

Reactive Power Study Report

Crane County Solar Farm

100.4600000.00000

Report No. CRN-RS-212.01

11/08/2019

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RECORD OF REVISION

|  |  |  |
| --- | --- | --- |
| Rev. No. | Date | Description |
| 0 | 10/04/2019 | Issued for Construction |
| 1 | 10/07/2019 | Issued for Construction |
| 2 | 10/14/2019 | Issued for Construction |
| 3 | 10/22/2019 | Issued for Construction |
| 4 | 11/08/2019 | Issued for Construction |

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Acronyms

|  |  |
| --- | --- |
| Crane | Crane County Solar Farm |
| ERCOT | Electricity Reliability Council of Texas |
| Ft | Foot |
| FERC | Federal Energy Regulatory Commission |
| HV | High Voltage |
| LGIA | Large Generator Interconnection Agreement |
| Mortenson | Mortenson Engineering Services, Inc |
| MPT | Main Power Transformer |
| MV | Medium Voltage |
| MVAr | Mega-Volt-Ampere reactive |
| MW | Mega-Watt |
| PF | Power Factor |
| POI | Point of Interconnection |
| pu | Per Unit |
| Vpu | Voltage in Per Unit |

# Executive Summary

## Overview

Mortenson Engineering Services, Inc. (Mortenson) completed a reactive power study for the Crane County solar farm (Crane). Crane is located in Crane County, Texas. It consists of a photovoltaic plant that is 150MWac, a collection system, and an interconnect substation. An overhead transmission slack span will connect the Crane County substation to the point of interconnection (POI) at the proposed Castle Mountain Substation. The substations high side voltage is rated at 138 kV and the low side is rated at 34.5 kV. The substation will consist of one 100/133/167 MVA 138/34.5 kV main power transformer, three feeder breakers, one reactive breaker, one two-step capacitor bank, and an electrical equipment enclosure. The substation main power transformer (MPT) is equipped with load tap changer (LTC), on the high voltage side.

The study was performed to determine whether Crane can meet the power factor (PF) requirement at the point of interconnection (POI) using the reactive power capabilities of the solar farm or if any automatic switched capacitor banks are needed to meet this requirement. According to Electricity Reliability Council of Texas (ERCOT) rules, Crane needs to comply with the 0.95 power factor requirement at the POI.

The reactive power study included the most up-to date collection system, substation MPT, inverters and their transformers as of the issue date above.

## Key Findings

Mortenson found that Crane can meet the PF requirement at the POI for the POI voltage range from 1.05 Vpu to 0.95 Vpu. This can be done using a combination of the reactive capability of the solar inverters along with switched static capacitor banks installed on the low voltage bus in the substation.

The Mortenson analysis followed the study methodology in the ERCOT document *Reactive Study Scope* dated April 2017. Utilizing the substation MPT tap settings the PF requirements could be met for all POI voltages tested.

Additionally, the Mortenson analysis showed that a 25.0 MVAr of capacitor banks are needed to meet the PF requirement at the POI. The capacitor banks recommended to be installed in two steps of 12.5 MVAr. The target voltage for the 34.5 kV voltage in the substation should be 1.0691 pu.

The findings of this report depend on the design information available as of the issue date above. Any changes to the design information and model assumptions could impact the findings and recommendations of this report.

# Modeling Methodology

Mortenson built a detailed phasor-domain model of the 150MWac photovoltaic plant in PSS®E version 33.11. Underground cables connecting the individual inverter transformers (padmounts) were modeled as pi-equivalent segments. The grid was represented as a swing source at the POI. The high voltage tie-line to the POI was modeled as a pi-equivalent segment with impedance data based on a specific tower configuration (transmission line data that is included in the latest Interconnection Agreement, dated 07/03/2019).

Solar PV panel/inverters were modeled as machines with reactive power capability according to the inverter capabilities. Inverter transformers and substation MPT impedances were modeled along with their no-load losses.

Several power flow cases were performed. At each POI voltage, all inverters were dispatched to meet the PF requirement at the POI by absorbing or supplying the maximum possible reactive power while observing the 0.90 Vpu to 1.1 Vpu collector system voltage.

All data used to build the model is given in Appendix 1. The collector system layout is given in Appendix 2. The PSS®E single line diagram is given in Appendix 3. Inverter temperature derate curve documentation is attached in Appendix 4. Turbine reactive power capability is attached in Appendix 5.

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# Capacitor Bank Size

The voltage at the POI is scheduled across a range of voltage [0.95-1.05] Vpu with the turbines set to provide maximum reactive power. Enough capacitors were then added to meet the PF requirement at the POI. Once this was done, the LTC was set to control the voltage throughout the collection system range of operation without violating the constraints listed in Section 2. It should be noted that, the LTC was set to raise the voltage within the collection system to maximize turbine reactive power contribution. Adding capacitors provided a safety margin for the reactive power at the high side of the substation MPT to guard against modeling inaccuracies. This process determined the amount of capacitors needed.

In summary, Mortenson recommends a total of 25.0 MVArs of capacitors be installed to meet the PF requirement at the POI, with the capacitors to be switched in to 12.5 MVAr steps.

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# Reactive Power Capability

Various power flow cases were created at different output levels and at different POI voltage levels. At each output level and voltage level, a lagging and leading power flow case was created. The inverters were dispatched to supply or absorb as much reactive power as possible to meet the PF requirement at the POI. The inverter P/Q curve is included in Figure 1. To calculate the maximum reactive power that the project is capable of supplying with a lagging PF, the inverters were set to supply as much reactive power without the voltage at their terminals exceeding 1.1 Vpu with the capacitor banks engaged at all output levels. In the leading PF cases, the reactive power of the inverters was set to absorb as much reactive power without the voltage at their terminals exceeding 0.9 Vpu with the capacitor banks de-energized at all output levels.

Per the ERCOT document *Reactive Study Scope* dated April 2017, the results are specified in Table 1 and Table 2. The following text is from the *ERCOT Reactive Study Scope* document, limiting the use of LTC control within lagging to leading tests at the same dispatch.

*On-Load-Tap Changing transformers are assumed to be relatively slow and may not count towards the dynamic reactive capability of a resource. Thus, when performing the study, on-load-tap-changing station transformers may only be adjusted when testing a different POI voltage or different real power dispatch. These transformers may not be adjusted when transitioning between maximum leading and maximum lagging for the same POI voltage and same real power dispatch.*

In summary, the project can meet the lagging PF requirement for the full POI voltage range from 1.05 Vpu to 0.95 Vpu, with a total of 25 MVAr capacitor banks. Further, the reactive power output for the lagging operation is curtailed to limit the collection system voltage below the 1.1 Vpu limit when the dispatch is above 10.7 MW (gross).

The Mortenson analysis revealed that Crane project is able to provide 0.95 leading to 0.95 lagging PF for the voltage range of 1.05 Vpu to 0.95 Vpu at the POI. The full reactive power capability of the project at different voltage levels is provided in Figure 2. As can be seen from the graph, the project can meet the leading and lagging PF requirement at output levels for the voltage range of 1.05 Vpu to 0.95 Vpu.

Notice, the results in Table 2 and Figure 2 show plant capability, as described above. Whereas, the results in Table 3 show the 1.05 Vpu and 0.95 Vpu medium voltage substation bus reactive power simulated results. Specifically, the differences between Table 2 and Figure 2 with Table 3 includes (1) reporting system performance at a different point of the test system; (2) the lagging results reported are less the 25.0 MVAr capacitor bank output; and (3) the 100% dispatch leading results have reactive power curtailed to meet the 163.35 MVA limit for the RARF. Finally, the results in Table 2 show that the target voltage for the 34.5 kV voltage in the substation should be 1.0691 pu.

The findings of this report depend on the design information available as of the issue date above. Any changes to the design information and model assumptions could impact the findings and recommendations of this report.

Table 1. Reactive Device Inventory

* Project net power deliverable to grid (@ POI): 150 MW.
* Required VAR capability @ POI, calculated as 32.8% of net deliverable: ± 49.2 MVAr.
* Inventory total gross reactive capability (nominal, @ device terminals, excluding losses):
  1. Generating Units (10% output or LSL[[1]](#footnote-2)): 80.29 MVAr lag / -80.29 MVAr lead
  2. Generating Units (100% output): 58.54 MVAr lag / -58.54 MVAr lead
  3. Switchable shunts: 25.0 MVAr lag / 0 MVAr lead
  4. Auxiliary Dynamic Devices[[2]](#footnote-3): 0 MVAr lag / 0 MVAr lead
  5. Grand Total (add #2, 3, 4): 83.54 MVAr lag / -52.65 MVAr lead
  6. Total Dynamic at 10% or LSL (add #1, 4): 80.29 MVAr lag / -80.29 MVAr lead
  7. Total Dynamic at 100% (add #2, 4): 58.54 MVAr lag / -58.54 MVAr lead
  + How are the switchable shunts controlled? E.g.: “Automatic control, adjust in response to voltage”, “automatic control, adjust in response to power dispatch”, or, “manual control”. Automatic control
  + What is the estimated response time of the shunts to a low voltage? 5 sec
* Paste manufacturer charts showing:
  + Reactive capability versus real power output (“PQ chart”, or “D-curve”). (See Figure 1; temperature derate curves are included in Appendix 4.)
  + Reactive capability versus terminal voltage (“QV chart” or family of D-curves).

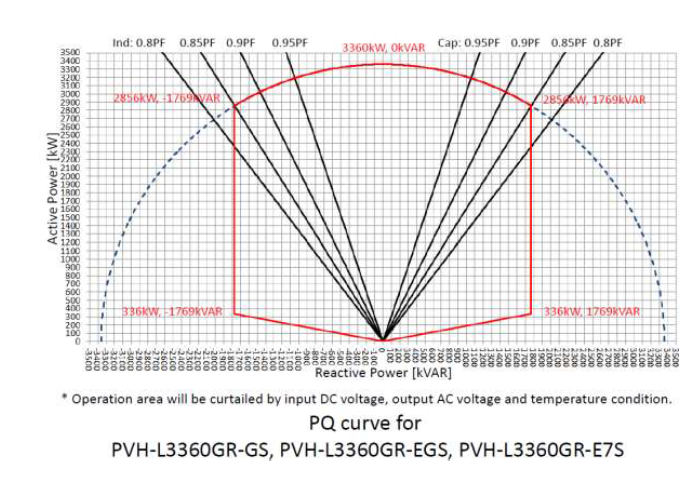


Figure 1. Inverter P-Q Curve

* List acceptable steady-state voltage ratings:
  + Generating units: 567 volts low / 693 volts high
  + Collector system & equipment: 31.05k volts low / 37.95k volts high
* Will the generator utilize automatic voltage regulation? Y (Y/N)
* Will this project be capable of maintaining a voltage setpoint at the POI? Y (Y/N)
* Anticipated Voltage Droop (if currently known)? NA   
  (Droop is defined as % voltage set-point error causing 100% reactive power dispatch[[3]](#footnote-4).)

Table 2. Reactive Power Capability Results

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| POI Voltage [pu] | Gross Generation [MW] | Reactive Test | POI Real Power [MW] | POI Reactive Power [MVAr] | Tap Position | Switched Shunt [MVAr] | Substation 34.5 kV Voltage [pu] | Minimum Terminal Voltage [pu] | Maximum Terminal Voltage [pu] |
| 0.95 | 1.5 | Leading | -1.27 | 7.452 | 6 | 0 | 0.9075 | 0.9035 | 0.904 |
| 1.5 | Lagging | -1.156 | -38.276 | -16 | 25 | 1.0919 | 1.0944 | 1.095 |
| 15.25 | Leading | -14.27 | 103.737 | -15 | 0 | 0.9495 | 0.9082 | 0.9134 |
| 15.25 | Lagging | -14.525 | -95.119 | -3 | 25 | 1.0668 | 1.093 | 1.0973 |
| 106.75 | Leading | -104.835 | 118.559 | -15 | 0 | 0.9417 | 0.9081 | 0.9104 |
| 106.75 | Lagging | -105.253 | -91.209 | -1 | 25 | 1.0584 | 1.0919 | 1.0995 |
| 152.5 | Leading | -149.816 | 116.358 | -12 | 0 | 0.9271 | 0.9035 | 0.9051 |
| 152.5 | Lagging | -150.417 | -63.715 | -5 | 25 | 1.0586 | 1.0874 | 1.0954 |
| 0.98 | 1.5 | Leading | -1.263 | 7.445 | 11 | 0 | 0.9088 | 0.9049 | 0.9053 |
| 1.5 | Lagging | -1.177 | -38.591 | -12 | 25 | 1.0959 | 1.0985 | 1.099 |
| 15.25 | Leading | -14.26 | 103.855 | -10 | 0 | 0.9461 | 0.9048 | 0.91 |
| 15.25 | Lagging | -14.547 | -95.088 | 2 | 25 | 1.0665 | 1.0927 | 1.097 |
| 106.75 | Leading | -104.808 | 118.891 | -10 | 0 | 0.9382 | 0.9045 | 0.9067 |
| 106.75 | Lagging | -105.23 | -91.214 | 4 | 25 | 1.0585 | 1.092 | 1.0996 |
| 152.5 | Leading | -149.78 | 116.719 | -7 | 0 | 0.9244 | 0.9008 | 0.9023 |
| 152.5 | Lagging | -150.434 | -63.618 | 0 | 25 | 1.0579 | 1.0868 | 1.0947 |
| 1.04 | 1.5 | Leading | -1.25 | 7.33 | 16 | 0 | 0.9377 | 0.9339 | 0.9342 |
| 1.5 | Lagging | -1.169 | -38.615 | -3 | 25 | 1.0964 | 1.0989 | 1.0994 |
| 15.25 | Leading | -14.255 | 103.799 | -1 | 0 | 0.9475 | 0.9062 | 0.9114 |
| 15.25 | Lagging | -14.517 | -95.092 | 12 | 25 | 1.0661 | 1.0923 | 1.0966 |
| 106.75 | Leading | -104.809 | 118.702 | -1 | 0 | 0.9397 | 0.906 | 0.9083 |
| 106.75 | Lagging | -105.235 | -91.233 | 14 | 25 | 1.0587 | 1.0922 | 1.0998 |
| 152.5 | Leading | -149.798 | 116.323 | 2 | 0 | 0.9273 | 0.9037 | 0.9053 |
| 152.5 | Lagging | -150.444 | -64.138 | 9 | 25 | 1.0626 | 1.0913 | 1.0992 |
| 1.05 | 1.5 | Leading | -1.237 | 7.292 | 16 | 0 | 0.9469 | 0.9431 | 0.9435 |
| 1.5 | Lagging | -1.172 | -38.436 | -1 | 25 | 1.093 | 1.0956 | 1.0961 |
| 15.25 | Leading | -14.25 | 103.928 | 1 | 0 | 0.9441 | 0.9026 | 0.9078 |
| 15.25 | Lagging | -14.519 | -94.96 | 14 | 25 | 1.0642 | 1.0905 | 1.0948 |
| 106.75 | Leading | -104.793 | 119.067 | 1 | 0 | 0.936 | 0.9022 | 0.9045 |
| 106.75 | Lagging | -105.231 | -91.057 | 16 | 25 | 1.057 | 1.0905 | 1.0981 |
| 152.5 | Leading | -149.758 | 116.768 | 4 | 0 | 0.9239 | 0.9002 | 0.9018 |
| 152.5 | Lagging | -150.43 | -63.938 | 11 | 25 | 1.0604 | 1.0892 | 1.0971 |

Note 1: 10% dispatch case required in the ERCOT *Reactive Study Scope*

Note 2: 100% dispatch case required in the ERCOT *Reactive Study Scope*

Table 3. Reactive Power Performance at Low Voltage Side of the Substation MPT

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | MW1 1%∙Pmax | Lagging MVAR Limit | Leading MVAR Limit | MW2 10%∙Pmax | Lagging MVAR Limit | Leading MVAR Limit | MW3 70%∙Pmax | Lagging MVAR Limit | Leading MVAR Limit | MW4 Pmax | Lagging MVAR Limit | Leading MVAR Limit |
| 0.95 | 1.5 | 39.6 | -7.4 | 15.25 | 105 | -93.7 | 106.75 | 112.5 | -95.7 | 152.5 | 91.5 | -82.2 |
| 1.05 | 1.5 | 39.8 | -7.2 | 15.25 | 104.9 | -93.8 | 106.75 | 112.3 | -95.9 | 152.5 | 91.7 | -82.4 |

Figure 2. P-Q Capability of the Project at Different POI Voltages

# Capacitor Bank Arrangement

The Mortenson analysis showed that a 25.0 MVAr capacitor bank is needed to meet the PF requirement at the POI. The capacitor bank includes two steps of 12.5 MVAr. Per the IEEE std. 1036-2010, the voltage change, , in percentage at the POI due to capacitor switching is given by the following equation:

Where is the capacitor step size [MVAr] and is the three-phase short circuit [MVA]. The PSSE modeled three-phase short circuit currents at the POI (HV bus) and MV collector system and calculated voltage change are given in Table 4.

Table 4. IEEE 1036 Voltage Change

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
| POI | 13.546 | 3,238 | 12.5 | 0.39 |
| MV Collector System | 15.714 | 939 | 12.5 | 1.33 |

The results in Table 4 are well below the threshold for voltage step size. Indicating no concerns with the specified 25.0 MVAr capacitor bank with two steps of 12.5 MVAr.

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# Results

The Mortenson study found that Crane can meet the PF requirement at the POI for the POI voltage range from 1.05 Vpu to 0.95 Vpu. This can be done using a combination of the reactive capability of the solar inverters along with switched static capacitor banks installed on the low voltage bus in the substation.

The Mortenson study followed the study methodology in the ERCOT document *Reactive Study Scope* dated April 2017. Utilizing the substation MPT tap settings the PF requirements could be met for all POI voltages tested.

Additionally, the Mortenson analysis showed that a 25.0 MVAr capacitor bank is needed to meet the PF requirement at the POI. The capacitor banks include two steps of 12.5 MVAr.

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Appendix 1. Modeling Assumptions

* High Voltage Transmission Line Specifications

The overhead line structure that connects the project to the POI was based on the data in Table 5. The parameters per mile are given in the table below. An overhead transmission slack span will connect the Crane County substation to the point of interconnection (POI) at the proposed Castle Mountain Substation. The positive sequence data of the line was calculated using ETAP (version 19.0.1). Tie line data is included in the latest Interconnection Agreement.

Table 5. High Voltage Tie-Line Specification

|  |  |
| --- | --- |
| Conductor Type (Phase and Ground): | 795 Drake (Multiple) |
| Positive/negative Sequence Resistance [Ω/mile] | 0.11927 |
| Positive/negative Sequence Reactance [Ω/mile] | 0.72784 |
| Positive/negative Sequence Capacitance [μSiemens/mile] | 5.88539 |
| Shield Wire Height [ft] | 85 ft |
| Number of Shield Wires | 2 |
| Spacing Between Shield Wires [ft] | 50 ft |
| Phase Conductor Height [ft] | 60 ft |
| Phase Conductor Spacing [ft] |  |
|  |
|  |

* Utility Contribution

Future (2020) utility contribution was modeled in this study. Utility data is summarized in Table 6. The utility fault data was obtained via email from LCRA on 06/15/2019.

Table 6. Utility Fault Current Data

|  |  |  |  |
| --- | --- | --- | --- |
|  | Fault Apparent Power [MVA] | Fault Current [kA] | X/R |
| Three Phase to Ground | 2,808.3 | 12.911 | 8.399 |
| Single Line to Ground | 1,768.5 | 8.130 | 5.855 |

* Underground Cable Specification

Cable impedance model data is based on the data sheets in Appendix 4. The positive sequence parameters are shown in Table 7. The data sheets were obtained via email from WTEC on 09/12/2019.

Table 7. Cable Positive Sequence Impedance

|  |  |  |  |
| --- | --- | --- | --- |
| MV cable | R [µΩ/ft] | XL [µΩ/ft] | Capacitance [µSiemes/kft] |
| 1250 MCM | 20.0 | 37.0 | 0.12090 |
| 1000 MCM | 25.0 | 39.0 | 0.09174 |
| 750 MCM | 34.0 | 40.0 | 0.08230 |
| 500 MCM | 49.0 | 43.0 | 0.07041 |
| 4/0 AWG | 117.0 | 48.0 | 0.05273 |

* Solar Ware Samurai PVH-L3360GR Specifications based on RES 8745 - Mortenson Crane Solar - 220MW - PVH-L3360GR technical specification - Rev 7.pdf (received via email from JSHP on 5/30/2019) and 50295189-10-1.pdf (received via email from TMEIC on 8/9/2019). Model data for the inverter and generator is summarized in Table 8.

Table 8. Crane Machine Model Data

|  |  |  |
| --- | --- | --- |
| Rating [MW] | 3.0545 | |
| Max Temperature [°C] | 43 | |
| MVA at max temperature | 3.267 | |
| Leading Reactive Power at Peak Output [MVAr] | 1.1708 | |
| Lagging Reactive Power at Peak Output [MVAr] | -1.1708 | |
| Inverter Transformer Voltage [kV] | 34.5/0.63 | |
| Inverter Transformer Winding Configuration: | Yd1 | |
| Inverter Transformer No load losses [kW] | 3.9325 | |
| Positive Sequence Impedance [pu base=3.36 MVA]: | Z | 6.18 |
| X/R | 8.36 |

* Substation MPT specifications based on Nameplate\_Mortenson\_Release to Fabrication\_20160109.pdf (received via email from JSHP on 5/30/2019). Applicable data for the substation MPT is summarized in Table 9.

Table 9. MPT Model Data

|  |  |  |
| --- | --- | --- |
| Rating [MVA] | 100/133/167 | |
| Voltage [kV] | 138.0/34.5/11.5 | |
| Cooling Class | ONAN/ONAF1/ONAF2 | |
| Winding Configuration | YNyn0 | |
| No load losses [kW] | 68 | |
| LTC | Regulated bus | MV bus |
| Min/Max tap | ±10% |
| Number of taps | 33 |
| Positive Sequence Impedance [pu base=100 MVA]: | Z | 0.10 |
| X/R | 85.9938 |

Appendix 2. Collection System Design

The study was based on the collector system design as of 07/08/2019:

| Feeder | From Node | To Node | Length [ft] | Cable Size |
| --- | --- | --- | --- | --- |
| 13 | fed13 | sub13 | 1 | '1250' |
| 13 | JB11 | fed13 | 27 | '1250' |
| 13 | INV50 | JB11 | 533 | '4/0' |
| 13 | INV48 | INV50 | 980 | '4/0' |
| 13 | INV49 | INV48 | 660 | '4/0' |
| 13 | INV35 | JB11 | 1779 | '500' |
| 13 | INV34 | INV35 | 660 | '500' |
| 13 | INV19 | INV34 | 2215 | '4/0' |
| 13 | INV20 | INV19 | 659 | '4/0' |
| 13 | INV21 | INV20 | 660 | '4/0' |
| 13 | INV09 | fed13 | 6721 | '1250' |
| 13 | INV08 | INV09 | 959 | '1000' |
| 13 | INV07 | INV08 | 661 | '750' |
| 13 | INV06 | INV07 | 671 | '750' |
| 13 | INV05 | INV06 | 661 | '500' |
| 13 | INV04 | INV05 | 660 | '500' |
| 13 | INV03 | INV04 | 660 | '4/0' |
| 13 | INV01 | INV03 | 964 | '4/0' |
| 13 | INV02 | INV01 | 964 | '4/0' |
| 12 | fed12 | sub12 | 1 | '1250' |
| 12 | INV18 | fed12 | 5152 | '1250' |
| 12 | INV17 | INV18 | 662 | '1000' |
| 12 | INV16 | INV17 | 660 | '1000' |
| 12 | INV15 | INV16 | 660 | '750' |
| 12 | INV14 | INV15 | 660 | '500' |
| 12 | INV13 | INV14 | 670 | '500' |
| 12 | INV12 | INV13 | 660 | '4/0' |
| 12 | INV11 | INV12 | 663 | '4/0' |
| 12 | INV10 | INV11 | 660 | '4/0' |
| 12 | INV29 | fed12 | 3741 | '1000' |
| 12 | INV28 | INV29 | 660 | '1000' |
| 12 | INV27 | INV28 | 660 | '750' |
| 12 | INV26 | INV27 | 660 | '500' |
| 12 | INV24 | INV26 | 2191 | '500' |
| 12 | INV23 | INV24 | 660 | '4/0' |
| 12 | INV25 | INV23 | 981 | '4/0' |
| 12 | INV22 | INV25 | 1076 | '4/0' |
| 11 | fed11 | sub11 | 1 | '1250' |
| 11 | JB51 | fed11 | 2076 | '1000' |
| 11 | INV39 | JB51 | 659 | '500' |
| 11 | INV38 | INV39 | 660 | '4/0' |
| 11 | INV37 | INV38 | 660 | '4/0' |
| 11 | INV36 | INV37 | 660 | '4/0' |
| 11 | INV33 | JB51 | 1121 | '500' |
| 11 | INV32 | INV33 | 660 | '4/0' |
| 11 | INV31 | INV32 | 660 | '4/0' |
| 11 | INV30 | INV31 | 959 | '4/0' |
| 11 | JB61 | fed11 | 199 | '1000' |
| 11 | INV47 | JB61 | 2057 | '500' |
| 11 | INV46 | INV47 | 663 | '500' |
| 11 | INV45 | INV46 | 660 | '4/0' |
| 11 | INV44 | INV45 | 660 | '4/0' |
| 11 | INV43 | INV44 | 660 | '4/0' |
| 11 | INV42 | JB61 | 599 | '4/0' |
| 11 | INV41 | INV42 | 660 | '4/0' |
| 11 | INV40 | INV41 | 660 | '4/0' |

Appendix 3. PSSE Single Line Diagram

(Click to open attachment)

Appendix 4. Inverter Temperature Derate

(Click to open attachment)

Appendix 5. Cable Impedance Data

(Click to open attachment)

1. LSL: Low Sustained Limit, see ERCOT Nodal Protocols Chapter 2. [↑](#footnote-ref-2)
2. Aux dynamic devices such as SVCs, STATCOMs, DVARs. Rating should include their overload capability. [↑](#footnote-ref-3)
3. 100% Reactive Power Dispatch: 100% of MVARs corresponding to 0.95 pf at maximum MW output. [↑](#footnote-ref-4)