Feasibility Study

Proposed interconnection

of

15.0 MVA generating facility

with

Progress Energy Carolinas distribution system

near Clarkton, North Carolina

(CAROLINA POWER & LIGHT COMPANY)

100 E. DAVIE ST.

TWO PROGRESS PLAZA, 17TH FLOOR

RALEIGH, NORTH CAROLINA 27601
# Feasibility Study for 15 MVA solar farm, near Clarkton, NC

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Summary

Customer submitted to Progress Energy Carolinas (PEC) a Feasibility Study Agreement for its proposed generation project near Clarkton, North Carolina. Customer intends to interconnect a maximum of 15.0 MVA of photovoltaic generation with the PEC distribution system.

PEC has completed a Feasibility Study for Customer’s interconnection request.

Interconnection of Customer’s proposed facility to PEC’s local Electric Power System is feasible, provided certain Interconnection Facilities are installed and certain System Upgrades are completed. Details on the facilities required are shown in sections titled “General” and “Description and non-binding estimated cost of facilities required to interconnect the proposed generating facility.”
Feasibility study scope

In order to properly evaluate Feasibility, PEC’s study involved the following:
1. Evaluation of short circuit capabilities of all fault-clearing devices;
2. Evaluation of thermal loading;
3. Evaluation of voltage limit violations;
4. Initial review of grounding requirements;
5. Initial evaluation of system protection;
6. Description and non-binding estimated cost of facilities required to interconnect the proposed generating facility and to address any identified short circuit, overload, or voltage issues.

This Feasibility study uses as its criteria the following aspects of PEC’s system operation, which PEC has an obligation to maintain and not see compromised by the existence and operation of Customer’s facility on the Progress Energy system:
1. Safety of personnel and public
2. Protection of equipment and property
3. Reliability of service and power quality for PEC retail customers

This document describes the impact of Customer’s proposed facility to PEC’s local Electric Power System and contains ballpark cost & time-to-construct estimates for Interconnection Facilities and System Upgrades.
General

Overview of facilities required for interconnection

A review of facilities in the area reveals that the most reasonable physical means of interconnection is to connect the solar farm’s intertie to an existing three phase tap line located about 500 feet west of the planned intertie location (pole at PEC LocID# BN81AS). See “Interconnection Site Overview” at the end of the document.

This facility’s intertie would be within approximately 2500’ of the Clarkton 115 kV Substation, with interconnection on the existing Harriet Henderson 22.86 kV feeder (with some distribution line reworking required). The Clarkton substation is equipped with a 15 MVA (nominal) transformer and can accommodate full backfeed of the solar farm, not accounting for the small amount of distribution system load on the feeder.

Since the local distribution load peaks at approximately 11 MW, and since there is significant distribution line exposure on the adjacent Clarkton feeder, a transfer-trip scheme appears appropriate for reasons mutually beneficial to Customer and Progress Energy Carolinas. Further details are provided in the section on “Electric System Protection.”

Local voltage levels are also a concern, and further details are provided on this in the “Evaluation of thermal loading and voltage limits violations” section.

As part of this work, the following Interconnection Facilities and System Upgrades will be required:

Interconnection Facilities
1. Just past (east of) the PEC pole at LocID# BN81AS, installation of:
   a. Two to three spans of overhead poles & conductor facilities
   b. Intertie protection: Three phase recloser with intertie recloser relay
   c. Primary metering

2. Transfer-trip scheme to relay transmission line and distribution feeder relay trip signals to SEL-651R relay at interconnection site:
   a. Install a new three-section relay cabinet in substation for the following Transfer Trip components:
      i. 1-RFL GARD 8000 FSK DDT Receiver (Weatherspoon Plt 115kV)
      ii. 1-RFL GARD 8000 FSK DDT Receiver (Delco 115kV)
      iii. 1-Transformer Hybrid for connecting DTT receivers to Line Tuner
      iv. 1-SEL-2411 Programmable Automation Controller
v.  5-SEL-2812MT Fiber Transceivers for communications between SEL-2411 and SEL-351S & SEL-651 relays
vi.  All required test switches, control switches, and auxiliary equipment
vii.  Install necessary coax cable and connectors connecting DDT receiver equipment to line tuner.
b.  Install fiber between SEL-2411 and both SEL-651 and Harriet Henderson FCB SEL-351S relays
c.  Design/implement communication between SEL-2411 and remote device at generating facility
d.  Create relay settings required for SEL-2411 Transfer Trip functionality
e.  Perform necessary relay setting modifications to Harriet Henderson FCB SEL-351S relay for automation, control, and communications.

3.  Perform necessary modifications required for passing SCADA information between DSCADA and DCC/ECC. To include generator analog output data, recloser indication, alarms.

System Upgrades

1.  Existing three phase tap line from Clarkton substation to pole at PEC LocID# BN81AS (angle pole near solar farm intertie) will have to be upgraded to allow for 15 MVA capacity. This will involve installation of additional poles for maximum spans of 280’, and installation of 477 AAC conductor.

2.  Circuit reconfiguration near Clarkton substation that connects upgraded tap line and other tap line (both fed from pole at PEC LocID# CL22AS) to the Harriet Henderson feeder (fed from substation BPN2 - feeder breaker position #2). The Harriet Henderson feeder is shorter and has less overhead line exposure which could contribute to lesser fault & outage activity for the generator than would interconnection to the Clarkton feeder.

3.  Replacement of Cooper type 4E 100 amp reclosers at PEC LocID# B398, due to inadequate fault current interrupting rating.
Operational requirements

An interconnection agreement will be required before operation of Customer’s facility can parallel to Progress Energy’s system. The following points illustrate a few of the items such an agreement will include.

Customer generation: voltage regulation

Please reference the special note on voltage regulation in the “Evaluation of thermal loading and voltage limits violations” section.

Equipment maintenance and testing

PEC will retain the right to inspect and test all of its facilities associated with the Customer generation site as frequently as once annually; Customer may be required to shut down its generation facility during these times. PEC will make every effort to coordinate with Customer personnel on appropriate maintenance times if Customer wishes to simultaneously perform internal maintenance activities.

PEC also retains the right to inspect and test all of its facilities associated with the Customer generation site more frequently than once annually if PEC retail customer service reliability or power quality degradation is taking place and the Customer generation is suspected as a contributor to this degradation.

Generator operation during Hot Line Tag conditions

PEC will generally allow Customer to continue to operate its facility when a Hot Line Tag is placed on the feeder circuit breaker or any of the protective devices on the feeder to which the generating facility is interconnected. PEC retains the right to use special settings or logic at the interconnection site (recloser) when Hot Line Tag conditions are present. PEC also retains the right to require Customer to shut down its facility during Hot Line Tag conditions on any device on the feeder (or other feeder if line-tying is taking place) if PEC engineering staff dictates that special conditions warrant doing so.
Evaluation of short circuit capabilities of all fault-clearing devices

Cases studied
Inverter specifications were unclear as to their short circuit contribution capability. Before PEC embarks upon a System Impact or Facilities Study, PEC will need clarifications from the manufacturer as to the short circuit contribution capability of this type of inverter.

One specification indicated that the inverter could output 2.5 times its full load rating during a short circuit condition. Assuming this specification, with the solar farm capable of a full load output of 15 MVA at 22.86 kV (379 amps), 2.5 times this output would equate to a short circuit contribution of 948 amps.

The available short circuit current at the 24 kV bus of the Clarkton substation (interconnection to be within 500’ of this location) is approximately 4,000 amps (LLL fault). It is clear that the inverters would increase the available fault current to well over 4,000 amps. Because of this, a set of Cooper 4E reclosers on the Clarkton feeder would need to be replaced, since they are just outside of the substation on the Clarkton feeder and would be exposed to the possibility of fault current greater than their 4,000 amp interrupting capacity. The cost estimates herein include replacement of these reclosers with vacuum bottle-based devices which have an 8,000 amp interrupting rating.
Evaluation of thermal loading & voltage limit violations

Cases studied
Load flow studies were performed for multiple cases in order to determine system power flow and voltage conditions without Customer generation and with Customer generation under various circumstances.

Four cases were run: Substation loading during peak distribution loading and at near zero distribution loading, along with Customer generation off-line and on-line.

Results
No thermal overloads are expected, and voltage levels are expected to remain within regulatory limits across all anticipated situations.

The simulations run assumed constant operation at unity power factor. Higher than desired voltages and/or transients will be dealt with through either (1) constant power factor operation in a leading region or (2) operation in a voltage-regulating mode.

SPECIAL NOTE on voltage regulation: While PEC normally requires independent generators on the distribution system to not actively regulate the voltage at the interconnection, PEC may not do so in this case, depending upon the capabilities of the proposed GE inverters in providing voltage regulation and reactive power. Due to the significant potential impact of cloud banks, etc., on local voltage conditions, PEC will require distinct and clear coordination of voltage control between PEC and Customer facilities. PEC expects that as part of a final Facilities Study, agreement would be made on whether or not the GE inverter voltage regulation and/or reactive power capabilities could be configured in a manner to further minimize any degradation in voltage quality for PEC customers.
## Load Flow/Voltage Drop Study results

Customer generation intertie simulated at substation bus

<table>
<thead>
<tr>
<th>Generation output</th>
<th>Substation distribution feeder load</th>
<th>Transmission system contingency</th>
<th>Substation 24 kV bus voltage, steady-state (volts per unit)</th>
<th>Substation 24 kV bus voltage change for solar farm trip event (volts per unit)</th>
<th>Substation 115 kV bus voltage change for solar farm trip event (volts per unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-line 11.1 MW, 0.9 MVAR</td>
<td>None</td>
<td>0.9681</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Off-line 11.1 MW, 0.9 MVAR</td>
<td>Delco end of line OPEN</td>
<td>0.9565</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Off-line 11.1 MW, 0.9 MVAR</td>
<td>Weatherspoon end of line OPEN</td>
<td>0.9632</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Off-line 1.0 MW, 0 MVAR</td>
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<td>N/A</td>
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<tr>
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<td>0.9708</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
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<tr>
<td>Off-line 1.0 MW, 0 MVAR</td>
<td>Weatherspoon end of line OPEN</td>
<td>0.9786</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>15 MW, 0 MVar 11.1 MW, 0.9 MVAR</td>
<td>None</td>
<td>0.9754</td>
<td>0.0073</td>
<td>0.0027</td>
<td></td>
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<tr>
<td>15 MW, 0 MVar 11.1 MW, 0.9 MVAR</td>
<td>Delco end of line OPEN</td>
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<tr>
<td>15 MW, 0 MVar 11.1 MW, 0.9 MVAR</td>
<td>Weatherspoon end of line OPEN</td>
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<tr>
<td>15 MW, 0 MVar 1.0 MW, 0 MVAR</td>
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<td>0.9808</td>
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</tr>
<tr>
<td>15 MW, 0 MVar 1.0 MW, 0 MVAR</td>
<td>Delco end of line OPEN</td>
<td>0.9732</td>
<td>0.0026</td>
<td>0.0026</td>
<td></td>
</tr>
<tr>
<td>15 MW, 0 MVar 1.0 MW, 0 MVAR</td>
<td>Weatherspoon end of line OPEN</td>
<td>0.9818</td>
<td>0.0035</td>
<td>0.0035</td>
<td></td>
</tr>
</tbody>
</table>
Initial review of grounding requirements and electric system protection

Grounding review
Customer’s facility grounding should comply with applicable codes.

PEC’s system neutral will be grounded at the point of primary metering.

PEC assumes that Customer understands that this interconnection is to a multi-grounded, unbalanced distribution system, and that current and voltage imbalance will most likely be present.

PEC assumes that in general, Customer is taking full responsibility for protection of their generation equipment with their own protective equipment.

Electric system protection
In order to properly integrate the solar farm into the local distribution & transmission systems, the system protection scheme and associated facilities will consist of several elements.

Intertie recloser
An intertie recloser with recloser control, located within one span of the requested interconnection point, is needed to serve as the primary interconnection protection equipment. When abnormal feeder conditions (faults, excessive voltage depressions, etc.) warrant, the interconnection recloser relay can act to quickly trip the recloser. Once feeder conditions are normal for approximately three minutes, the recloser can close, thereby allowing the generation to resynchronize locally when convenient.

Transfer-trip scheme
In order to allow the solar farm to ride through voltage transients that occur on other transmission lines and on the Clarkton feeder (adjacent feeder), transfer trip schemes will be required that trip the generation offline strictly in the event of a Delco-Weatherspoon transmission line fault or in the event of a distribution line fault on the Harriet Henderson feeder. This transfer-trip scheme is also needed in order to protect PEC’s 115 kV arresters at the Clarkton substation, as single-line-to-ground faults on the transmission line could go undetected at the interconnection and could cause excessive voltages on the unfaulted phases of the 115 kV line.

The transfer-trip scheme will also trip the generation offline in the event of a fault on the Harriet Henderson feeder; this will be relayed from the distribution feeder breaker.

All of this will be accomplished through the use of underbuilt fiber optic communications, installed on the overhead distribution line from Clarkton substation to the interconnection site.
Description and non-binding estimated cost of facilities required to interconnect the proposed generating facility

In order to allow interconnection of the Customer generation facility while maintaining the critical aspects of service mentioned above, the following Interconnection Facilities and System Upgrades and are required. For more details, see the sections dedicated to these subjects:

**Summary**

Interconnection Facilities (Distribution) ..............$95,400  
Interconnection Facilities (Transmission) ...........$203,686  
System Upgrades (Distribution) .........................$78,870  
System Upgrades (Transmission) .........................N/A  

The estimated time-to-install for all facilities is 12 months after commitment to proceed.
Interconnection Facilities

The cost estimate for all Interconnection Facilities is as follows:

Distribution

Metering facilities (PTs, CTs, four-quadrant meter, pole, associated items) $12,500
Interconnection tap line, G&W Viper ST recloser, & 651R relay $45,000
Under-built fiber optic communications from substation $20,000
Interconnection engineering & commissioning $12,000
SCADA engineering & commissioning $5,900
Distribution TOTAL $95,400

Transmission

Install a new 115 kV, 1200A line trap and CCVT on a steel support stand w/ concrete foundation, including jumpers, conduit and cable. Attach to the B phase between the high-side of the transformer and the circuit switcher.

Install conduit for a new line tuner (by P&C) attached to the new trap/CCVT support stand.

Install leg supports and foundations, grounding and conduit for the installation of a new TT relay cabinet (provided by P&C).

Install approximately 400 ft. of 2" PVC conduit running from the new relay cabinet to 1) the new line tuner, 2) to the existing Harriet Henderson 24 kV FCB, and 3) to a fiber optic communications interface box just outside the substation fence.

Transmission TOTAL $203,686
### System Upgrades

The cost estimate for all System Upgrades is as follows:

<table>
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<tr>
<th>Distribution</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Distribution tap line upgrade &amp; circuit reconfiguration</td>
<td>$67,870</td>
</tr>
<tr>
<td>Replacement of single phase reclosers</td>
<td>$10,832</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$78,702</strong></td>
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</table>

#### Distribution tap line upgrade & circuit reconfiguration

Existing three phase tap line from Clarkton substation to pole at PEC LocID# BN81AS (angle pole near solar farm intertie) will have to be upgraded to allow for 15 MVA capacity. This will involve installation of additional poles for maximum spans of 280’, and installation of 477 AAC conductor.

Circuit reconfiguration will be required near the Clarkton substation that connects upgraded tap line and other tap line (both fed from pole at PEC LocID# CL22AS) to the Harriet Henderson feeder (fed from substation BPN2 - feeder breaker position #2). The Harriet Henderson feeder is shorter and has less overhead line exposure which could contribute to lesser fault & outage activity than the Clarkton feeder.

#### Replacement of single phase reclosers

Cooper type 4E 100 amp reclosers on the Harriet Henderson feeder must be replaced with Hubbell Versa-Tech reclosers, at PEC LocID# B398, due to inadequate fault current interrupting rating.
Study Attachments
**Interconnection site details**

Detailed Description of “Interconnection Facilities”:

1. **Location**: Latitude 34.481882 N, 78.648312 W (approximately 700 straight south of the intersection of East Green Street [NC Highway 211] and North Elmhurst Street). Interconnection is proposed on south side of existing 115 kV transmission line ROW (right-of-way).

2. **Location (closest Progress Energy location ID#)**: approximately 500 feet east-southeast of PEC pole ID# BN81AS

3. **Maximum Physical Export Capability Requested**: 15 MVA

4. **Description of interconnection facilities to be installed by Progress Energy**: Interconnection recloser & relaying, one span of overhead circuit (477 AAC phase conductors), and primary metering transition pole.

   NOTE: Interconnection customer should refer to FIGURE 70 in the April 2011 Progress Energy “White Book” and document CSI-EDGX-00001 (“Requirements for the Parallel Interconnection and Operation of Electric Power Generation on the Progress Energy Distribution System”) for details on requirements for generating facilities. The “White Book” is available at:


   Document “CSI-EDGX-00001” is available upon request.

5. **Nominal voltage at point of demarcation of facilities**: 22,860 volts, 3-phase, 4-wire, AC

6. **Nominal voltage at metering location**: 22,860 volts, 3-phase, 4-wire, AC