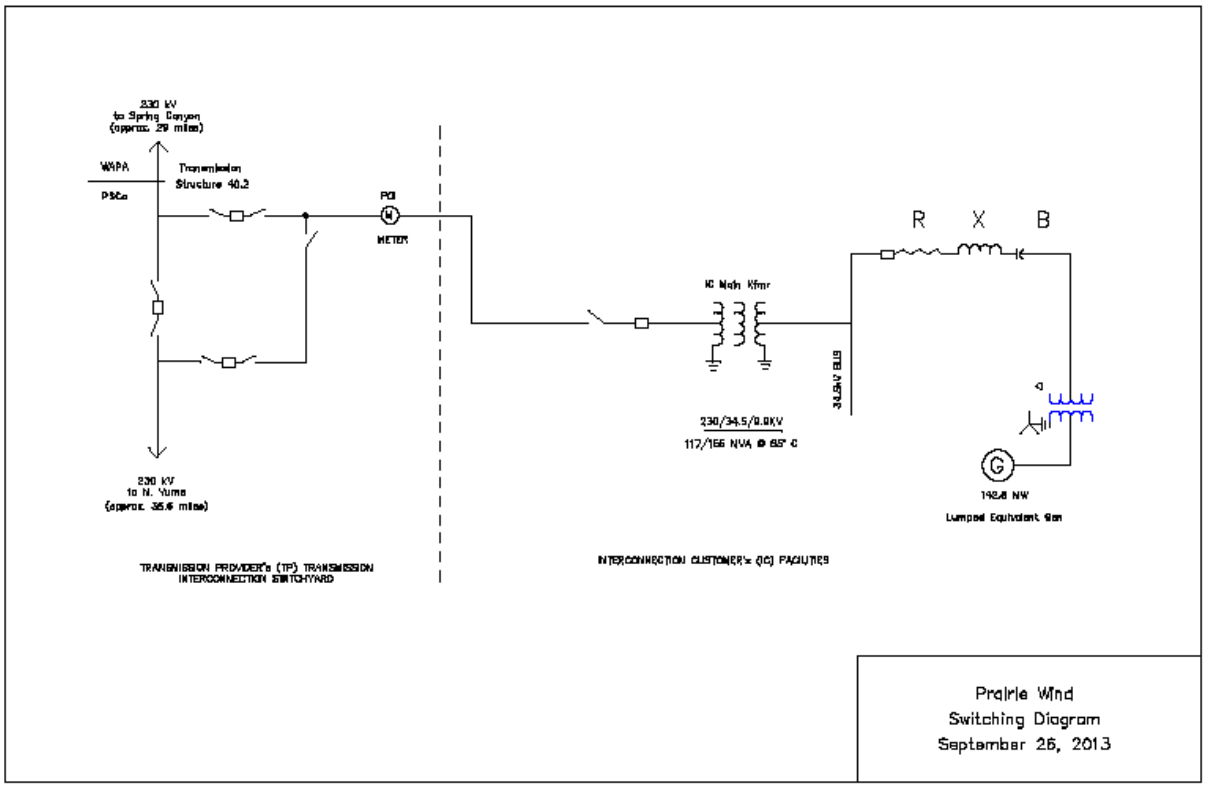


**Figure 1: Proposed GI-2013-7 One-Line Diagram**

## Introduction

Public Service Company of Colorado (PSCo) Transmission Planning received a generation request on September 12, 2013, to determine the feasibility of interconnecting a new 140 MW wind generation facility interconnecting to the Spring Canyon – North Yuma 230kV line approximately 29 miles south of the PSCo owned Spring Canyon Substation. The Customer's project facility would consist of 84 GE 1.7 MW wind turbines and would be located in Logan County, Colorado, bounded by County Road 46 on the north, US Highway 6 on the south, County Road 69 on the west, and County Road 89 on the east. Generation from the expansion will be supplied to the WAPA BA.

Initially, the Customer requested two POI's; a primary POI located in Logan County, Colorado near transmission structure 40.2 via a 230 kV switching station that segments the Spring Canyon – North Yuma 230 kV transmission line, and an alternative POI at the existing PSCo Spring Canyon Substation. The Customer has decided to study the primary POI only; therefore the alternative POI was not studied. In addition, in order to accelerate the Feasibility Study, the Customer has agreed with the recommendation to forego the short-circuit analysis and project schedule as a part of the Feasibility Study. Furthermore, upon completion of the Feasibility Study, the Customer plans to withdraw this study request from the PSCo queue and enter into the TSGT project queue. The short-circuit analysis and project schedule will be studied by Tri-State Generation and Transmission (TSGT) in a future System Impact Study (SIS).

The Customer has proposed a commercial operation date of December 15, 2014 with an assumed back-feed (for site energization) date of June 15, 2014. Because the Customer has agreed to postpone the project schedule until the SIS, TSGT will confirm whether or not the proposed dates are feasible during the SIS.

The Customer has requested that this project be evaluated as both an Energy Resource (ER) and a Network Resource (NR).

## Study Scope and Analysis

PSCo conducted a Feasibility Study Analysis for the interconnection of a 140 MW wind generation facility. Only a power flow analysis was studied. The power flow analysis provided a preliminary identification of thermal and/or voltage limit violations resulting from the interconnection.

PSCo adheres to NERC / WECC Reliability Criteria, as well as internal Company criteria for planning studies. During system intact conditions, transmission system bus voltages are to be maintained between 0.95 and 1.05 per-unit of system nominal / normal conditions, and steady state power flows within 1.0 per-unit of all elements thermal (continuous current or MVA) ratings. Operationally, PSCo tries to maintain a transmission system voltage profile ranging from 1.03 per-unit or higher at generation buses, to 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 1.05 per-unit, and power flows within 1.0 per-unit of the elements continuous thermal ratings.

For this project, potential affected parties include Western Area Power Administration (WAPA) and Tri-State Generation & Transmission (TSGT). PSCo has coordinated and cooperated on its study assessment through e-mail and phone correspondence and has also forwarded a copy of this feasibility study report to the affected parties.

## Power Flow Study Models

A 2013 Heavy Summer (HS) Western Electricity Coordinating Council (WECC) case was modified to reflect topological, loading and generation changes as discussed with the affected parties and the Customer. This benchmark case scenario was used to analyze the impacts when adding GI-2013-7 to the existing transmission system. Automated contingency power flow studies were completed on all case models, switching out single elements (lines and transformers) one at a time in the study area. In addition, double contingency and bus outages were simulated for this area of the system. Results from the contingency analyses were compared to identify thermal or voltage limit violations resulting from the addition of GI-2013-7.

Generation dispatch in area 70 (PSCo) for the benchmark case was adjusted to simulate high north-to-south flow levels across the TOT3 transfer path. The TOT3 interface flow was set to 1340 MW. Manchief units 1 and 2, Ft. St. Vrain units 5 and 6, and UNC units 1, 2 and 3 were each set off-line, while the Rawhide units A, B and D were turned on.

The GI-2012-3 wind project (60 MW expansion) at Spring Canyon Substation was modeled in the benchmark base case.

PSCo control area (Area 70) wind generation facilities near Pawnee, and the Peetz Logan and Cedar Creek facilities were dispatched at approximately 21% of their respective ratings. Wind generation at Missile Site and the Spring Canyon facility were modeled at 100%. Additionally, a sensitivity analysis was conducted with the Ridgecrest generation; initially modeling it at 21% output and then at 100% output.

Tri-State's Burlington generation Units 1 and 2 were modeled at 50 MW each, Limon generation Units 1 and 2 68 MW each and Kit Carson at 51 MW.

A complete list of the generation facilities for each of the models in area 70 (PSCo) and area 73 (WAPA) is presented in Table A1 in the Appendix.

The proposed generation project, as modeled, consists of one lumped generation unit representing the 84 individual GE 1.7 MW wind turbines with a reactive capability of 0.98 lead/lag power factor. The generator has a terminal voltage of 34.5 kV and is connected to the 230 kV system through one 230/34.5/9.9 kV transformer with a rating of 117/155 MVA.

The new substation is modeled 29 miles south of the Spring Canyon 230kV substation on the Spring Canyon – North Yuma 230kV line. For modeling purposes, the generator was set to control the bus voltage on the facility's 34.5 kV bus to 1.030 per-unit.

A single-line diagram showing the transmission system model with high TOT3 flows is presented as Figure B1 in the Appendix. Figure B2 in the Appendix indicates the flows with the addition of the GI-2012-3 project.

**Stand Alone Power Flow Results (PSCo)**

ER = 0 MW

NR = 0 MW

Interconnection to the PSCo network is feasible however, firm capacity is not available due to existing firm transmission commitments, 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 (TOT 3, etc.) and the operational status of transmission facilities.

With addition of GI-2013-7, the Peetz - Sidney 115 kV and Peetz - Sterling 115 kV lines exceed their emergency thermal limit of 109 MVA by 105.1% and 106.6%, respectively. These thermal overloads are caused by the addition of the GI-2013-7 project generation. As a result, both transmission lines will need to be upgraded (reconductored) to handle the additional power flow for loss of the North Yuma - POI 230 kV line contingency.

Loss of the North Yuma - POI 230 kV line also results in the Sidney 230/115 kV transformer overloading to 141.7% of its emergency thermal rating of 203 MVA. Currently there is an agreement which indicates the existing Spring Canyon facility must curtail its wind generation to 0 MW at Spring Canyon in the event either end of the North Yuma – Spring Canyon 230 kV line unintentionally opens. TSGT has indicated it will not permit curtailment of generation to be a mitigation solution to an N-1 overload of a TSGT transmission element. Therefore, when adding GI-2013-7 wind generation (140 MW), the operating procedure will not be allowed to mitigate overloads above the Sidney transformer's 203 MVA (continuous and emergency) rating. As a result, a new Sidney 230/115 transformer is required for this interconnection.

For the N-2 contingency and bus outage analysis, the North Yuma 230/115 kV transformer exceeded its emergency thermal limit by 107.5% for loss of the North Yuma - Story 345 kV line and North Yuma - Wray 230 kV line. As a result, an operating procedure is required for either reduction in generation, load or both. If an operating procedure is not possible, a new North Yuma 230/115 transformer is required for this interconnection.

Loss of Craig - Ault 345kV line and North Park - Terry Ranch 230 kV line, the McKenzie - Marys Lake 69 kV line exceeds its thermal limit of 33 MVA by 100.6%. In addition, the Mary's Lake 115-69 kV transformer exceeds its emergency thermal limit of 25 MVA by 136.7%. These thermal overloads are a result of replacing Craig generation with the project generation. As a result, these thermal overloads will not be mitigated by the project.

Low voltage violations (below 0.90 per unit) were observed at the Dalton, Sidney and Greenwood 115 kV busses for loss of the Sidney 230/115 kV transformer; however, the impact from the GI-2013-7 project is negligible. A number of low voltage violations were observed for the N-2 contingency results; however, the impact was negligible. Results from the contingency analysis can be seen below in Table 1 and 2.

**Table 1: N-1 Contingency Analysis for GI-2013-7**

| | | | | Benchmark Stressed Case | | Stressed with GI-2013-7 | |
|---|---|---|---|---|---|---|---|
| **Contingency** | **Monitored Element** | **Normal Rating (MVA)** | **Emergency Rating (MVA)** | **Flow (MVA)** | **Percent Loading** | **Flow (MVA)** | **Percent Loading** |
| N.Yuma (73143) - POI_GI2013-7 (73720) 230kV Line† | Peetz (73150) - Sidney (73179) 115kV Line | 109 | 109 | 90 | 83 | 116 | 105.1 |
| N.Yuma (73143) - POI_GI2013-7 (73720) 230kV Line† | Peetz (73150) - Sterling (73191) 115kV Line | 109 | 109 | 91 | 84.4 | 115 | 106.6 |
| N.Yuma (73143) - POI_GI2013-7 (73720) 230kV Line† | Sidney (73179) 115 - Sidney (73180) 230kV Transformer | 203 | 203 | 232 | 114.4 | 288 | 141.7 |
| Spring Canyon (73579) - POI_GI2013-7 (73720) 230kV line† | Sidney (73179) 115 - Sidney (73180) 230kV Transformer | 203 | 203 | 232 | 114.4 | 227 | 111.9 |
| Didn't exceed thermal limit, but above 95% of thermal rating. | | | | | | | |
| Archer (73009) - Stegall (73190) 230kV Line | Sidney (73179) 115 - Sidney (73180) 230kV Transformer | 203 | 203 | 167 | 82.5 | 195 | 95.9 |
| Ault (73012) - Lar.River (73108) 345kV Line | Sidney (73179) 115 - Sidney (73180) 230kV Transformer | 203 | 203 | 172 | 84.5 | 199 | 98.2 |
| Ault (73012) - Lar.River (73108) 345kV Line | Archer (73009) - Stegall (73190) 230kV Line | 459 | 459 | 423 | 92.1 | 440 | 95.9 |
| **Contingency** | **Monitored Element** | | | | **Voltage (pu)** | | **Voltage (pu)** |
| Sidney (73179) 115 - Sidney (73180) 230kV Transformer | Dalton 115kV (73046) | | | | 0.89296 | | 0.89028 |
| Sidney (73179) 115 - Sidney (73180) 230kV Transformer | Sidney 115kV (73179) | | | | 0.8948 | | 0.89219 |
| Sidney (73179) 115 - Sidney (73180) 230kV Transformer | Greenwood 115kV (73236) | | | | 0.9012 | | 0.89847 |

† Pre-Project loading is based on Loss of the Spring Canyon - N.Yuma 230kV line.

## Table 2: N-2 Contingency Analysis for GI-2013-7

| Contingency | Monitored Element | Normal Rating (MVA) | Emergency Rating (MVA) | Benchmark Stressed Case | | Stressed with GI-2013-7 | |
|---|---|---|---|---|---|---|---|
| | | | | Flow (MVA) | Percent Loading† | Flow (MVA) | Percent Loading |
| 22-N.Yuma (73143) - Story (73192) 230kV & N.Yuma (73143) - Wray (73224) 230kV line | N.Yuma (73142) 115-N.Yuma (73143) 230kV Tran | 167 | 167 | 133 | 79.4 | 180 | 107.5 |
| 10-N.Yuma (73143)-N.Yuma (73142) 230-115kV Tran N.Yuma (73143)-POI_GI2013-7 (73720) 230kV line† | Sidney (73179) 115 - Sidney (73180) 230kV Tran | 203 | 203 | 234 | 115.1 | 289 | 142.3 |
| 11-N.Yuma (73143)-Wray (73224) 230kV line & SprCanyon-POI_GI2013-7 (73720) 230kV line† | Sidney (73179) 115 - Sidney (73180) 230kV Tran | 203 | 203 | 234 | 115.1 | 289 | 142.3 |
| 21-N.Yuma (73143) - Story (73192) 230kV & N.Yuma (73143) - N.Yuma (73142) 230-115kV Tran | Sidney (73179) 115 - Sidney (73180) 230kV Tran | 203 | 203 | 167 | 82.4 | 208 | 102.4 |
| 22-N.Yuma (73143) - Story (73192) 230kV & N.Yuma (73143) - Wray (73224) 230kV line | Sidney (73179) 115 - Sidney (73180) 230kV Tran | 203 | 203 | 167 | 82.1 | 206 | 101.6 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | Sidney (73179) 115 - Sidney (73180) 230kV Tran | 203 | 203 | 174 | 85.8 | 215 | 106.1 |
| 34 - Bus Outage: Stegall (73189) 115kV Bus | Sidney (73179) 115 - Sidney (73180) 230kV Tran | 203 | 203 | 227 | 111.7 | 242 | 119.4 |
| 4-Craig (79014) - Ault (73012) 345kV line & Npark (73616) - Terry Ranch (73488) 230kV line | McKenzie (73132) - MaryslkSB (73436) 69kV Line | 33 | 33 | 29 | 86.4 | 34 | 100.6 |
| 4-Craig (79014) - Ault (73012) 345kV line & Npark (73616) - Terry Ranch (73488) 230kV line | Marylksb (73232) 115 - Marylksb (73436) 69kV Tran | 25 | 25 | 29 | 117.4 | 34 | 136.7 |
| 5-Craig (79014) - Ault (73012) 345kV line & Ault (73012) - Ault (73011) 345-230kV Tran | Marylksb (73232) 115 - Marylksb (73436) 69kV Tran | 25 | 25 | 26 | 105.1 | 30 | 120.2 |
| 15-Story (73192) - Pawnee (70311) 230kV line & Story (73193) - Story (73192) 345-230kV Tran | Marylksb (73232) 115 - Marylksb (73436) 69kV Tran | 25 | 25 | 22 | 89 | 25 | 101.6 |
| 28-Story (73192) - Pawnee (70311) 230kV line & Story (73192) - B.Ck Tri (73016) 230kV Line | Marylksb (73232) 115 - Marylksb (73436) 69kV Tran | 25 | 25 | 22 | 89.1 | 25 | 101.6 |
| 37 - Bus Outage: Sterling (73191) 115kV Bus | Marylksb (73232) 115 - Marylksb (73436) 69kV Tran | 25 | 25 | 22 | 89.4 | 25 | 101.7 |
| 10-N.Yuma (73143)-N.Yuma (73142) 230-115kV Tran N.Yuma (73143)-POI_GI2013-7 (73720) 230kV line† | Peetz (73150) - Sidney (73179) 115kV Line | 109 | 109 | 92 | 84.7 | 118 | 106.6 |
| 11-N.Yuma (73143)-Wray (73224) 230kV line & SprCanyon-POI_GI2013-7 (73720) 230kV line† | Peetz (73150) - Sidney (73179) 115kV Line | 109 | 109 | 92 | 84.7 | 118 | 106.6 |
| 10-N.Yuma (73143)-N.Yuma (73142) 230-115kV Tran N.Yuma (73143)-POI_GI2013-7 (73720) 230kV line† | Peetz (73150) - Sterling (73191) 115kV Line | 109 | 109 | 94 | 86.1 | 116 | 108.1 |
| 11-N.Yuma (73143)-Wray (73224) 230kV line & SprCanyon-POI_GI2013-7 (73720) 230kV line† | Peetz (73150) - Sterling (73191) 115kV Line | 109 | 109 | 94 | 86.1 | 116 | 108.1 |
| Didn't exceed thermal limit, but above 95% of thermal rating. | | | | | | | |
| 13-Ault (73012) - Lar.River (73108) 345kV Line & Ault (73012) - Ault (73011) 345-230kV Tran | Archer (73009) - Stegall (73190) 230kV Line | 459 | 459 | 423 | 92.1 | 432 | 97 |
| 24-Lar.River (73107) - Stegall (73190) 230kV & Stegall (73190) - Sidney (73180) 230kV line | Sidney (73179) 115 - Sidney (73180) 230kV Tran | 203 | 203 | 152 | 75 | 195 | 96 |
| 13-Ault (73012) - Lar.River (73108) 345kV Line & Ault (73012) - Ault (73011) 345-230kV Tran | Sidney (73179) 115 - Sidney (73180) 230kV Tran | 203 | 203 | 172 | 84.5 | 199 | 98.2 |
| 30 - Bus Outage: Archer (73009) 230kV Bus | Sidney (73179) 115 - Sidney (73180) 230kV Tran | 203 | 203 | 149 | 73.4 | 197 | 96.9 |

## Table 2 (Continued): N-2 Contingency Analysis for GI-2013-7

| Contingency | Monitored Element | | | | Voltage (pu) | | Voltage (pu) |
|---|---|---|---|---|---|---|---|
| 33 - Bus Outage: Stegall (73190) 230kV Bus | TORRNGTN 115.00 (73202) | | | | 0.84882 | | 0.85268 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | WILDCAT 115.00 (73214) | | | | 0.85748 | | 0.85967 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | GERING 115.00 (73067) | | | | 0.86169 | | 0.86366 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | LYMAN 115.00 (73126) | | | | 0.85999 | | 0.86379 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | LYMANTP 115.00 (73256) | | | | 0.86019 | | 0.86399 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | EMIGRANT 115.00 (73365) | | | | 0.86194 | | 0.86411 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | STEGALL 115.00 (73189) | | | | 0.86381 | | 0.86602 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | LINGLE 115.00 (73112) | | | | 0.87495 | | 0.87954 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | LINGLETP 115.00 (73255) | | | | 0.87729 | | 0.88187 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | MCGREW 115.00 (73131) | | | | 0.88414 | | 0.88505 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | GLENDO1 6.9000 (73351) | | | | 0.88701 | | 0.89095 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | LAGRANGE 115.00 (73104) | | | | 0.89378 | | 0.89422 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | WHTROCK 115.00 (73568) | | | | 0.89187 | | 0.89675 |
| 33 - Bus Outage: Stegall (73190) 230kV Bus | WHTROCK 34.500 (73569) | | | | 0.89187 | | 0.89675 |
| 34 - Bus Outage: Stegall (73189) 115kV Bus | WILDCAT 115.00 (73214) | | | | 0.73391 | | 0.73327 |
| 34 - Bus Outage: Stegall (73189) 115kV Bus | EMIGRANT 115.00 (73365) | | | | 0.73918 | | 0.73854 |
| 34 - Bus Outage: Stegall (73189) 115kV Bus | GERING 115.00 (73067) | | | | 0.74575 | | 0.74512 |
| 34 - Bus Outage: Stegall (73189) 115kV Bus | MCGREW 115.00 (73131) | | | | 0.78236 | | 0.78177 |
| 34 - Bus Outage: Stegall (73189) 115kV Bus | BRIDGEPT 115.00 (73029) | | | | 0.83631 | | 0.83578 |
| 34 - Bus Outage: Stegall (73189) 115kV Bus | GREENWOD 115.00 (73236) | | | | 0.87538 | | 0.8749 |
| 36 - Bus Outage: Sidney (73180) 230kV Bus | DALTON 115.00 (73046) | | | | 0.88422 | | 0.88544 |
| 36 - Bus Outage: Sidney (73180) 230kV Bus | SIDNEY 115.00 (73179) | | | | 0.88834 | | 0.88904 |
| 36 - Bus Outage: Sidney (73180) 230kV Bus | GREENWOD 115.00 (73236) | | | | 0.8905 | | 0.89204 |
| 36 - Bus Outage: Sidney (73180) 230kV Bus | BRIDGEPT 115.00 (73029) | | | | 0.89744 | | 0.89908 |

† Pre-Project loading is based on Loss of the Spring Canyon - N.Yuma 230kV line.

For the sensitivity analysis the Ridgecrest generation modeled at its full output of 29.7 MW (core study had it modeled at 6.3MW). This analysis identified that with higher Ridgecrest generation, the thermal overload on the Peetz - Sidney 115 kV line is reduced from 105.1% to 92.1%. Also, the thermal overload on the Peetz - Sterling 115 kV line increases from 106.6% to 116% of its emergency thermal limit.

Loss of the Ault - Laramie River 345 kV line results in the Archer - Stegall 230 kV line loading to 95.9% of its 459 MVA rating. With maximum Ridgecrest generation, the Archer - Stegall 230 kV line increases to 98%.

With maximum Ridgecrest generation, the Sidney 230 -115 kV transformer loading is reduced from 141.7% to 138% for loss of the North Yuma - POI 230 kV line.

In summary, the higher Ridgecrest generation does not mitigate all thermally overloaded elements during all system conditions. However, the sensitivity results identify that the Ridgecrest generation affect the thermal loading for identified elements in Tables 1 and 2.

## Short Circuit Study Results

The Customer is in agreement with the recommendation that the short-circuit analysis will not be completed as a part of the Feasibility Study; however, it will be studied by TSGT in the SIS.

## Costs Estimates and Assumptions

The estimated total cost for the required upgrades for is **$25,500,000** and includes the labor materials and overhead associated with adjusting the existing metering to accommodate the Project. The estimated costs shown are a non binding, good faith estimate, estimated in 2013 dollars (no escalation applied) 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, engineering, design, procurement and construction of these new facilities. This estimate does not include the cost for any other Customer owned equipment and associated design and engineering. The following table lists the improvements required to accommodate the interconnection and the delivery of the Project. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to change upon more detailed analysis.

**Table 3: Cost Estimates for GI-2013-7**

| Overloaded Element | Upgrade | Owner | Cost |
|---|---|---|---|
| Sidney (73179) - Peetz (73150) 115kV Line<br>Peetz (73150) - Sterling (73191) 115kV Line | Reconductor | WAPA | $ 17,500,000 |
| Sidney (73179) 115 - Sidney (73180) 230kV Transformer | New Transformer | TSGT | $ 3,000,000 |
| POI: New 3 Breaker Substation at Structure 40.2 | New Substation | TSGT | $ 5,000,000 |
| Total | | | $ 25,500,000 |

## Assumptions for Alternatives

- Cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery were developed by PSCo Engineering staff.
- Estimates are based on 2013 dollars (appropriate contingency and escalation applied)
- Estimates are non binding, good faith estimates only
- AFUDC has been excluded.
- Engineering will be performed in house.
- Lead times for materials were considered for the schedule.
- The Generation Facility is not in PSCo's retail service territory.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- Construction labor is estimated for straight time only – no overtime included.

- The estimated time to design, procure and construct the interconnection facilities is approximately 6 months after authorization to proceed has been obtained.
- Authorization to proceed is considered to be the execution of the LGIA.
- This project is completely independent of other queued projects and their respective ISD's.
- Line and substation bus outages will need to be authorized during the construction period to meet requested backfeed dates.

**Project Schedule**

The Customer is in agreement with the recommendation that the project schedule will not be completed as a part of the Feasibility Study; however, it will be studied by TSGT in the SIS. At that time TSGT will confirm whether or not the proposed dates are feasible for the project.

# Appendix

## A. Generation Dispatch

**Table A1: Generation Dispatch**

| | | | | *Benchmark* | *GI-2013-7* |
|---|---|---|---|---|---|
| **Bus Number** | **Bus Name** | **Id** | **Pmax (MW)** | **Pgen (MW)** | **Pgen (MW)** |
| 70034 | ARAP3 13.800 | C3 | 48 | 40 | 40 |
| 70035 | ARAP4 13.800 | C4 | 118 | 98 | 98 |
| 70069 | CABCRKA 13.800 | HA | 162 | 80 | 80 |
| 70070 | CABCRKB 13.800 | HB | 162 | 80 | 80 |
| 70083 | CANON_55 13.800 | C1 | 18 | 14 | 14 |
| 70084 | CANON_59 13.800 | C1 | 24 | 20 | 20 |
| 70104 | CHEROK2 15.500 | SC | 0 | 0 | 0 |
| 70105 | CHEROK3 20.000 | C3 | 150 | 161.89 | 164.33 |
| 70106 | CHEROK4 22.000 | C4 | 383 | 383 | 383 |
| 70119 | COMAN_1 24.000 | C1 | 360 | 355 | 355 |
| 70120 | COMAN_2 24.000 | C2 | 365 | 360 | 360 |
| 70133 | CTY_LAM 13.800 | G1 | 27 | 0 | 0 |
| 70135 | CTY LAM 13.800 | G2 | 17 | 0 | 0 |
| 70160 | E_CANON 69.000 | G1 | 8 | 0 | 0 |
| 70180 | FRUITA 13.800 | G1 | 17 | 0 | 0 |
| 70188 | FTLUP1-2 13.800 | G1 | 50 | 0 | 0 |
| 70188 | FTLUP1-2 13.800 | G2 | 50 | 0 | 0 |
| 70306 | PP_MINE 69.000 | G1 | 3 | 0 | 0 |
| 70310 | PAWNEE 22.000 | C1 | 530 | 505 | 505 |
| 70314 | MANCHEF1 16.000 | G1 | 140 | 0 | 0 |
| 70315 | MANCHEF2 16.000 | G2 | 140 | 0 | 0 |
| 70334 | PUB_DSLS 4.1600 | G1 | 10 | 0 | 0 |
| 70337 | PUEBPLNT 14.000 | G1 | 20 | 0 | 0 |
| 70337 | PUEBPLNT 14.000 | G2 | 9 | 0 | 0 |
| 70344 | R.F.DSLS 4.1600 | G1 | 10 | 8 | 8 |
| 70350 | RAWHIDE 24.000 | C1 | 304 | 300 | 300 |
| 70351 | RAWHIDEA 13.800 | GA | 70 | 60 | 60 |
| 70385 | SHOSHA&B 4.0000 | H1 | 7 | 7 | 7 |
| 70385 | SHOSHA&B 4.0000 | H2 | 8 | 8 | 8 |
| 70406 | ST.VR_2 18.000 | G2 | 130 | 130 | 130 |
| 70407 | ST.VR_3 18.000 | G3 | 130 | 130 | 130 |
| 70408 | ST.VR_4 18.000 | G4 | 130 | 130 | 130 |
| 70409 | ST.VRAIN 22.000 | G1 | 342 | 300 | 300 |

| | | | | *Benchmark* | *GI-2013-7* |
|---|---|---|---|---|---|
| **Bus Number** | **Bus Name** | **Id** | **Pmax (MW)** | **Pgen (MW)** | **Pgen (MW)** |
| 70446 | VALMONT 20.000 | C5 | 188 | 160 | 160 |
| 70448 | VALMONT6 13.800 | G6 | 53 | 50 | 50 |
| 70479 | ZUNI2S 13.800 | G2 | 73 | 0 | 0 |
| 70485 | ALMSACT1 13.800 | G1 | 17 | 0 | 0 |
| 70486 | ALMSACT2 13.800 | G2 | 19 | 0 | 0 |
| 70487 | QF_TC-T4 13.800 | G4 | 33 | 33.7 | 33.7 |
| 70487 | QF_TC-T4 13.800 | G5 | 33 | 33.7 | 33.7 |
| 70490 | QF_TC-T3 13.800 | G3 | 33 | 33.7 | 33.7 |
| 70490 | QF_TC-T3 13.800 | ST | 51 | 51.7 | 51.7 |
| 70493 | QF_TI-T2 13.800 | ST | 51 | 0 | 0 |
| 70495 | QF_TI-T1 13.800 | G1 | 33 | 0 | 0 |
| 70495 | QF_TI-T1 13.800 | G2 | 33 | 0 | 0 |
| 70498 | QF_BCP2T 13.800 | G3 | 30 | 19.4 | 19.4 |
| 70498 | QF_BCP2T 13.800 | ST | 36 | 19.3 | 19.3 |
| 70499 | QF_B4-4T 13.800 | G4 | 24 | 20 | 20 |
| 70499 | QF_B4-4T 13.800 | G5 | 25 | 20 | 20 |
| 70500 | QF_CPP1T 13.800 | G1 | 24 | 20 | 20 |
| 70500 | QF_CPP1T 13.800 | G2 | 24 | 20 | 20 |
| 70501 | QF_CPP3T 13.800 | ST | 27 | 27 | 27 |
| 70502 | QF_UNC 13.800 | G1 | 29 | 0 | 0 |
| 70502 | QF_UNC 13.800 | G2 | 29 | 0 | 0 |
| 70502 | QF_UNC 13.800 | G3 | 17 | 0 | 0 |
| 70503 | PONNEQUI 26.100 | W1 | 30 | 6.3 | 6.3 |
| 70548 | APT_DSLS 4.1600 | G1 | 10 | 0 | 0 |
| 70553 | ARAP5&6 13.800 | G5 | 37 | 0 | 0 |
| 70553 | ARAP5&6 13.800 | G6 | 37 | 0 | 0 |
| 70554 | ARAP7 13.800 | G7 | 45 | 0 | 0 |
| 70556 | QF_B4D4T 12.500 | ST | 70 | 50 | 50 |
| 70557 | VALMNT7 13.800 | G7 | 37 | 0 | 0 |
| 70558 | VALMNT8 13.800 | G8 | 37 | 0 | 0 |
| 70560 | LAMAR_DC 230.00 | DC | 210 | 101 | 101 |
| 70561 | RAWHIDEF 18.000 | GF | 138 | 135 | 135 |
| 70562 | SPRUCE1 18.000 | G1 | 140 | 130 | 130 |
| 70563 | SPRUCE2 18.000 | G2 | 140 | 130 | 130 |
| 70565 | BRTNNUG1 13.800 | G1 | 64 | 35 | 35 |
| 70566 | BRTNNUG2 13.800 | G2 | 64 | 0 | 0 |
| 70567 | RAWHIDED 13.800 | GD | 70 | 60 | 60 |
| 70568 | RAWHIDEB 13.800 | GB | 70 | 60 | 60 |

| | | | | Benchmark | GI-2013-7 |
|---|---|---|---|---|---|
| Bus Number | Bus Name | Id | Pmax (MW) | Pgen (MW) | Pgen (MW) |
| 70569 | RAWHIDEC 13.800 | GC | 70 | 60 | 60 |
| 70577 | FTNVL1&2 13.800 | G1 | 40 | 0 | 0 |
| 70577 | FTNVL1&2 13.800 | G2 | 40 | 0 | 0 |
| 70578 | FTNVL3&4 13.800 | G3 | 40 | 0 | 0 |
| 70578 | FTNVL3&4 13.800 | G4 | 40 | 0 | 0 |
| 70579 | FTNVL5&6 13.800 | G5 | 40 | 0 | 0 |
| 70579 | FTNVL5&6 13.800 | G6 | 40 | 0 | 0 |
| 70580 | PLNENDG1 13.800 | G0 | 5.5 | 4.8 | 4.8 |
| 70580 | PLNENDG1 13.800 | G1 | 5.5 | 4.8 | 4.8 |
| 70580 | PLNENDG1 13.800 | G2 | 5.5 | 4.8 | 4.8 |
| 70580 | PLNENDG1 13.800 | G3 | 5.5 | 4.8 | 4.8 |
| 70580 | PLNENDG1 13.800 | G4 | 5.5 | 4.8 | 4.8 |
| 70580 | PLNENDG1 13.800 | G5 | 5.5 | 4.8 | 4.8 |
| 70580 | PLNENDG1 13.800 | G6 | 5.5 | 4.8 | 4.8 |
| 70580 | PLNENDG1 13.800 | G7 | 5.5 | 4.8 | 4.8 |
| 70580 | PLNENDG1 13.800 | G8 | 5.5 | 4.8 | 4.8 |
| 70580 | PLNENDG1 13.800 | G9 | 5.5 | 4.8 | 4.8 |
| 70585 | PLNENDG3 13.800 | G1 | 8.4 | 7.2 | 7.2 |
| 70585 | PLNENDG3 13.800 | G2 | 8.4 | 7.2 | 7.2 |
| 70585 | PLNENDG3 13.800 | G3 | 8.4 | 7.2 | 7.2 |
| 70585 | PLNENDG3 13.800 | G4 | 8.4 | 7.2 | 7.2 |
| 70585 | PLNENDG3 13.800 | G5 | 8.4 | 7.2 | 7.2 |
| 70585 | PLNENDG3 13.800 | G6 | 8.4 | 7.2 | 7.2 |
| 70585 | PLNENDG3 13.800 | G7 | 8.4 | 7.2 | 7.2 |
| 70586 | PLNENDG4 13.800 | G1 | 8.4 | 7.2 | 7.2 |
| 70586 | PLNENDG4 13.800 | G2 | 8.4 | 7.2 | 7.2 |
| 70586 | PLNENDG4 13.800 | G3 | 8.4 | 7.2 | 7.2 |
| 70586 | PLNENDG4 13.800 | G4 | 8.4 | 7.2 | 7.2 |
| 70586 | PLNENDG4 13.800 | G5 | 8.4 | 7.2 | 7.2 |
| 70586 | PLNENDG4 13.800 | G6 | 8.4 | 7.2 | 7.2 |
| 70586 | PLNENDG4 13.800 | G7 | 8.4 | 7.2 | 7.2 |
| 70587 | PLNENDG2 13.800 | G0 | 5.5 | 4.8 | 4.8 |
| 70587 | PLNENDG2 13.800 | G1 | 5.5 | 4.8 | 4.8 |
| 70587 | PLNENDG2 13.800 | G2 | 5.5 | 4.8 | 4.8 |
| 70587 | PLNENDG2 13.800 | G3 | 5.5 | 4.8 | 4.8 |
| 70587 | PLNENDG2 13.800 | G4 | 5.5 | 4.8 | 4.8 |
| 70587 | PLNENDG2 13.800 | G5 | 5.5 | 4.8 | 4.8 |
| 70587 | PLNENDG2 13.800 | G6 | 5.5 | 4.8 | 4.8 |

| | | | | *Benchmark* | *GI-2013-7* |
|---|---|---|---|---|---|
| **Bus Number** | **Bus Name** | **Id** | **Pmax (MW)** | **Pgen (MW)** | **Pgen (MW)** |
| 70587 | PLNENDG2 13.800 | G7 | 5.5 | 4.8 | 4.8 |
| 70587 | PLNENDG2 13.800 | G8 | 5.5 | 4.8 | 4.8 |
| 70587 | PLNENDG2 13.800 | G9 | 5.5 | 4.8 | 4.8 |
| 70588 | RMEC1 15.000 | G1 | 142 | 142 | 142 |
| 70589 | RMEC2 15.000 | G2 | 141 | 141 | 141 |
| 70591 | RMEC3 23.000 | G3 | 322 | 322 | 322 |
| 70593 | SPNDLE1 18.000 | G1 | 134 | 129 | 129 |
| 70594 | SPNDLE2 18.000 | G2 | 134 | 129 | 129 |
| 70622 | MIS_SITE 34.500 | W1 | 250 | 250 | 250 |
| 70625 | MISSILEW2 34.500 | W2 | 201 | 200 | 200 |
| 70626 | MISSILEW3 34.500 | W3 | 201 | 200 | 200 |
| 70701 | CO_GRN_E 34.500 | W1 | 81 | 17 | 17 |
| 70702 | CO_GRN_W 34.500 | W2 | 81 | 17 | 17 |
| 70703 | TWNBUTTE 34.500 | W1 | 75 | 15.8 | 15.8 |
| 70710 | PTZLOGN1 34.500 | W1 | 201 | 42.2 | 42.2 |
| 70712 | PTZLOGN2 34.500 | W2 | 120 | 25.2 | 25.2 |
| 70713 | PTZLOGN3 34.500 | W3 | 79.5 | 16.7 | 16.7 |
| 70714 | PTZLOGN4 34.500 | W4 | 175 | 36.8 | 36.8 |
| 70721 | SPRNGCAN 34.500 | W1 | 60 | 60 | 60 |
| 70721 | SPRNGCAN 34.500 | W2 | 60 | 0 | 0 |
| 70723 | RDGCREST 34.500 | W1 | 29.7 | 6.3 | 6.3 |
| 70777 | COMAN_3 27.000 | C3 | 805 | 400 | 400 |
| 70822 | CEDARCK1 34.500 | W1 | 150 | 31.5 | 31.5 |
| 70823 | CEDARCK2 34.500 | W2 | 150 | 31.5 | 31.5 |
| 70824 | CEDAR3 34.500 | W3 | 250 | 52.5 | 52.5 |
| 70931 | GR_SANDH_PV 34.500 | S1 | 17 | 9.98 | 9.98 |
| 70932 | SOLAR_GE 34.500 | S1 | 30 | 19.5 | 19.5 |
| 70933 | COGENTIX_PV 34.500 | S1 | 30 | 19.5 | 19.5 |
| 70950 | ST.VR_5 18.000 | G5 | 150 | 0 | 0 |
| 70951 | ST.VR_6 18.000 | G6 | 150 | 0 | 0 |
| 71001 | BAC_MSA 13.800 | G1 | 100 | 100 | 100 |
| 71002 | BAC_MSA 13.800 | G1 | 100 | 100 | 100 |
| 71003 | BAC_MSA 13.800 | G1 | 40 | 40 | 40 |
| 71003 | BAC_MSA 13.800 | G2 | 40 | 40 | 40 |
| 71003 | BAC_MSA 13.800 | S1 | 20 | 20 | 20 |
| 71004 | BAC_MSA 13.800 | G1 | 40 | 40 | 40 |
| 71004 | BAC_MSA 13.800 | G2 | 40 | 40 | 40 |
| 71004 | BAC_MSA 13.800 | S1 | 20 | 20 | 20 |

| | | | | *Benchmark* | *GI-2013-7* |
|---|---|---|---|---|---|
| **Bus Number** | **Bus Name** | **Id** | **Pmax (MW)** | **Pgen (MW)** | **Pgen (MW)** |
| 71009 | BUSCHRWTG1 0.7000 | 1 | 28.8 | 28.8 | 28.8 |
| 72714 | KIT.CARSON 0.6900 | G1 | 51 | 51 | 51 |
| 73054 | ELBERT-1 11.500 | 1 | 100 | 99 | 99 |
| 73129 | MBPP-1 24.000 | 1 | 605 | 480.187 | 493.2949 |
| 73130 | MBPP-2 24.000 | 1 | 605 | 605 | 605 |
| 73181 | SIDNEYDC 230.00 | 1 | 200 | 196 | 196 |
| 73226 | YELLO1-2 13.800 | 1 | 62.5 | 62 | 62 |
| 73226 | YELLO1-2 13.800 | 2 | 62.5 | 62 | 62 |
| 73227 | YELLO3-4 13.800 | 3 | 62.5 | 62 | 62 |
| 73227 | YELLO3-4 13.800 | 4 | 62.5 | 62 | 62 |
| 73285 | BENFRNCH 13.800 | 1 | 22.5 | 0 | 0 |
| 73288 | NSS1 13.800 | 1 | 18.6 | 18.6 | 18.6 |
| 73289 | RCCT1 13.800 | 1 | 17 | 17 | 17 |
| 73291 | RCCT2 13.800 | 2 | 17 | 17 | 17 |
| 73292 | RCCT3 13.800 | 3 | 17 | 17 | 17 |
| 73293 | RCCT4 13.800 | 4 | 17 | 1.4 | 1.4 |
| 73299 | BIGTHOMP 4.2000 | 1 | 4.5 | 4 | 4 |
| 73302 | BRLNGTN1 13.800 | 1 | 60.3 | 50 | 50 |
| 73303 | BRLNGTN2 13.800 | 1 | 60.3 | 50 | 50 |
| 73306 | ESTES1 6.9000 | 1 | 17 | 17 | 17 |
| 73307 | ESTES2 6.9000 | 1 | 17 | 17 | 17 |
| 73308 | ESTES3 6.9000 | 1 | 17 | 17 | 17 |
| 73312 | GRANBYP1 6.9000 | 1 | 5 | 0 | 0 |
| 73313 | GRANBYP2 6.9000 | 1 | 5 | 0 | 0 |
| 73314 | GRANBYP3 6.9000 | 1 | 5 | 0 | 0 |
| 73316 | GREENMT1 6.9000 | 1 | 13 | 13 | 13 |
| 73317 | GREENMT2 6.9000 | 1 | 13 | 13 | 13 |
| 73319 | MARYLKPP 6.9000 | 1 | 8.1 | 8 | 8 |
| 73320 | NCWCD 13.800 | 1 | 36 | 0 | 0 |
| 73321 | OSAGE1 11.500 | 1 | 11.5 | 0 | 0 |
| 73322 | OSAGE2 11.500 | 2 | 11.5 | 0 | 0 |
| 73323 | OSAGE3 11.500 | 3 | 11.5 | 0 | 0 |
| 73324 | POLEHILL 13.800 | 1 | 38.2 | 36 | 36 |
| 73328 | WILLMFRK 2.4000 | 1 | 3 | 2 | 2 |
| 73330 | WILLOWCK 4.2000 | 1 | 4 | 0 | 0 |
| 73332 | ALCOVA1 6.9000 | 1 | 20.7 | 21 | 21 |
| 73333 | BOYSEN1 4.2000 | 1 | 7.5 | 7 | 7 |
| 73333 | BOYSEN1 4.2000 | 2 | 7.5 | 7 | 7 |

| | | | | *Benchmark* | *GI-2013-7* |
|---|---|---|---|---|---|
| **Bus Number** | **Bus Name** | **Id** | **Pmax (MW)** | **Pgen (MW)** | **Pgen (MW)** |
| 73334 | BBILL1-2 6.9000 | 1 | 6 | 5 | 5 |
| 73334 | BBILL1-2 6.9000 | 2 | 6 | 5 | 5 |
| 73339 | HEART MT 2.4000 | 1 | 5 | 5 | 5 |
| 73341 | NSS2 13.800 | 2 | 93.7 | 93.7 | 93.7 |
| 73347 | SHOSHONE 6.9000 | 1 | 3 | 2 | 2 |
| 73349 | FREMONT1 11.500 | 1 | 33.4 | 29 | 29 |
| 73350 | FREMONT2 11.500 | 1 | 33.4 | 29 | 29 |
| 73351 | GLENDO1 6.9000 | 1 | 15 | 15 | 15 |
| 73352 | GLENDO2 6.9000 | 1 | 15 | 15 | 15 |
| 73353 | GUERNSY1 2.4000 | 1 | 3.2 | 2.5 | 2.5 |
| 73356 | KORTES1 6.9000 | 1 | 12.2 | 12 | 12 |
| 73357 | KORTES2 6.9000 | 1 | 12.2 | 12 | 12 |
| 73358 | KORTES3 6.9000 | 1 | 12.2 | 12 | 12 |
| 73363 | SEMINOE1-2 6.9000 | 1 | 13.3 | 12.5 | 12.5 |
| 73363 | SEMINOE1-2 6.9000 | 2 | 13.3 | 12.5 | 12.5 |
| 73381 | BIRDSAL1 13.800 | 1 | 16 | 0 | 0 |
| 73382 | BIRDSAL2 13.800 | 1 | 16 | 0 | 0 |
| 73383 | BIRDSAL3 13.800 | 1 | 23 | 0 | 0 |
| 73418 | RD_NIXON 20.000 | 1 | 230 | 224.8 | 224.8 |
| 73424 | TESLA1 13.800 | 1 | 28 | 28 | 28 |
| 73427 | DRAKE 5 13.800 | 1 | 60 | 49 | 49 |
| 73428 | DRAKE 6 13.800 | 1 | 90 | 82.3 | 82.3 |
| 73429 | DRAKE 7 13.800 | 1 | 150 | 139.1 | 139.1 |
| 73434 | NIXONCT1 12.500 | 1 | 35 | 0 | 0 |
| 73435 | NIXONCT2 12.500 | 1 | 35 | 0 | 0 |
| 73438 | ALCOVA2 6.9000 | 1 | 20.7 | 20 | 20 |
| 73439 | BBILL3-4 6.9000 | 1 | 6 | 5 | 5 |
| 73441 | SEMINOE3 6.9000 | 1 | 13.3 | 13 | 13 |
| 73444 | GUERNSY2 2.4000 | 2 | 3.2 | 2.5 | 2.5 |
| 73448 | FLATIRN1 13.800 | 2 | 43 | 42 | 42 |
| 73449 | FLATIRN2 13.800 | 1 | 43 | 43 | 43 |
| 73449 | FLATIRN2 13.800 | 3 | 8.5 | 8 | 8 |
| 73461 | ELBERT-2 11.500 | 1 | 100 | 99 | 99 |
| 73462 | SPIRTMTN 6.9000 | 1 | 4.5 | 4 | 4 |
| 73507 | FTRNG1CC 18.000 | 1 | 158 | 100 | 100 |
| 73508 | FTRNG2CC 18.000 | 1 | 158 | 100 | 100 |
| 73509 | FTRNG3CC 21.000 | 1 | 180 | 162 | 162 |
| 73520 | BFDIESEL 4.1600 | 1 | 10 | 0 | 0 |

| | | | | Benchmark | GI-2013-7 |
|---|---|---|---|---|---|
| Bus Number | Bus Name | Id | Pmax (MW) | Pgen (MW) | Pgen (MW) |
| 73520 | BFDIESEL 4.1600 | 5 | 10 | 0 | 0 |
| 73532 | LINCOLN1 13.800 | 1 | 67 | 68 | 68 |
| 73533 | LINCOLN2 13.800 | 1 | 67 | 68 | 68 |
| 73631 | COHIWND_G1 0.6900 | W | 67.2 | 67 | 67 |
| 73708 | SPNGCN2D 0.6900 | 1 | 59.5 | 59.5 | 59.5 |
| 73726 | GI2013-7 EQ1 0.6900 | 1 | 142.8 | N/A | 142.8 |
| 74014 | NSS_CT1 13.800 | 1 | 40 | 40 | 40 |
| 74015 | NSS_CT2 13.800 | 1 | 40 | 40 | 40 |
| 74016 | WYGEN 13.800 | 1 | 93.7 | 93.7 | 93.7 |
| 74017 | WYGEN2 13.800 | 1 | 100 | 95 | 95 |
| 74018 | WYGEN3 13.800 | 1 | 110 | 110 | 110 |
| 74029 | LNG_CT1 13.800 | 1 | 40 | 40 | 40 |
| 74042 | CLR_1 0.6000 | 1 | 29.4 | 29.4 | 29.4 |
| 74043 | SS_GEN1 0.6000 | 1 | 42 | 42 | 42 |
| 74051 | BC_DVAR 25.000 | 1 | 0 | 0 | 0 |
| 74399 | BHPLPLAN 13.800 | 1 | 100 | 100 | 100 |
| 76301 | ARVADA1 13.800 | 1 | 7.2 | 0 | 0 |
| 76302 | ARVADA2 13.800 | 1 | 7.2 | 0 | 0 |
| 76303 | ARVADA3 13.800 | 1 | 7.2 | 0 | 0 |
| 76305 | BARBERC1 13.800 | 1 | 7.2 | 0 | 0 |
| 76306 | BARBERC2 13.800 | 1 | 7.2 | 0 | 0 |
| 76307 | BARBERC3 13.800 | 1 | 7.2 | 0 | 0 |
| 76309 | HARTZOG1 13.800 | 1 | 7.2 | 0 | 0 |
| 76310 | HARTZOG2 13.800 | 1 | 7.2 | 0 | 0 |
| 76311 | HARTZOG3 13.800 | 1 | 7.2 | 0 | 0 |
| 76313 | TK DVAR1 0.4800 | 1 | 0 | 0 | 0 |
| 76314 | TK DVAR2 0.4800 | 1 | 0 | 0 | 0 |
| 76351 | RCDC W 230.00 | 1 | 200 | -130 | -130 |
| 76404 | DRYFORK 19.000 | 1 | 440 | 440 | 440 |
| 76502 | SPFSHPRK 69.000 | 1 | 4 | 0 | 0 |
| 79015 | CRAIG 1 22.000 | 1 | 470 | 400 | 260 |
| 79016 | CRAIG 2 22.000 | 1 | 470 | 257 | 250 |
| 79017 | CRAIG 3 22.000 | 1 | 470 | 208 | 208 |
| 79019 | MORRO1-2 12.500 | 1 | 82 | 81 | 81 |
| 79019 | MORRO1-2 12.500 | 2 | 82 | 81 | 81 |
| 79040 | HAYDEN1 18.000 | 1 | 212 | 175 | 175 |
| 79041 | HAYDEN2 22.000 | 1 | 286 | 250 | 250 |
| 79123 | FONTNLLE 4.1600 | 1 | 10 | 9.5 | 9.5 |

| | | | | *Benchmark* | *GI-2013-7* |
|---|---|---|---|---|---|
| **Bus Number** | **Bus Name** | **Id** | **Pmax (MW)** | **Pgen (MW)** | **Pgen (MW)** |
| 79154 | FLGORG1 11.500 | 1 | 50 | 50 | 50 |
| 79155 | FLGORG2 11.500 | 1 | 50 | 50 | 50 |
| 79156 | FLGORG3 11.500 | 1 | 50 | 50 | 50 |
| 79157 | BMESA1-2 11.000 | 1 | 43.2 | 42 | 42 |
| 79157 | BMESA1-2 11.000 | 2 | 43.2 | 42 | 42 |
| 79158 | NUCLA 1 13.800 | 1 | 12.6 | 12.6 | 12.6 |
| 79159 | NUCLA 2 13.800 | 1 | 12.6 | 12.6 | 12.6 |
| 79160 | NUCLA 3 13.800 | 1 | 12.6 | 12.6 | 12.6 |
| 79161 | NUCLA 4 13.800 | 1 | 73.3 | 72 | 72 |
| 79162 | CRYSTAL 12.500 | 1 | 27.5 | 27 | 27 |
| 79164 | TOWAOC 6.9000 | 1 | 12 | 11 | 11 |
| 79166 | MOLINA-L 4.2000 | 1 | 4.9 | 4.5 | 4.5 |
| 79172 | MOLINA-U 4.2000 | 1 | 8.6 | 8.5 | 8.5 |
| 79176 | MCPHEE 2.4000 | 1 | 1.3 | 1 | 1 |
| 79251 | QFATLAS1 13.800 | 1 | 31.2 | 0 | 0 |
| 79251 | QFATLAS1 13.800 | 2 | 18.2 | 0 | 0 |
| 79252 | QFATLAS2 13.800 | 3 | 18.2 | 0 | 0 |
| 79252 | QFATLAS2 13.800 | 4 | 18.2 | 0 | 0 |

## B. One Line Diagrams

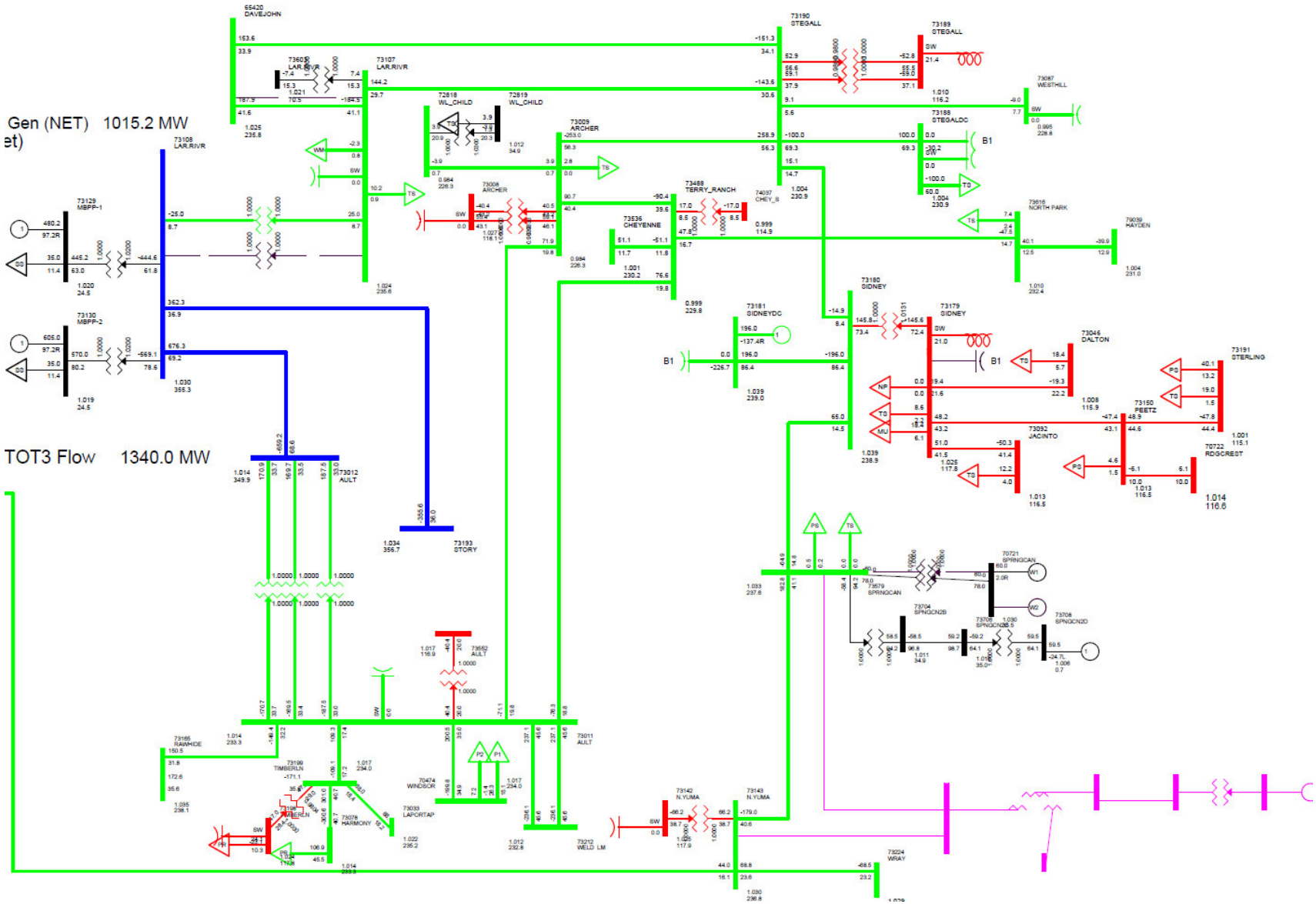


**Figure B1: One Line Diagram with high TOT3 flows**

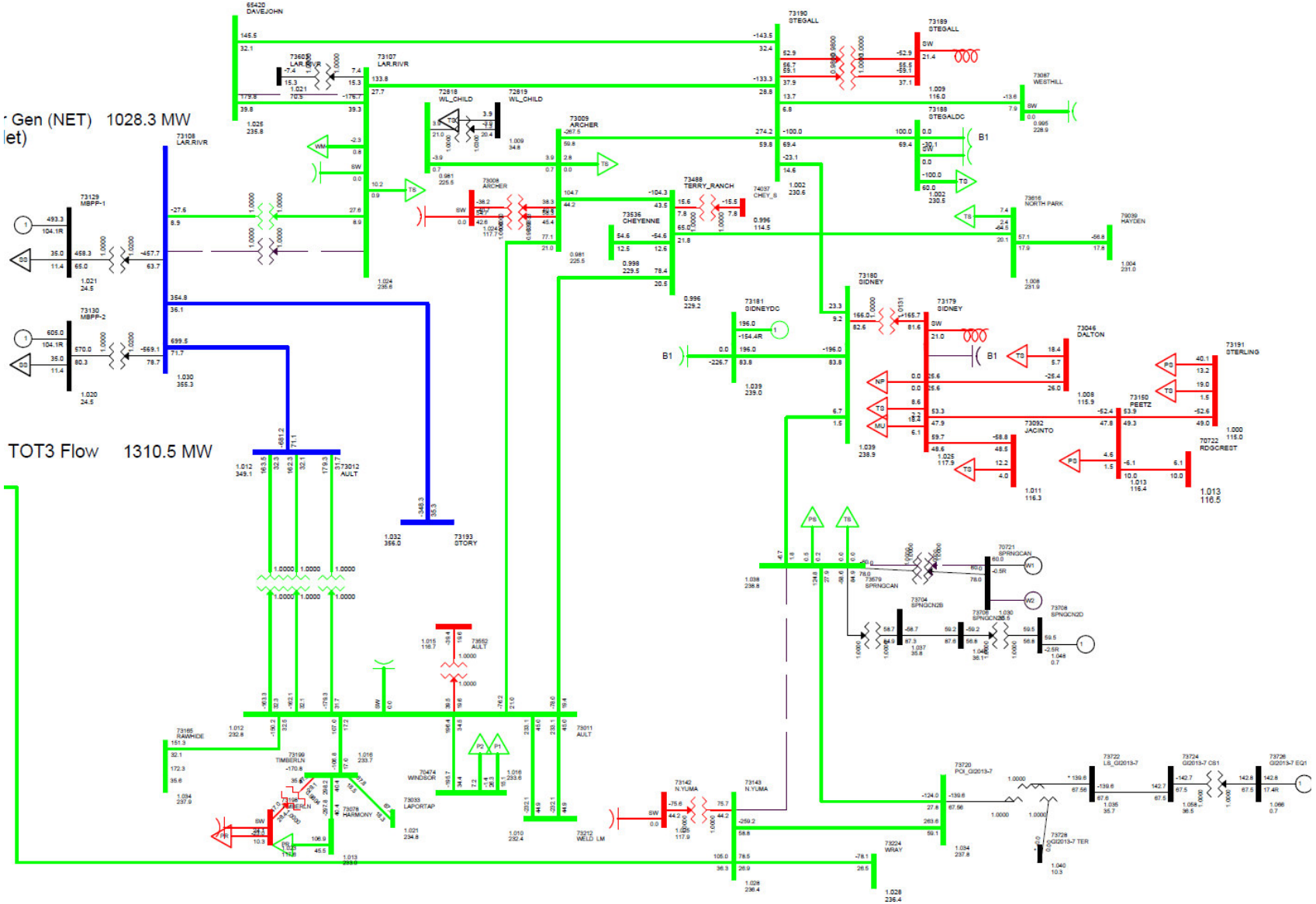


**Figure B2: One Line Diagram with Addition of GI-2013-7**