PJM Generator Interconnection Request
Queue # V2-010
Stewartsville 34.5 kV
Feasibility/Impact Study Report

PJM DOCS No. 565223
October, 2009

Introduction

This Combined Feasibility/Impact Study report provides the documentation of an RTEP system assessment that has been performed by FirstEnergy (FE) in response to a request made by the Warren Solar I, LLC for the connection of a 20 MW solar generation project to the Jersey Central Transmission System. It also includes an analysis of network impacts performed by PJM Interconnection.

As per the PJM Interconnection study process, the Warren Solar (V2-010) Project assessment was accomplished by: 1. Evaluating the reliability impact of the proposed facilities and connection on the interconnected transmission system by the performance of a power flow study; 2. Ensuring compliance with the NERC, ReliabilityFirst, PJM and FE Reliability Standards by identifying the system reinforcements that will need to be installed for an interconnection of the proposed project; 3. Coordinating and cooperating with the PJM staff and Warren Solar I, LLC by conducting meetings and issuing this report as a part of the RTEP study process; 4. Performing a Steady State, Short-Circuit and Dynamics Study as necessary; 5. Conducting all studies in accordance with the PJM Manuals, the "FE Requirements for Transmission Connected Facilities", and the "FE Study Guide".

Network Impacts

This analysis was performed by PJM Interconnection Engineers. The results are presented in summary here and are also presented integrated in sections of the balance of the report.

The queue V2-010 project was studied as a 20MW injection (7.6MW of which was capacity) into JCPL's system at the Stewartsville 34.5kV substation. The project was studied on a combined feasibility-impact basis which utilizes an AC analysis, and incorporates all contingency types. Project V2-010 was evaluated for compliance with reliability criteria for summer peak conditions in 2013. Potential network impacts were as follows:

Generator Deliverability

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

No problems identified.

Multiple Facility Contingency

(Double Circuit Tower Line, Stuck breaker and Bus Fault contingencies for the full energy output)

No problems identified.

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)

No problems identified.

New System Reinforcements

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

None.

Contribution to Previously Identified System Reinforcements
(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

None.

Short Circuit

Not required.

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:

No problems identified.

Connection Facilities

The Warren Solar I, LLC has submitted a "Form of Generation Interconnection Feasibility Study Agreement" to the PJM Interconnection, L.L.C. (PJM) requesting transmission service for a new solar generation project that is to be constructed near the town of Stewartsville in Warren County New Jersey. While the total capability of the Warren Solar (V2-010) Project is 20 MW, it will only be considered as a 7.6 MW capacity resource as per the PJM Agreements. The remaining 12.4 MW will be considered as energy only generation for study purposes.

As defined by the Warren Solar I, LLC in its service application, the collector substation for the Warren Solar (V2-010) Project will be located on a site approximately 150 feet from the existing Stewartsville 34.5 kV switching station. Attachment 1 shows a map of the Warren Solar I, LLC property with the location of the proposed new Warren Solar (V2-010) collector substation highlighted.

In accordance with the FE Requirements for Transmission Connected Facilities, the Warren Solar (V2-010) Project must be connected to the Jersey Central system at a substation designed in a ring bus configuration. While it would be desirable to expand the existing Stewartsville 34.5 kV switching station to a ring bus design for this purpose, it has been determined that this is not feasible. The primary reason is that there is insufficient space at the Stewartsville 34.5 kV switching station to implement such a plan without its rebuild. It also would not be the least cost option and would jeopardize the service to existing customers during the construction process. For these reasons a new 34.5 kV three breaker ring bus substation will need to be constructed at the Warren Solar I, LLC collector site to accommodate the Warren Solar (V2-010) Project connection. This will also require an

extension of the Washington and Morris Park to Stewartsville 34.5 kV lines through the Stewartsville switching station to the new Warren Solar substation. Attachment 2 shows an aerial view of the existing Stewartsville 34.5 kV switching station with the location of the new Warren Solar substation highlighted. It also identifies the facilities at the Stewartsville 34.5 kV switching station and the proposed extension of the 34.5 kV lines from Washington and Morris Park.

A conceptual one-line diagram for the new Warren Solar three breaker 34.5 kV ring bus substation, its connection to the Stewartsville switching station and the radial point of interconnection to the Warren Solar (V2-010) Project is shown on Attachment 3. While FE will construct, own and operate the new Warren Solar 34.5 kV substation and the facilities for its attachment to the FE system, the Warren Solar I, LLC will be responsible for acquiring all easements, properties and permits that will be required. The Warren Solar I, LLC will also be responsible for providing a level graded site for the new Warren Solar 34.5 kV substation and an access road as a prerequisite before work can begin. A summary of the Warren Solar (V2-010) Project Direct Connection facilities that will be required and their estimated cost are shown on Attachment 4.

Power Flow Analysis

A Power Flow study was conducted to determine the reliability impact of the proposed Warren Solar (V2-010) Project on the FE Transmission System. This study was completed using a 2013 summer peak load base case power flow that was provided by the PJM staff. It contains a detailed representation of the Jersey Central 34.5 kV system in the area near the Stewartsville connection point. The FE review of the Warren Solar (V2-010) Project included a contingency analysis to identify any facility loading or voltage condition that violates the ReliabilityFirst, PJM or FE Planning Criteria. The results of the FE analysis show that there are no criteria violations attributable to this project.

Short Circuit and Dynamics Analysis

A short circuit analysis was conducted by PJM and confirmed by the FE Protection staff. This analysis showed that no FE circuit breaker will exceed its interrupting capability with the implementation of the Warren Solar (V2-010) project. Therefore no network reinforcements will be required.

In accordance with the RTEP Feasibility Study process, the PJM staff did not perform a dynamic analysis for the Warren Solar (V2-010) Project. The project stability studies, if necessary, will be performed by the PJM staff as a part of the Facilities Study.

System Protection Analysis

An analysis was conducted to assess the impact of the Warren Solar (V2-010) Project on the system protection requirements in the area. The results of this review have identified the following minimum requirements:

Stewartsville 34.5 kV Substation

1. Construct a new control building or expand the existing one to accommodate the SCADA equipment required for the Direct Connection facilities. A final determination will be made as a part of the Facilities Study.

Warren Solar 34.5 kV Substation

The following relay equipment will be required:

1. Warren - Morris Park (W23-1) 34.5 kV line
   - SEL-321 (Primary)
   - SEL-311C (Backup)
   - SEL-501 (Breaker Failure)
   - SATEC meter
   - Set of 34.5 kV CCVTs

2. Warren - Washington (W23-2) 34.5 kV line
   - SEL-321 (Primary)
   - SEL-311C (Backup)
   - SEL-501 (Breaker Failure)
   - SATEC meter
   - Set of 34.5 kV CCVTs

3. Common Bus Breaker
   - SEL-387L (Primary)
   - SEL-311L (Backup)
   - SEL-501 (Breaker Failure)
   - SATEC meter

Warren Solar I, LLC will also be responsible for installing all project facilities beyond the point of interconnection and at its generation substation in compliance with the FE and regional requirements. This includes breaker protection, unit over/under voltage protection, over/under frequency protection and zero sequence voltage protection as may be required. Warren Solar I, LLC will also be responsible for all leasing costs for the circuits that may be required for the communication of data to PJM. FE will not provide a cost estimate for these facilities as a part of this report.

Metering

Warren Solar I, LLC will be required to comply with all FE Revenue Metering Requirements for Generation Interconnection Customers. These FE requirements are detailed on Attachment 5 to this report.

Compliance Issues

Warren Solar I, LLC will be responsible for meeting all criteria defined in the "FE Requirements for Transmission Connected Facilities" document that is posted on the PJM and FE web sites. This includes the provision of a reactive power capability sufficient to maintain a composite power delivery for the facility at the interconnection point at a power factor between .95 leading (absorbing MVARs) and .90 lagging (producing MVARs). Since the proposed solar generation project will provide no reactive power, Warren Solar I, LLC will be required to install a 6.6 MVAR switched capacitor with a series reactor to provide an equivalent amount of reactive compensation. The FE Transmission Operations group will provide a normal schedule for its operation.

Warren Solar I, LLC will also need to meet all PJM, ReliabilityFirst and NERC reliability criteria and operating procedures for standards compliance. For example, Warren Solar I, LLC must properly locate and report the over and under-voltage and over and under-frequency system protection elements for its project as well as submit the generator model and system protection data when requested by PJM and ReliabilityFirst when audits are performed. A failure to comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the FE system.

FE Facility Upgrades and Costs

The results of the FE analysis shows that no FE planning criteria violations are attributable to the addition of the Warren Solar (V2-010) Project for the conditions studied. Therefore the conclusion is that no transmission reinforcements will be required to provide the requested service.

The following is a summary of Direct Connection Local Upgrades on and around FE facilities that will be required for the direct connection of the Warren Solar (V2-010) Generation Project:

1. Construct new “Warren Solar” 34.5 kV Substation for 3 Breaker Ring Bus for the project attachment. This includes the required design and engineering, the acquisition of materials and construction of the required facilities.
   (Cost Estimate $2,799,500, PJM NUN n1615)

2. Implement the upgrades required at the Stewartsville 34.5 kV substation. This includes:

a. The installation of one disconnect switch between the Hull Lane and Washington 34.5 kV Lines and the installation of two line terminations for the looped attachments (PJM NUN n1616)
b. The construction of a new control building for the SCADA facilities that will be needed. (PJM NUN n1617)
c. Extension of the Morris Park - Stewartsville and Washington - Stewartsville 34.5 kV lines from the Stewartsville substation to the Warren Solar substation. (PJM NUN n 1618)
   (Cost Estimate $367,700 for items 2a thru 2c inclusive)

All cost data contained in this document should be considered estimated. The applicant will be responsible for the actual cost of construction. FE herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any connections to the transmission system.

Warren Solar I, LLC Requirements

The Warren Solar I, LLC will be responsible for constructing the radial attachment facilities from its collector point to the Warren Solar 34.5 kV substation. Warren Solar I, LLC will also

be responsible for meeting all criteria as specified in the applicable sections of the "FE Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of the minimum required FE generation interconnection relaying and control facilities.

2. The purchase and installation of a 34.5 kV interconnection metering instrument transformer. FE will provide the ratio and accuracy specifications based on the customer load and generation levels.

3. The purchase and installation of a revenue class bi-directional meter to measure the power delivery from the Warren Solar I, LLC units in compliance with the FE standards.

4. Since no backup 34.5 kV service has been requested, a reverse power relay must be installed to disconnect the project whenever an energy flow from the Jersey Central 34.5 kV system is detected. As an alternative to this relay, Warren Solar I, LLC has the option of executing a tariff agreement with Jersey Central that will specify the charges for any capacity and energy service that is provided.

5. The purchase and installation of supervisory control and data acquisition (SCADA) equipment to provide information in a compatible format to the FE Transmission System Control Center.

6. The establishment of dedicated communication circuits for SCADA report to the FE Transmission System Control Center and for dialup access to revenue metering.

7. A compliance with the FE and PJM generator power factor and voltage control requirements. Since the proposed solar units have no reactive capability, the installation of a 6.6 MVAR capacitor bank will be required to meet the established FE criteria. This includes the need to place a reactor in series with the capacitor bank to prevent switching surges from exceeding the capability of its attachment breaker and those located at the Stewartsville 34.5 kV substation. A specification of the size of this reactor and the need for any additional protection at the Stewartsville 34.5 kV substation will be determined as a part of the Impact and/or Facilities Study.

Note that the above requirements are in addition to any metering and communication facilities that must be installed for PJM compliance.

Summary

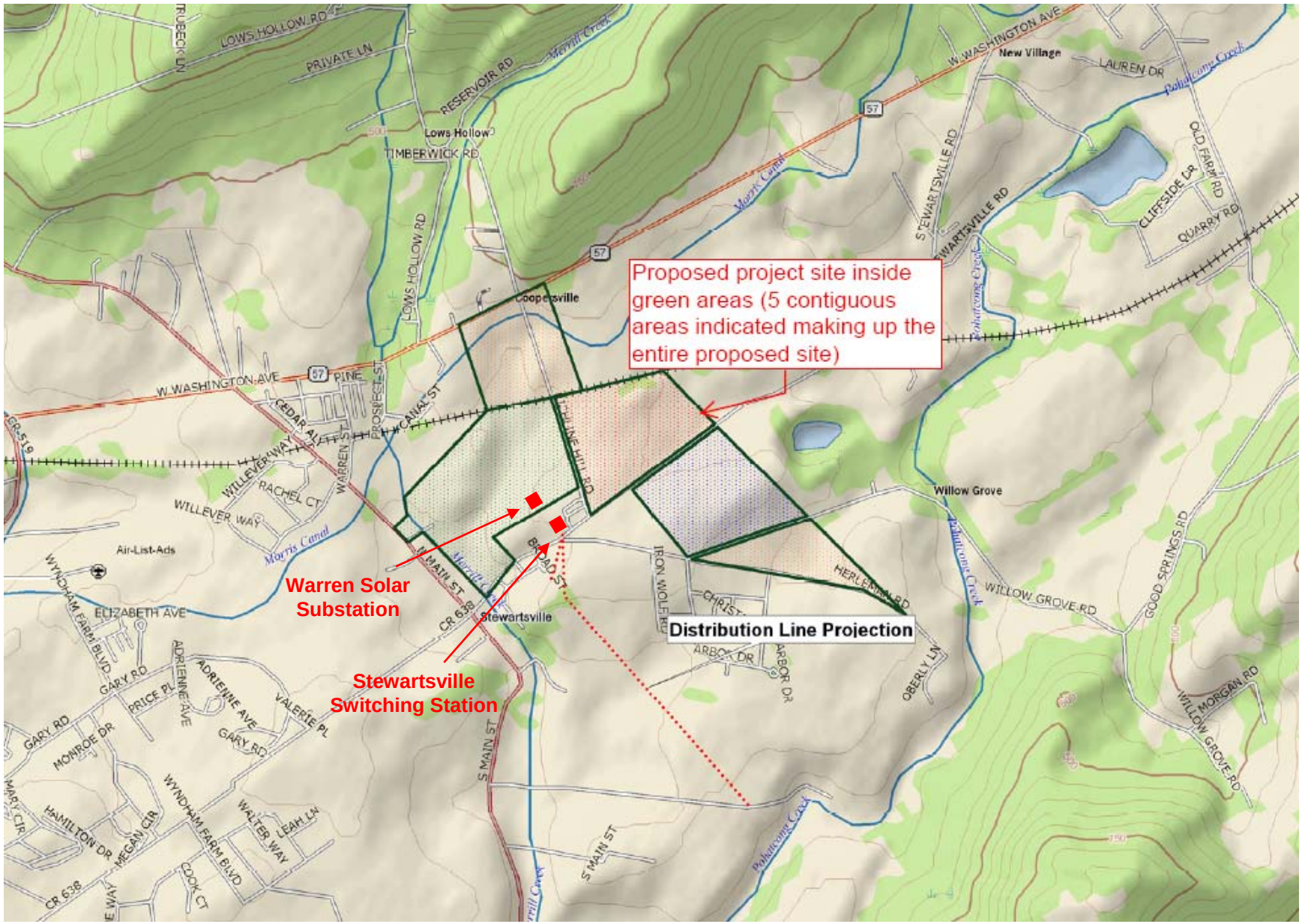
The direct connection of the Warren Solar (V2-010) Project generation to the FE transmission system will require the construction of a new three breaker 34.5 kV ring bus substation on a site to be provided by the Warren Solar I, LLC. This substation will be connected to the Jersey Central transmission system by two 34.5 lines that extend from the Stewartsville switching station and are sourced from the Morris Park and Washington substations. The total estimated cost of the Direct Connection upgrades is $3,167,200. No network facility or circuit breaker upgrades will be required to meet the PJM deliverability criteria. However; the Warren Solar I, LLC will be responsible for the installation of a 6.6 MVAR capacitor on its side of the point of interconnection in lieu of the generator not meeting the FE power factor requirements.

Based on the extent of the FE direct connection upgrades required to support this project, it is expected to take a minimum of one (1) year from the signing and full compliance with the financial, data and legal terms of a Connection Service Agreement to complete the upgrades required for the Warren Solar (V2-010) project. This also assumes that a meeting is scheduled by PJM to discuss the construction issues and mutually agree on an action plan immediately after all contractual conditions are satisfied.

The Warren Solar I, LLC will have the obligation to provide all right-of-way, permits, easements, etc. that will be needed for the attachment line. The project schedule assumes that there will be no delays in acquiring the permits that will be needed and that the transmission outages required can be scheduled when needed.

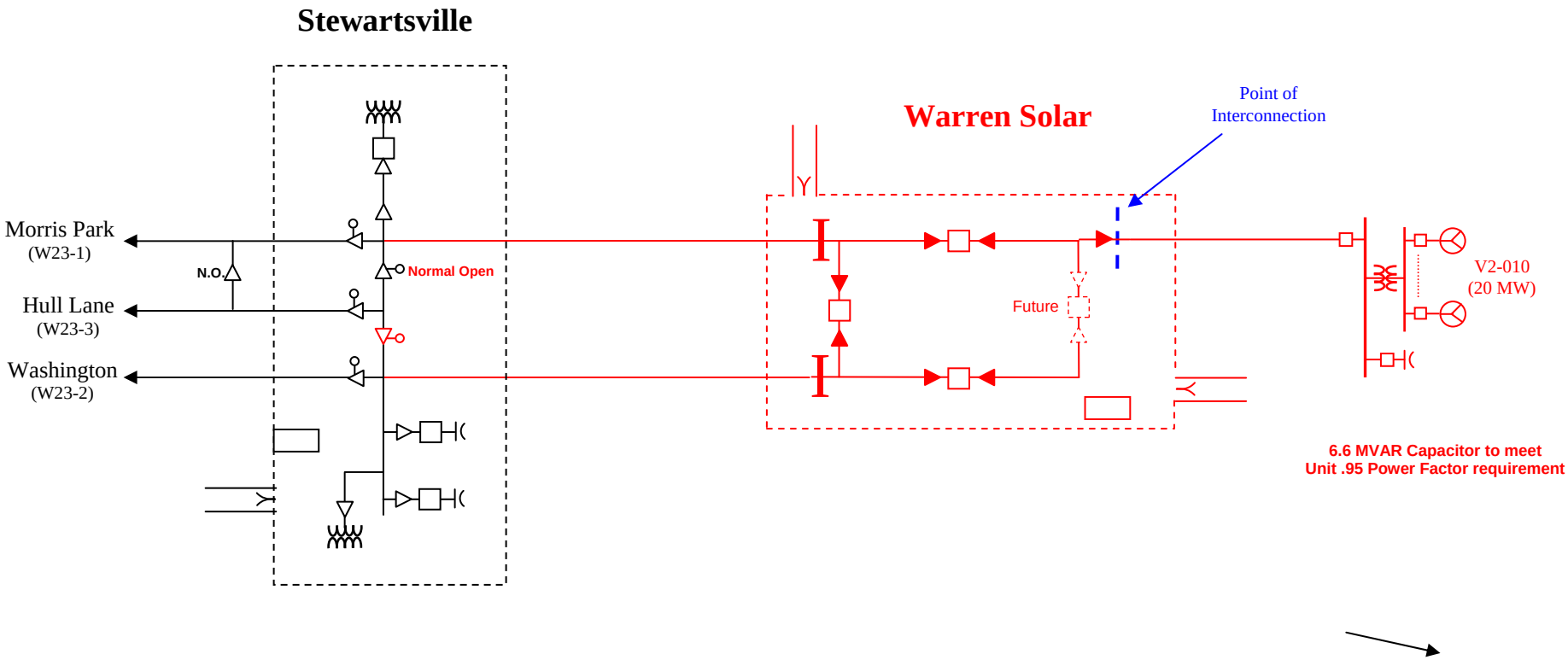
Note that the FE findings were made from a conceptual review of this project. A more detailed review of the connection facilities and their cost will be identified in the Facilities Study.

Attachment 1
Warren Solar (V2-010) Project Location



Attachment 2
Warren Solar (V2-010) Project Direct Connection

Attachment 3
Warren Solar (V2-010) Project Direct Connection
Conceptual One-Line



Attachment 4

Warren Solar (V2-010) Project Generation Project Feasibility Study

Looped Connection from Stewartsville 34.5 kV Substation

Substation Facility Upgrades

Substation	Connection Facilities	Cost ($)
Warren Solar 34.5 kV	Construct New 34.5 kV Substation for 3 Breaker Ring Bus	
	Include Control Building for Relay Panels, SCADA, etc.	
	Install Three 34.5 kV Circuit Breakers - Standard 2000 Amp, 40 kA Interrupting Capability each	
	Install Six New Disconnect Switches for Circuit Breakers- Standard 2000 Amp each	
	Install One New Disconnect Switch for Radial Generator Attachment - Standard 2000 Amp each	
	Install 795 ACSR Substation Conductor or Bus-bar as Needed	
	Install Three Line Termination Structures for the 34.5 KV Attachment Lines	
	Install Drop Loops for the Three Attachment Lines - 795 ACSR Wire	
	Miscellaneous Protection, Metering, RTU, SCADA	
	Total Cost:	**2,799,500**

Substation	Connection Facilities	Cost ($)
Stewartsville 34.5 kV	Install One Disconnect Switch Between the Hull Lane and Washington 34.5 kV Lines	
	Install Two Line Terminations for the 34.5 KV Looped Attachment of Warren Solar 34.5 kV Substation Lines	
	Install Drop Loops for the Two Attachment Lines - 397.5 Kcmil 26/7 ACSR Wire or Better	
	Construct New Control Building for Relay Panels, SCADA, etc.	
	Install SCADA for MOAB Supervisory Control	

New Facility Description	Network Upgrade Detail	
Warren Solar Project Line Extensions	Construct Morris Park-Stewartsville 34.5 kV Line Underground Cable Extension to Warren Solar Substation (200 feet)	
	Construct Washington-Stewartsville 34.5 kV Line Underground Cable Extension to Warren Solar Substation (200 feet)	
	Total Cost:	**367,700**

Total Direct Connection Upgrade Costs: **3,167,200**

Attachment 5

FirstEnergy Revenue Metering Requirements for Generation Interconnection Customer

Interconnection Customer shall install, own, operate, test and maintain the necessary revenue quality Metering Equipment. This includes current transformers, voltage transformers, mounting structures, wiring, meters, communication circuits, and associated devices. The Metering Equipment must meet the specifications listed in the FirstEnergy and regional transmission organization (RTO) connection documents. The FirstEnergy "Requirements for Transmission Connected Facilities" are located at: http://www.firstenergycorp.com/feconnect

The Metering Equipment shall be located at the generation facility on the high voltage side of the generator step-up transformers or facility main step-up transformer and/or station service power transformers. Power flows to and from the facility shall be compensated to the Point of Interconnection.

FirstEnergy will provide revenue quality Metering Equipment for a station service power supply at a generation facility if the supply is from the local FirstEnergy distribution system.

The revenue quality Metering Equipment shall be capable of collecting and storing bidirectional billing data. The billing data shall be stored in intervals specified by FirstEnergy, typically fifteen minutes or thirty minutes. The Interconnection Customer must provide FirstEnergy with remote access to the billing data in the Metering Equipment via a dedicated voice-grade analog telephone circuit. The Interconnection Customer shall provide FirstEnergy with contact information for the person or persons responsible for meter programming and Metering Equipment maintenance.

The Interconnection Customer shall consult with FirstEnergy regarding the revenue quality metering system design and provide the following information:

- Facility one line and revenue metering installation drawings (schematics, wiring diagrams, etc.)
- Estimated power flows to and from the facility at all revenue metering points
- Current transformer and voltage transformer specifications, including manufacturer, type, nameplate drawings, and certified accuracy test reports
- Revenue meter specifications including manufacturer, type, model number, and accuracy
- Revenue meter program information including but not limited to billing data recorder channel assignments, recorder pulse weights (Ke), and read-only password for access to interval data by the FirstEnergy billing data collection system (MV-90)
- Revenue meter telephone number
- Revenue meter loss compensation data (if applicable)

The Interconnection Customer shall provide FirstEnergy with prior notification of any modifications at the facility that will affect the revenue meter measurements, including substation reconfigurations and meter program changes.

The revenue metering system at each location shall be tested for accuracy by the Interconnection Customer once every two years. The Interconnection Customer shall give reasonable notice to FirstEnergy of the time when the testing is scheduled so that FirstEnergy may have representatives present. FirstEnergy and the RTO shall have the right to audit the revenue metering equipment and/or related documents. The Interconnection Customer shall be given a reasonable period of time to comply with any requests associated with an audit.