Generation Interconnection
Feasibility Study Report
Queue Position Z2-012

The Interconnection Customer (IC) has proposed a 20 MWE (7.6 MWC; 20 MW MFO) solar powered generating facility to be located in Cape Charles, Northampton County, Virginia. PJM studied Z2-012 as a 20 MW injection into the Old Dominion Electric Cooperative (ODEC) system as a tap of the Weirwood-Eastville 69 kV circuit and evaluated it for compliance with reliability criteria for summer peak conditions in 2018. The planned in-service date, as stated in the Attachment N, is December 31, 2014.

Point of Interconnection

The Z2-012 project will connect with the ODEC system as a tap of the Weirwood-Eastville 69 kV circuit.

Interconnection Customer Scope of Direct Connection Work

Queue Z2-012 IC will be responsible for the construction of all generating station facilities on the Z2-012 side of the Point of Interconnection (POI). The Z2-012 IC is required to design, construct, and own the 69 kV line from the POI to the Customer Facility. This line must be built in accordance RUS standards or an accepted national standard, be effectively grounded, and appropriately shielded from lightning. (Refer to RUS bulletins 1728f-810 and 1724E-200.) The IC's transformer shall be connected wye-ground on the 69 kV side and delta on the low-voltage side. ODEC requires that intertie protection relaying (including provision to receive transfer trip), and supervisory control and data acquisition (SCADA) be located at the IC's 69 kV interrupting device location (POI).

Protection equipment --
The IC is responsible for the design and implementation of all protection equipment on the Z2-012 side of the POI and will do so in accordance with good utility practice.

ODEC will provide sensing and a transfer trip signal to the POI for all 69 kV faults on the line from Tasley to Kellam. Z2-012 will provide a 69 kV interrupting device at the POI beyond which ODEC protection will no longer be a primary means of interrupting fault current. The device **shall not** reclose after tripping. Z2-012 is required to provide ODEC with any information necessary to set ODEC line relaying and coordinate with their protective device, and to trip the device upon receipt of the transfer trip signal.

Metering Equipment --
Installation of revenue grade metering equipment will be required at the Z2-012 POI. At the IC's discretion, ODEC will design and supply the required metering equipment but all the installation cost would be borne by the customer. ODEC requires that power quality metering be installed to monitor compliance with industry standards for harmonics.

The IC is also required to provide revenue metering and real-time telemetry data to PJM in compliance with the requirements listed in PJM Manuals M-01 and M-14. At the IC's discretion, ODEC will design and supply the required telemetering equipment but all the installation cost would be borne by the customer.

Distribution Service Requirements--
The IC must submit a request for electric service through ANEC if back up electric service at less than 69 kV is desired.

Transmission Owner (ODEC) Scope of Direct Connection Work

The total estimated cost of Direct Connection Facilities needed to connect Queue Z2-012 to the ODEC 69 kV system is **$ 510,000** excluding any applicable state or federal taxes.

A further breakdown of the direct connection cost is as follows:

$150,000.00	69kV structures
$130,000.00	69 kV circuit switchers
$ 20,000.00	69kV switch
$ 10,000.00	69kV lightning arrestors
$ 10,000.00	Power quality metering (Installed on Customer CT's and VT's)
$ 30,000.00	Additional conduit/junction boxes/control wiring
$ 60,000.00	Engineering
$ 100,000.00	Construction Labor
$ 510,000.00	Total Estimated Direct Connection Cost

The total estimated construction time for the Direct Connection facilities is **12 months**.

Connection cost estimates are based on the assumptions stated in the following Direct Connection Issues section, and the assumption that the developer desires to have the entire generator output (20MW) deliverable during sunny light load conditions. Network impacts and associated upgrade requirements are addressed at the end of the report.

These transmission costs exclude any applicable state or federal taxes. If at a future date Federal CIAC taxes are deemed necessary by the IRS for this project, PJM, ANEC, and ODEC shall be reimbursed by the Interconnection Customer for such taxes.

Costs for extraordinary Threatened and Endangered Species, Archaeological, Cultural, or other as yet unidentified mitigation strategies are not estimated nor included in the above estimate. No environmental, real estate, or permitting issues were reviewed for the Z2-012 Feasibility Study.

Direct Connection Issues

Z2-012 Inverter and GSU modeling

The Z2-012 IC must provide ODEC and PJM with the transformer test reports and a model of the inverters once they are available in order to perform more detailed analyses.

Z2-012 Generator Harmonic Requirements

Harmonic Voltage Requirements:

On the 69 kV system, the total harmonic distortion to the fundamental voltage wave from a single customer is limited to 1.5% of nominal. In addition, no individual harmonic component can exceed 1.0% of the fundamental system voltage.

Maximum Allowable Harmonic Voltage Distortion Table (Tariff Rule 32)		
Voltage Level	**Distortion Factor (% System Voltage)**	**Individual Harmonic (% System Voltage)**
69 kV through 138 kV	1.5	1

Harmonic current limits must comply with IEEE standard 519 (see table 10.2 and 10.3 limits for power generation). Harmonic filtering sufficient to limit harmonic current to the limits proscribed by these tables may need to be installed. Z2-012 will be responsible for installing such filtering and may be disconnected until remedies are taken if these standards are violated.

Current Distortion Limits in % of 60~ Current (from IEEE 519 tables 10.2 and 10.3)						
Voltage Level	<11	11<h<17	17<h<23	23<h<35	35<h	TDD
69 kV	2.0	1.0	0.75	0.3	0.15	2.5
25 kV	4.0	2.0	1.5	0.6	0.3	5.0

Z2-012 Inverter Regulation or Reactive Support Requirements

As specified in Interconnection Service Agreement, Appendix 2, Section 4.7.1.1 of the PJM OATT (Open Access Transmission Tariff), the Z2-012 generator may need to design its Facility to meet the following power factor requirement, depending on the outcome of the system impact study:

"For all new wind-powered and other non-synchronous generation facilities, if determined in the system impact study to be required for the safety or reliability of the Transmission System, the Generation Interconnection Customer shall design its Customer Facility with the ability to maintain a composite power delivery at continuous rated power output at a power factor of at least 0.95 leading to 0.95 lagging."

Preliminary Schedule and Notes / Assumptions

ODEC will begin the project only after the PJM 3-party Interconnection Service Agreement (ISA) and Interconnection Construction Service Agreement (ICSA) are fully executed and ODEC receives a written authorization by PJM to commence activities. The estimated time to complete the direct connection work is approximately **12 months** after the execution of an ICSA. The schedule for the 69 kV transmission and substation work to accommodate Z2-012 would depend on the project start date. The work to accommodate Z2-012 will require transmission line outages. ODEC's outage windows for construction are typically available in the spring and fall of the year. Missing an outage window could result in project delays.

Notes / Assumptions:
During construction, if extreme weather conditions or other system safety concerns arise, field construction may need to be rescheduled, which could possibly impact the schedule plan.

Excepting any operational, governmental and/or environmental regulatory delays, the use of additional resources, such as overtime, premiums for expedited material, and/or contractor labor, may enable ODEC to decrease this construction period. It is also assumed that all right-of-way and easements are secured without impact on anticipated construction start dates.

Transmission Network Impacts

Potential transmission network impacts are as follows:

Generator Deliverability

*(Single or N-1 contingencies for the **Capacity** portion only of the interconnection)*

None

Multiple Facility Contingency

*(Double Circuit Tower Line, Line with Failed Breaker and, Bus Fault contingencies for the **Full** energy output.*

None

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

1. (DP&L - DP&L) The KENT-NMEREDTH 69 kV line (from bus 232215 to bus 232812 ckt 1) loads from 105.25% to 105.89% (DC power flow) of its emergency rating (93 MVA) for the tower line contingency outage of 'DBL_4NC'. This project contributes approximately 1.33 MW to the thermal violation.

   CONTINGENCY 'DBL_4NC' /* RED LION-CEDAR CREEK 230;RED LION-CARTANZA 230
   OPEN LINE FROM BUS 231004 TO BUS 232002 CKT 1
   OPEN LINE FROM BUS 231004 TO BUS 232003 CKT 1
   END

   Please refer to Appendix 1 for a table containing the generators having contribution to this flowgate.

Short Circuit

No issues identified.

Stability Analysis

Not required due to project size.

Light Load Analysis
(Light Load Studies to be conducted during later study phases (applicable to wind, coal, nuclear, and pumped storage projects).

Not Required.

New System Reinforcements
(Upgrades required to mitigate reliability criteria violations, i.e. "Network Impacts," initially caused by the addition of this project's generation)

None

Contribution to Previously Identified System Reinforcements
(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project.

1. To mitigate the (DP&L - DP&L) The KENT-NMEREDTH 69 kV line (from bus 232215 to bus 232812 ckt 1) overload will require the following:

   Replace Disconnect Switch Kent – New Meredith 69kV and Upgrade Line 6704 Relays at Kent Substation
   Cost Estimate: **$145,000**
   Time Estimate: **18 months**

   Reconductor Kent – New Meredith 69kV and Replace Tap Switches
   Cost Estimate: **$6,480,000**
   Time Estimate: **24 -30 months**

Potential Congestion due to Local Energy Deliverability
(PJM also studied the delivery of the energy portion of the surrounding generation. Any potential problems identified below are likely to result in operational restrictions to the project under study. The Interconnection Customer can proceed with Network Upgrades to eliminate the operational restriction at their discretion by submitting a Transmission Interconnection Request. Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full deliverability for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which analyzes all overload

conditions associated with the identified overloaded element(s). As a result of the aggregate energy resources in the area, the following violations were identified:

These are ***not*** required reliability upgrades.

1. (DP&L - DP&L) The PINEY_69-M HERMON 69 kV line (from bus 232274 to bus 232272 ckt 1) loads from 111.95% to 113.67% (DC power flow) of its emergency rating (143 MVA) for the single line contingency outage of 'LORETO AT1&2'. This project contributes approximately 2.55 MW to the thermal violation.

2. (DP&L - DP&L) The OAKHL_69-WATTSVIL 69 kV line (from bus 232280 to bus 232281 ckt 1) loads from 113.51% to 123.15% (DC power flow) of its emergency rating (89 MVA) for the single line contingency outage of 'CKT 137AC'. This project contributes approximately 8.4 MW to the thermal violation.

Appendices

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact.
It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

Appendix 1

(DP&L - DP&L) The KENT-NMEREDTH 69 kV line (from bus 232215 to bus 232812 ckt 1) loads from 105.25% to 105.89% (DC power flow) of its emergency rating (93 MVA) for the tower line contingency outage of 'DBL_4NC'. This project contributes approximately 1.33 MW to the thermal violation.

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CONTINGENCY 'DBL_4NC'                                   /* RED LION-CEDAR CREEK
230;RED LION-CARTANZA 230
OPEN LINE FROM BUS 231004 TO BUS 232002 CKT 1
OPEN LINE FROM BUS 231004 TO BUS 232003 CKT 1
END
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Bus Number	Bus Name	Full Contribution
232900	DEMECSMY	0.52
232851	DUP-SFR1	0.06
232906	IR3	13.27

232923	MR1	1.32
232924	MR2	1.32
232910	NRG_G1	0.96
232911	NRG_G2	0.96
886231	T-144 C	0.65
886232	T-144 E	0.64
297076	V2-028 C	0.12
297077	V2-028 E	0.2
904212	V4-022 E	0.21
232813	VAUGHN	0.07
901003	W1-003 C	0.5
901004	W1-003 E	0.82
901013	W1-004 C	0.5
901014	W1-004 E	0.82
901023	W1-005 C	0.5
901024	W1-005 E	0.82
901033	W1-006 C	0.5
901034	W1-006 E	0.82
901041	W1-008 C	0.51
901042	W1-008 E	0.82
901411	W1-062	0.58
904791	W3-160 C	0.29
904792	W3-160 E	0.47
907052	X1-032 E	0.26
907341	X1-096 C	1.25
907342	X1-096 E	8.37
909191	X2-066	37.05
909201	X2-067	23.94
910591	X3-015 C	0.37
910592	X3-015 E	0.61
910662	X3-040 E	1.2
910672	X3-041 E	0.72
912202	X4-040 E	0.15
913411	Y1-080 C	0.07
913412	Y1-080 E	0.11
914341	Y2-108	0.13
915522	Y3-054 E	1.27
915541	Y3-058 C	0.36
915542	Y3-058 E	0.59
916231	Z1-076 C	0.36
916232	Z1-076 E	0.58
916241	Z1-077 C	0.25
916242	Z1-077 E	0.41
916431	Z1-099	0.54
916441	Z1-100	0.28

916451	Z1-101	0.28
916461	Z1-102	0.28
916471	Z1-103	0.28
916482	Z1-104 E	1.28
917081	Z2-012 C	0.51
917082	Z2-012 E	0.82