Generation Interconnection
Feasibility Study Report
Queue Position V4-022

The Interconnection Customer (IC) has proposed a 5 MWE (1.9 MWC) solar powered generating facility consisting of ground mounted fixed panel solar arrays to be located in Accomack County, Virginia. PJM studied V4-022 as a 5 MW injection into the Old Dominion Electric Cooperative (ODEC) system at the Tasley1 24.9 kV substation. The project was evaluated for compliance with reliability criteria for summer peak conditions in 2014.

Point of Interconnection

V4-022 will interconnect with the ODEC system via a connection to the A&N Electric Cooperative (ANEC) 24.9 kV Tasley #2220 line.

Direct Connection Requirements

Transmission Owner (ANEC) Scope of Direct Connection Work

ANEC will design and construct a 24.9 kV tap structure to interconnect V4-022 to the Tasley #2220 line. A breakdown of the direct connection work and costs is as follows:

$	62,800.00	New 24.9-kV three-phase distribution line rated at 10 MVA
	47,000.00	New 24.9-kV circuit breakers, qty 2
	40,000.00	New 24.9-kV CTs/VTs (Metering)
	10,000.00	Power Quality Metering
	30,000.00	Relaying modifications 2220 Line
	25,000.00	Engineering & ROW
$	214,800.00	Total Direct Connection

The total estimated cost of Direct Connection Facilities needed to connect Queue V4-022 to Tasley Sub #2220 Line 24.9-kV tap is **$214,800** excluding any applicable state or federal taxes.

The connection estimates are based on the assumptions stated in the following Direct Connection Issues section. The 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.

After the V4-022 / ANEC 2-party IA and V4-022 / PJM / ODEC three-party Interconnection Service Agreement (ISA) and Interconnection Construction Service Agreement (ICSA), if necessary, are signed and ODEC and ANEC receive written authorization by PJM to begin work, ODEC and ANEC will commence engineering design, material purchase, and construction of facilities identified above.

The typical time needed to complete the distribution design and construction work is estimated to be approximately **5 months**. This estimate assumes that suitable line outages can be scheduled as required to install the tapping facilities on the 2220 Line. Failure to meet a scheduled line outage may result in project delays.

Costs for extraordinary Threatened and Endangered Species, Archaeological, Cultural, or other as yet unidentified mitigation strategies are not estimated or included in the above estimate. No environmental, real estate, or permitting issues were reviewed for the V4-022 Feasibility Study.

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 ANEC 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.

Interconnection Customer Scope of Direct Connection Work

The Interconnection Customer (IC) will be responsible for the construction of all generating facilities on the V4-022 side of the Point of ownership change between V4-022 and ANEC. The V4-022 Interconnection Customer is responsible for the cost to design, construct, own and operate the 24.9-kV line from the ANEC 2220 Line tap to V4-022. 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 bulletin 1728F-803.) ANEC requires that intertie protection relaying (IPR), and supervisory control and data acquisition (SCADA) be located at ANEC's 24.9-kV circuit breaker location (*i.e.* at the point of ownership change from V4-022 to ANEC). For use of its distribution facilities (*e.g.,* Tasley 69-24.9 kV Transformer T4, breaker, and associated apparatus) ANEC will bill V4-022 monthly a *pro rata* amount equal to the annual ownership cost times total annual energy divided by annual energy produced by V4-022.

Protection Equipment

The Interconnection Customer is responsible for the design and implementation of all protection equipment on the V4-022 side of the point of ownership change between V4-022 and ANEC as shown on the one line diagram on page 2 and will do so in accordance with good utility practice.

ANEC will provide sensing and tripping of ANEC's 24.9 kV breaker for all 24.9-kV faults on the line from 2220 Line tap to V4-022. The ANEC breaker will not be the protective device for the V4-022 transformer. V4-022 will provide a 24.9-kV interrupting device at the remote end of the line beyond which ANEC protection will no longer be a primary means of interrupting fault current. V4-022 is required to provide ANEC with any information necessary to set ANEC relaying and coordinate with its protective devices. V4-022 will incorporate and react to trip signals as designed by ANEC pursuant to good utility practice.

Metering Equipment Installation at the point of V4-022 / ANEC ownership change

Installation of revenue grade Metering Equipment will be required at the Queue V4-022 / ANEC point of ownership change. At the customer's discretion, ANEC will design and supply the required metering equipment but all the installation cost would be borne by the customer.

Metering Equipment Installation / Changes at the POI (Point of Interconnection) to the PJM / ODEC system

None

Metering / Telemetry for PJM

The Interconnection Customer will also be required to install the equipment necessary to provide revenue metering (kWh and kVArh hourly data sent once per day) and real-time data (telemetry) for the Interconnection Customer's generating resource in compliance with PJM Manuals M-01 and M-14B, and the PJM Tariff. At the customer's discretion, ANEC will design and supply the required metering equipment but all the installation cost would be borne by the customer.

Direct Connection Issues

Inverter and Existing Distribution line Carrier Communications

An AMI/LM power line carrier system operates on ANEC's distribution system at a frequency of 9.615 kHz. Harmonic or other spurious emissions which emanate from V4-022 and interfere with the operation of this power line carrier system shall be mitigated by V4-022 to ANEC's satisfaction.

V4-022 Inverter and GSU modeling

The V4-022 Interconnection Customer must provide ODEC, ANEC, and PJM with the transformer test reports and a model of the inverters once they are available in order to perform more detailed analyses.

V4-022 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. V4-022 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
24.9 kV	4.0	2.0	1.5	0.6	0.3	5.0

V4-022 Generator Flicker Requirements

V4-022 must limit the severity of voltage variation to within a level which will not cause objectionable flicker to other customers. A voltage drop greater than 5% at the point of interconnection is not acceptable. The interconnection customer's facilities are required to be able to receive the necessary reactive power during normal operation to assure that voltage does not drop below guidelines during intermittent cloud cover. The present estimate is 1250 kVAr. This estimate will be revised when the interconnection design is complete.

ODEC and ANEC use the General Electric flicker-irritation curve as a guideline to determine if the system is operating within acceptable limits. ODEC and ANEC will require corrective actions by the V4-022 customer if their operation causes flicker that exceeds this guideline. One such correction could be the installation of static var compensators (SVC) to hold a constant voltage.

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)

None

Short Circuit

None

Stability Analysis

Not required due to project size.

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.

None

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 developer 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.

No problems identifed.