1. **Introduction**

A Generator Interconnection System Impact Study has been performed for the 6.8 MW Photovoltaic Distributed Generation proposed at the [Site] near the Hampton Substation in Hampton County, South Carolina. This study was intended to determine whether there existed any distribution load flow violations, any circuit coordination short circuit capability limits or any possible causes of overall system disturbances resulting from the interconnection. This report will also provide a non-binding, good faith estimate of the costs of the facilities required to interconnect the Generator to the Electrical Distribution System.

2. **General Discussion**

This System Impact Study Report is for a photovoltaic distributed generation system located on [Site] in Hampton, South Carolina. While the array configuration may vary, a total of 6.8 MW was studied. Customer will interconnect to the 12.47 KV Electric Power System in the area, providing his own transformers and inverters necessary to convert the output of the photovoltaic arrays to the system voltage of the adjacent overhead distribution circuit.

Customer has requested for SCE&G to tap the existing 12.47KV line near the Customer's property, build a short three phase 477 AAC tap, and install all necessary equipment to the Point of Interconnection (POI).
3. **Power Flow Analysis**

A load flow analysis was performed for the Electric Power System with consideration of the Customer photovoltaic generation. The general process of this study is to consider maximum circuit loads and minimum daylight circuit loads and the impact to the system considering the rapid absence or presence of the PV, as well as steady state voltage fluctuation to the existing Electric Power System assuming a constant Customer power factor. The results of this study indicate that the maximum voltage impact to the customers close to the point of interconnection is approximately 2.0 percent. The impact is greatest at peak load conditions.
The maximum impact to the substation occurs at minimum load and the voltage drop at the bus is approximately 0.6 volts.

For the purposes of this study, it was assumed that 825 feet of 1/0 ACSR will be reconducted between the customer and the substation. The existing line on Customer property, which is 1/0 ACSR, will also be rebuilt to 477 AAC, with the installation of all interconnection equipment. The remainder of the conductor between the substation and the POI is a combination of 4/0 ACSR and 477 AAC, which is sufficient to handle 6.8 MW at 12.47 KV (315 Amps).

4. Short Circuit Analysis

Inverters provide a limited current contribution to the Electric Power System in the event of a nearby fault. Often this contribution is limited to 110% - 120% of full load current. For the purposes of this study, the fault contribution of the inverters was assumed to be a worst case of 120% of full load current (315 amps X 1.2 = 378 amps). This amount of current will not cause any overload or overstressing of the Electric Power System and will not significantly affect protective device coordination of existing distribution facilities.

The size of the suggested PV distributed generation precludes any protective devices between the substation breaker and the point of interconnection recloser/relays. The
substation relays will have to be replaced to support current flow in two directions and set accordingly. This large PV will require relay modifications on the 46KV. No other circuit protection scheme changes should be necessary.

5. **Optional Categories**

The Customer is requesting an interconnection of a 6.8 MW photovoltaic array on the Hampton 46/12.47KV substation, on [insert]. This circuit has a peak load of 3.5 MVA and a minimum daylight load of 1.4 MVA. The other circuit on this substation transformer, [insert], has a peak load of 8.3 MVA and a minimum daylight load of 3.1 MVA.

At minimum daylight circuit load conditions, more than 5 MW of PV DG will flow back through the electric distribution system to the substation. This means that the conductors between these two points will have to be capable of this current. SCE&G uses a minimum of 4/0 ACSR for this current, so all of the wire less than this size will have to be reconducted. At the Customer site, some of the existing primary lines are underbuilt 46KV, and the cost of replacing these 46KV poles and transferring the 46KV to the new poles will be added.

6. **Preliminary Requirements and Cost Estimates**
At the site, SCE&G will install a three phase gang switch, a three phase SCADA controlled recloser, and a metering pole, which will be the POI. The Customer will install as his first pole, another three phase gang switch upstream of all Customer owned equipment. Depending on the exact POI, any existing conductor smaller than 4/0 ACSR will be reconductored. Details of this construction will be included in the Facilities Study.

1. Distribution Work – Recondutor approx. 825 ft of #1/0 ACSR to 477 AAC -- $50,000
2. Replace 4 – 46 KV transmission poles and reconductor approximately 1500 feet of single phase #4 ACSR with three phase 477 AAC - $75,000
3. Site Interconnection Equipment Required – Includes switches, reclosers, meters, etc. -- $50,000
4. Substation Equipment and Relay Upgrades – Includes breaker changes, LTC upgrades, relay upgrades, etc. -- $100,000

Total for Point of Interconnection Site 1 -- $275,000

7. Preliminary Recommendations

This PV DG represents a high penetration (6.8 MW) to the electric distribution system. It is roughly twice as large as the feeder peak load. It is nearly 5 times larger than the feeder minimum daylight load. And, the DG is greater than the substation transformer minimum daylight load. This very high penetration will result in regular reverse power flow. Therefore all existing voltage regulating and metering and protective devices will need to be capable of managing bi-directional electrical flow.

While it will not solve all of the islanding problems associated with such a large mismatch of the electric utility system versus this distributed generation, this situation will be improved by the installation of a SCADA transfer trip scheme between the substation relays and the point of interconnection recloser/relays. For faults on the electric distribution system that are detectable to the substation relays, this scheme will trip the recloser at the POI and transmit this information to the Dispatchers. The Dispatchers will be able to assure that the electrical distribution system has returned to normal before closing the POI recloser via SCADA.

Since the DG will occasionally flow power back to the 46KV transmission system, it will be necessary for the transmission relays be replaced and set to prevent overvoltage to the 46KV system.

A grounded wye/ungrounded wye connection between the electric distribution system and the PV will not provide an effectively grounded system during islanding or open conductor
conditions. It will be necessary to set the POI recloser/relays to detect negative sequence currents and/or unbalance causing larger than normal neutral currents to protect the nearby customers from overvoltage. SCE&G will not install any single phase devices between the Customer and the substation relays, minimizing but not eliminating the potential problem of open conductors.

8. **Study Conclusions**

In the previous section, 7. Preliminary Recommendations, the need for a Transfer Trip scheme was identified as part of the equipment necessary for interconnecting a DG of this size. In the Facilities Study, the Transfer Trip scheme will be explored and a determination will be made concerning the communication link between the substation and the POI SCADA recloser. If necessary, Customer may be required to provide a dedicated fiber link for this communication.

Assuming all modifications and additions to the Electric Power System are completed prior to interconnection, this Distributed Generation is not expected to cause adverse effects to the existing Electric Distribution System. This project may go forward to the next step – the Facilities Study.