PJM Generator Interconnection

Facilities Study Report

Queue #AB1-124
Carroll – Monocacy 34.5 kV

(Revised)

March 2017

Queue #AB1-124 Caroll-Monocacy 34.5 kV
Facilities Study Report

Transmission Owner Facilities Study Summary

Description of the Project

Legore Bridge Solar Center, LLC, hereinafter referred to as "Interconnection Customer", has proposed a solar generating facility located at 12386 Clyde Young Rd, Keymar, Frederick County, Maryland connecting to the Carroll – Monocacy 34.5 kV line. Figure 1 provides an aerial view of the proposed location of the facility. The installed facilities will have a total capability of 20 MW with 7.6 MW of this output being recognized as capacity. The generation facility will interconnect with **Potomac Edison (PE)**, a FirstEnergy Company (FE), hereinafter referred to as "Transmission Owner".

The proposed interconnection of the Legore Bridge Solar Center, LLC AB1-124 Project will be made by a tap connection from the Carroll – Monocacy 34.5 kV line. From this point, one span of new 34.5 kV overhead line will be built by the Transmission Owner to the Interconnection Customer's new 34.5kV pole line to the project site. Figure 2 shows a conceptual one-line diagram of the proposed connection of AB1-124 to the Potomac Edison transmission system.

Schedule

The Interconnection Customer's proposed Commercial Operation Date (COD) for the generation facility is December 31, 2019. A Project Kickoff meeting must occur no later than May 1, 2019 to meet the Assumed Milestone Schedule listed below:

Assumed Milestone Schedule

11/30/2019 - Initial Back-feed through Project Substation Date
12/31/2019 - Project Commercial Operation Date

In order to meet the Back-feed Date, a proposed seven (7)-month schedule is estimated to complete the engineering, construction and associated activities, listed below, from the date of a fully executed Interconnection Construction Service Agreement and Construction Kick-off Meeting as detailed in the sections below.

Amendments to the System Impact Study Data / Results

- None

Scope of Interconnection Customer's Work

Direct Connection Facilities

Interconnection Customer will construct and own facilities including the solar collection system, switchgear, generation step up (GSU) transformer, 34.5 kV breaker with associated relay/protection/controls, lockable 34.5 kV air-break switch, and 34.5 kV line up to the Point of Interconnection (POI). The POI will be located at Interconnection Customer-owned pole, as shown on the one-line diagram in Figure 2. A fully rated, fault interrupting circuit breaker owned by Interconnection Customer and located at the POI is required on the high side of the GSU, between the disconnect switch and the generating station, to protect Interconnection Customer's facilities. Additionally, the Interconnection Customer will be responsible for paying all expenses to meet the Protection Requirements due to direct connections and other upgrades required by this project.

Project Scope

The proposed attachment of the AB1-124 Project will be made by a tap connection from the Carroll – Monocacy 34.5 kV line. From this point, Transmission Owner will build a one (1) span 34.5 kV line extension to a new pole to be installed, owned and maintained by Interconnection Customer, as shown in Figure 2 as the Point of Interconnection. Interconnection Customer will construct a 34.5 kV line extension from its new pole to its project substation and is responsible for constructing all of the facilities on its side of the point of interconnection. Interconnection Customer will be responsible for acquiring all rights-of-way, easements, properties, vegetation clearing, and permits that may be required to construct all attachment facilities, including proposed Transmission Owner 34.5 kV line facilities up to the POI.

Description of Facilities Work

Required facilities work to be constructed by Transmission Owner:

Attachment Facilities

- Potomac Edison line tap on Carroll – Monocacy 34.5 kV circuit to AB1-124 POI, includes two (2) 34.5 kV, 1200 A, load-break air switches, conductor and hardware up to the POI. Metering equipment, provided by the Transmission Owner, shall be installed in AB1-124 facilities by the Transmission Owner.
- Revise relay and meter settings on the Carroll 34.5 kV Line for the AB1-124 Generation Interconnection at Monocacy Substation.
- Revise relay and meter settings on the Monocacy 34.5 kV Line for the AB1-124 Generation Interconnection at Carroll Substation.

Direct Connection

- There are no Direct Connection Facilities required to support this interconnection.

Non-Direct Connection

- There are no Non-Direct Connection Facilities required to support this interconnection.

System Reinforcements

- There are no System Reinforcements required to support this interconnection.

Total Estimated Costs of Transmission Owner Facilities:

Description	Total (w/ Tax)	Tax (if applicable)	Total Cost
Carroll – Monocacy 34.5 kV Line Tap & Metering Install two (2) 34.5 kV, 1200 A, load-break air switches on the Carroll – Monocacy 34.5 kV line. Tap the line and build a single span of 34.5 kV line to POI. Install 34.5 kV metering equipment in AB1-124 facilities.	$158,500	$38,100	$120,400
Monocacy Substation Revise relay and meter settings on the Carroll 34.5 kV line for the AB1-124 generation interconnection.	$7,600	$1,700	$5,900
Carroll Substation Revise relay and meter settings on the Monocacy 34.5 kV line for the AB1-124 generation interconnection.	$7,600	$1,700	$5,900
Total Attachment Facilities Costs	**$173,700**	**$41,500**	**$132,200**

Legore Bridge Solar Center, LLC will be responsible for the actual cost of the direct connection that is implemented. Potomac Edison will provide, own, operate, test and maintain the revenue metering at the Interconnection Customer's expense.

Summary of Proposed Schedule for Completion of Work:

The Transmission Owner assumes a seven (7)-month construction schedule to complete construction and the associated activities listed above from the date of a fully executed Interconnection Construction Service Agreement and Construction Kick-Off Meeting. Construction cannot begin until after all applicable permits have been obtained.

Activity Schedule	Start Month	End Month
Preliminary Engineering	1	2
Detailed Engineering	3	4
Equipment Procurement – Delivery	4	5
Above Grade Construction	4	6
Testing & Commissioning	6	7

Generation Connection Requirements

The proposed interconnection facilities must be designed in accordance with the Transmission Owner's *Requirements for Transmission Connected Facilities* document. The document is located at either of the following links:

www.firstenergycorp.com/feconnect
www.pjm.com/planning/design-engineering/to-tech-standards.aspx

Generation Connection Requirements

In addition to the Potomac Edison facilities, Legore Bridge Solar Center, LLC will also be responsible for meeting all criteria as specified in the applicable sections of the FirstEnergy "Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of fully rated, fault interrupting circuit breaker on the high side of the AB1-124 step up transformer, and located at the POI.

2. The purchase and installation of the minimum required FirstEnergy generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

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

4. The establishment of dedicated communication circuits for SCADA to the FirstEnergy Transmission System Control Center.

5. A compliance with the FirstEnergy and PJM generator power factor and voltage control requirements.

6. The execution of a back-up retail service agreement with the electric distribution company to serve the customer load supplied from AB1-124 generation project interconnection point when the units are out-of-service.

7. Provide a range of dynamic reactive capability that supports this project operation from 0.95 leading to 0.95 lagging power factor measured at Generator's Terminal (Power flow analysis). The addition of solar projects can cause voltage swings as their output oscillates with moving clouds without continuous regulation, and system voltages can exceed the established limits. Should the Interconnection Customer fail to provide dynamic reactive capability from this generation project for any reason once interconnected, PJM and/or FirstEnergy Dispatchers may curtail its output to prevent non-compliance with voltage criteria.

8. Any inverter to be used for this project shall meet UL 1741 standards otherwise anti-islanding direct transfer trip facilities to remote substations will be required.

9. The 34.5 kV side of the step up transformer shall be either ungrounded wye or delta in order to avoid possible miscoordination which triggers the need for a substation ring bus connection rather than a tap connection.

The above requirements are in addition to any metering or other requirements imposed by PJM.

Design Requirements

Interconnection Customer is responsible for specifying appropriate equipment and facilities such that the parallel generation is compatible with Transmission Owner's Transmission System. Interconnection Customer is also responsible for meeting any applicable federal, state, and local codes.

System Relay and Protection Requirements

- Standard 34.5 kV line protection for the Carroll - Monocacy 34.5 kV line and AB1-124 34.5 kV line.

- The customer will provide further information to ensure the inverter meets the requirements of UL 1741 without requiring the addition of transfer trip facilities, or provide an alternate inverter. If the UL 1741 standard is met in such a manner, then anti-islanding direct transfer trip to the remote substations will not be required.

The 34.5kV interconnection proposal will require Interconnection Customer to meet applicable "Technical Requirements" as outlined in First Energy's document titled *Requirements for Transmission Connected Facilities.* This document is located at either of the following links:

www.firstenergycorp.com/feconnect
www.pjm.com/planning/design-engineering/to-tech-standards.aspx

Metering, SCADA and Communications

PJM Requirements

The Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for Interconnection Customer's generating Resource. Reference PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

Interconnection Customer will be responsible for designing, furnishing and installing Supervisory Control and Data Acquisition (SCADA) Remote Terminal Unit (RTU) equipment in its generation substation, and for obtaining the telecommunication circuits and data transfer from the RTU to the Transmission Owner Data Center.

Transmission Owner (Potomac Edison) Requirements

Transmission Owner will provide 34.5 kV interconnection metering equipment and shall be installed in AB1-124 facilities by the Transmission Owner. Transmission Owner will provide the ratio and accuracy specifications based upon the customer load and generator levels.

Interconnection Customer to provide 34.5 kV revenue metering equipment poles/foundations, mounting structures, and telecommunications per Transmission Owner specifications.

More information on the Transmission Owner's Revenue Metering Requirements may be found in the *FirstEnergy Requirements for Transmission Connected Facilities* document located at the following links:

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www.pjm.com/planning/design-engineering/to-tech-standards.aspx

Environmental, Real Estate and Permitting Issues

The following are possible environmental, real estate and permitting issues:

- Interconnection Customer will be responsible for acquiring all right of ways, easements, permits, access, and grading for new Transmission Owner 34.5 kV line facilities.
- Interconnection Customer to provide a permanent easement to Transmission Owner for access to Interconnection Customer's POI and metering interconnection (Ref. Figure 2).
- It is not anticipated that any environmental permits for the Transmission Owner's portion of the project will be required.

Back-up Service Agreement

The execution of a back-up service agreement with the electric distribution company will be necessary to serve the customer load supplied from AB1-124 generation project interconnection point when the units are out-of-service. This assumes the intent of the Interconnection Customer is to net the generation with the load.

Assumptions/Qualifiers

The accomplishment of the work on the Transmission Owner system to support the estimated costs and proposed schedule is dependent on the following:

- Obtaining the necessary transmission line outages. Transmission line outages are typically not granted from June to September and are discouraged during extreme winter conditions. PJM and FirstEnergy TSO requires 6 to 12-month notice for greater than 5-day and 30-day outages respectively.
- Interconnection Customer provides rough grade of property for the TRANSMISSION OWNER 34.5 kV facilities and an access road of the delivery of equipment to this site to help prevent any equipment delivery, environmental, or regulatory delays.
- Estimates assume no significant rock encountered during construction, and suitable soil conditions exist to accommodate digging for new poles. This could affect costs and timing and equipment requirements.
- No equipment delivery, environmental, permitting, regulatory or real estate delays.
- No extreme weather.
- No force majeure.

ATTACHMENTS

Figure 1
PJM Queue AB1-124
Project Location

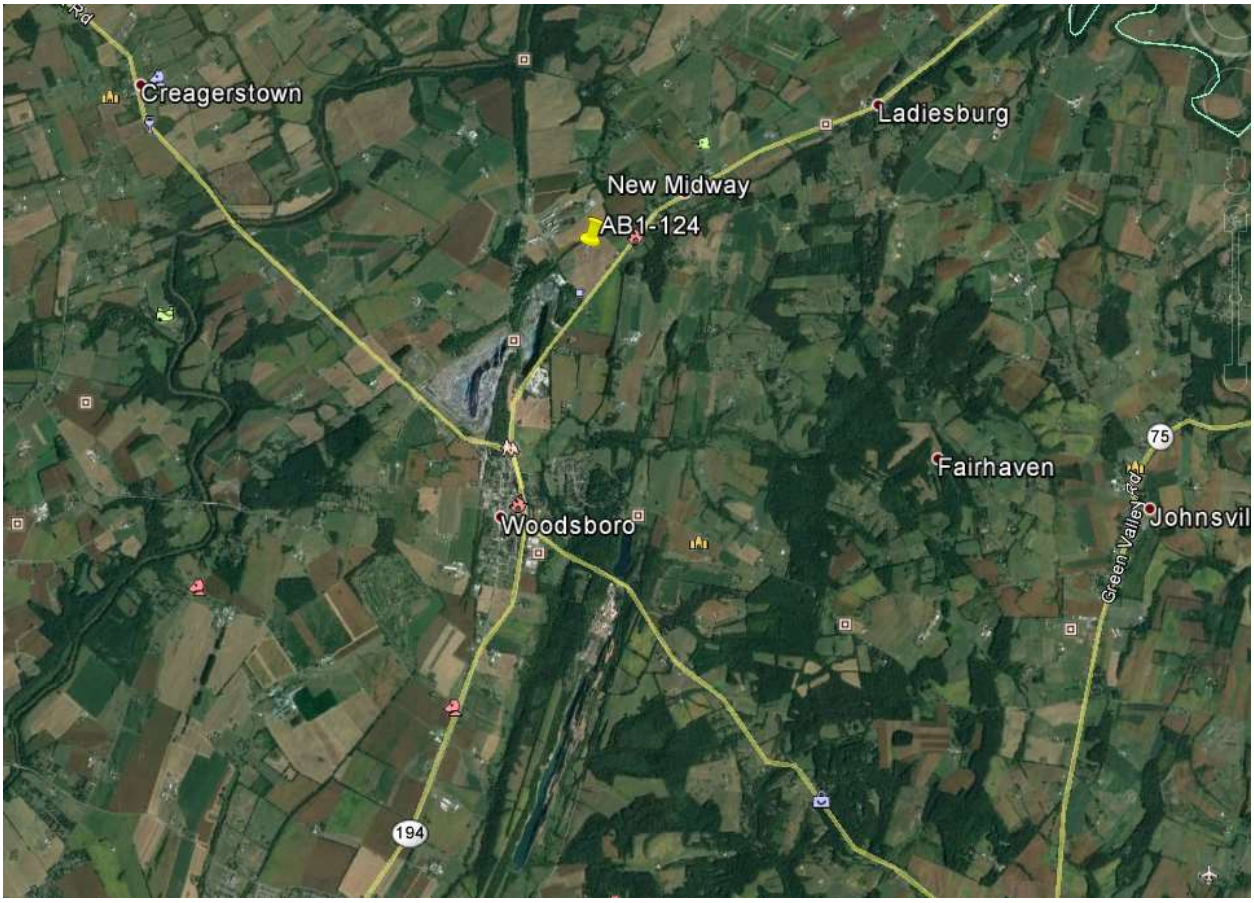
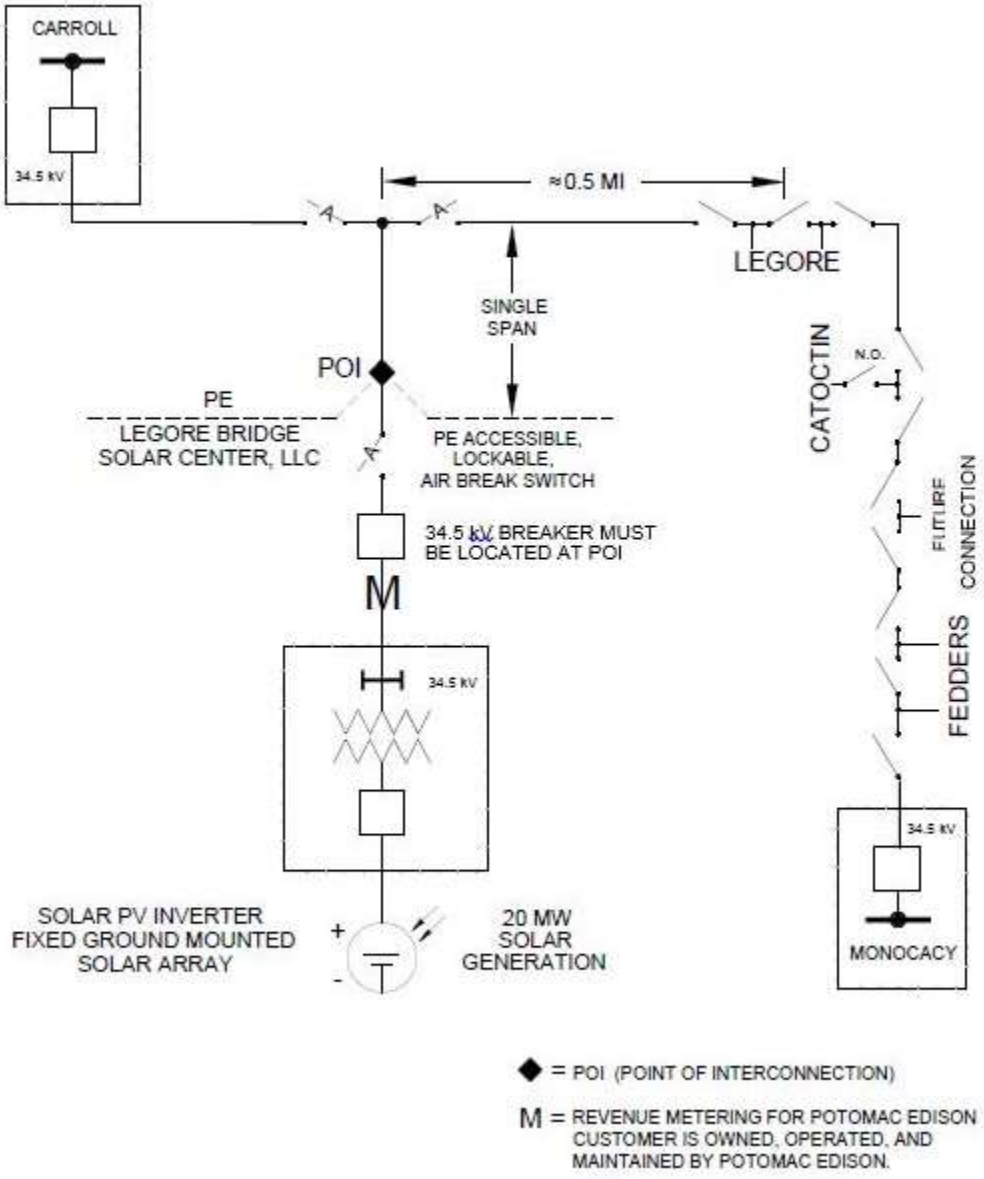


Figure 2
PJM Queue AB1-124
Interconnection Single-Line Diagram



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Amendments to the System Impact Study Data / Results

- None

Scope of Interconnection Customer's Work

Direct Connection Facilities

Interconnection Customer will construct and own facilities including the solar collection system, switchgear, generation step up (GSU) transformer, 34.5 kV breaker with associated relay/protection/controls, lockable 34.5 kV air-break switch, and 34.5 kV line up to the Point of Interconnection (POI). The POI will be located at Interconnection Customer-owned pole, as shown on the one-line diagram in Figure 2. A fully rated, fault interrupting circuit breaker owned by Interconnection Customer and located at the POI is required on the high side of the GSU, between the disconnect switch and the generating station, to protect Interconnection Customer's facilities. Additionally, the Interconnection Customer will be responsible for paying all expenses to meet the Protection Requirements due to direct connections and other upgrades required by this project.

Project Scope

The proposed attachment of the AB1-124 Project will be made by a tap connection from the Carroll – Monocacy 34.5 kV line. From this point, Transmission Owner will build a one (1) span 34.5 kV line extension to a new pole to be installed, owned and maintained by Interconnection Customer, as shown in Figure 2 as the Point of Interconnection. Interconnection Customer will construct a 34.5 kV line extension from its new pole to its project substation and is responsible for constructing all of the facilities on its side of the point of interconnection. Interconnection Customer will be responsible for acquiring all rights-of-way, easements, properties, vegetation clearing, and permits that may be required to construct all attachment facilities, including proposed Transmission Owner 34.5 kV line facilities up to the POI.

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Direct Connection

- There are no Direct Connection Facilities required to support this interconnection.

Non-Direct Connection

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System Reinforcements

- There are no System Reinforcements required to support this interconnection.

Total Estimated Costs of Transmission Owner Facilities:

Description	Total (w/ Tax)	Tax (if applicable)	Total Cost
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2. The purchase and installation of the minimum required FirstEnergy generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

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

4. The establishment of dedicated communication circuits for SCADA to the FirstEnergy Transmission System Control Center.

5. A compliance with the FirstEnergy and PJM generator power factor and voltage control requirements.

6. The execution of a back-up retail service agreement with the electric distribution company to serve the customer load supplied from AB1-124 generation project interconnection point when the units are out-of-service.

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- It is not anticipated that any environmental permits for the Transmission Owner's portion of the project will be required.

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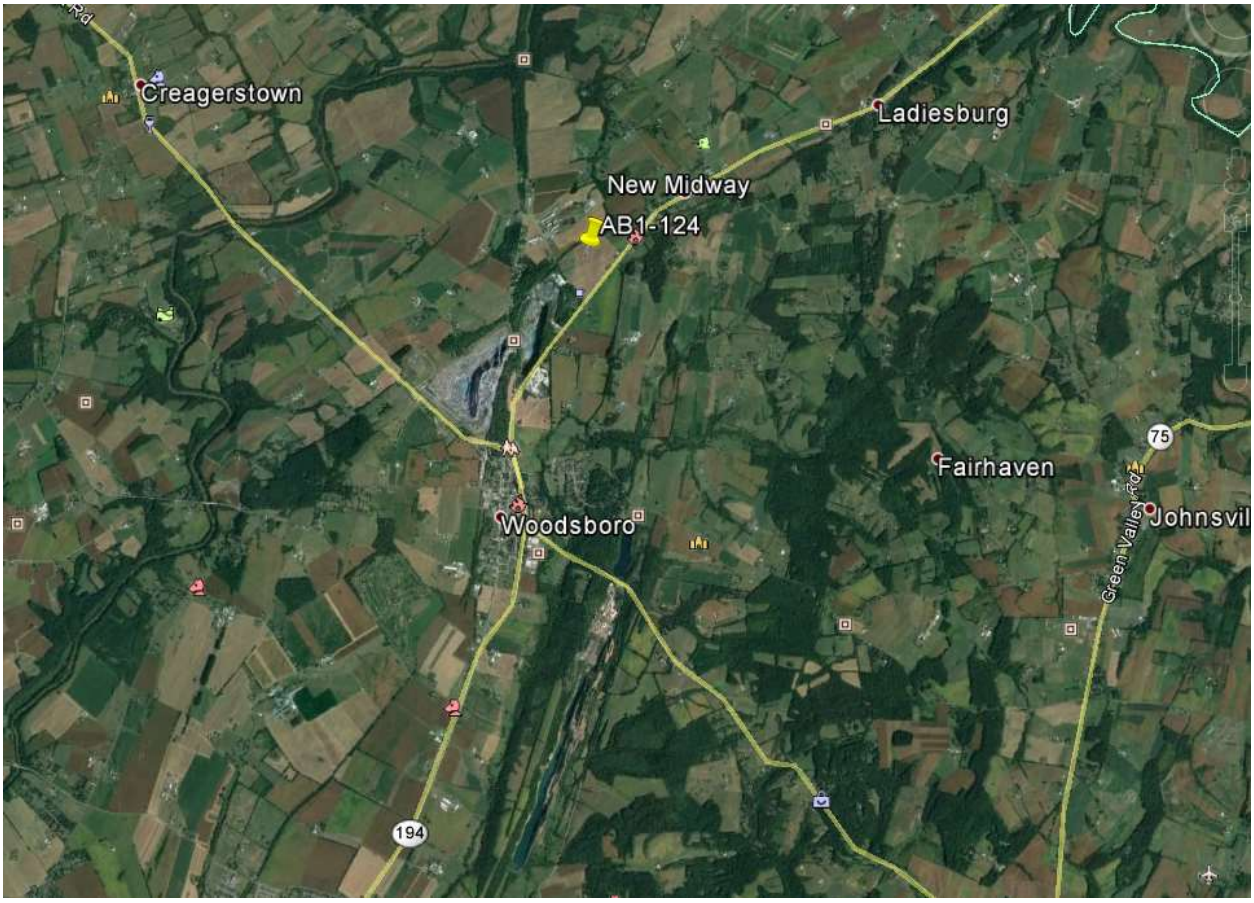

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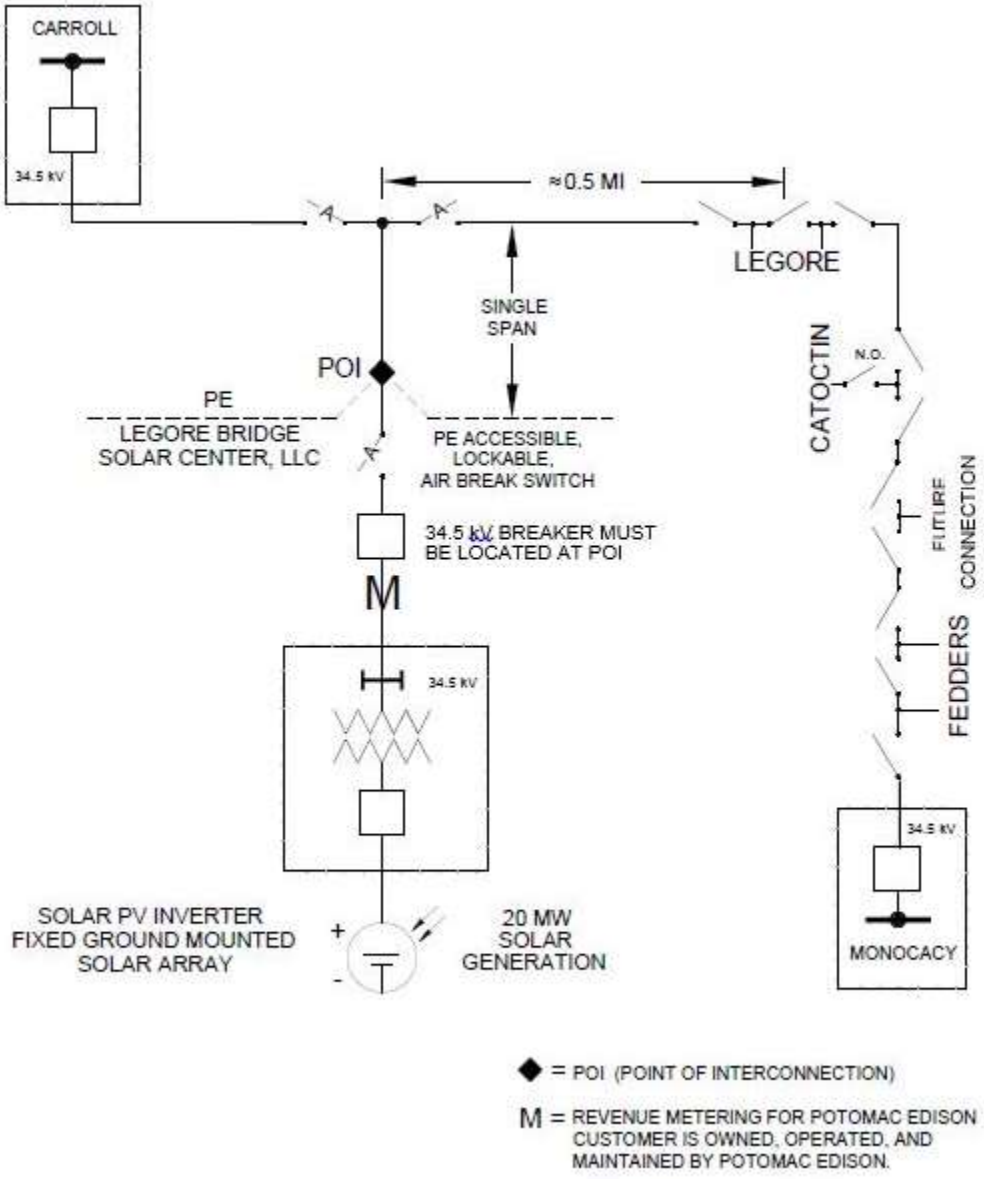

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Total Attachment Facilities Costs	**$173,700**	**$41,500**	**$132,200**

Legore Bridge Solar Center, LLC will be responsible for the actual cost of the direct connection that is implemented. Potomac Edison will provide, own, operate, test and maintain the revenue metering at the Interconnection Customer's expense.

Summary of Proposed Schedule for Completion of Work:

The Transmission Owner assumes a seven (7)-month construction schedule to complete construction and the associated activities listed above from the date of a fully executed Interconnection Construction Service Agreement and Construction Kick-Off Meeting. Construction cannot begin until after all applicable permits have been obtained.

Activity Schedule	Start Month	End Month
Preliminary Engineering	1	2
Detailed Engineering	3	4
Equipment Procurement – Delivery	4	5
Above Grade Construction	4	6
Testing & Commissioning	6	7

Generation Connection Requirements

The proposed interconnection facilities must be designed in accordance with the Transmission Owner's *Requirements for Transmission Connected Facilities* document. The document is located at either of the following links:

www.firstenergycorp.com/feconnect
www.pjm.com/planning/design-engineering/to-tech-standards.aspx

Generation Connection Requirements

In addition to the Potomac Edison facilities, Legore Bridge Solar Center, LLC will also be responsible for meeting all criteria as specified in the applicable sections of the FirstEnergy "Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of fully rated, fault interrupting circuit breaker on the high side of the AB1-124 step up transformer, and located at the POI.

2. The purchase and installation of the minimum required FirstEnergy generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

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

4. The establishment of dedicated communication circuits for SCADA to the FirstEnergy Transmission System Control Center.

5. A compliance with the FirstEnergy and PJM generator power factor and voltage control requirements.

6. The execution of a back-up retail service agreement with the electric distribution company to serve the customer load supplied from AB1-124 generation project interconnection point when the units are out-of-service.

7. Provide a range of dynamic reactive capability that supports this project operation from 0.95 leading to 0.95 lagging power factor measured at Generator's Terminal (Power flow analysis). The addition of solar projects can cause voltage swings as their output oscillates with moving clouds without continuous regulation, and system voltages can exceed the established limits. Should the Interconnection Customer fail to provide dynamic reactive capability from this generation project for any reason once interconnected, PJM and/or FirstEnergy Dispatchers may curtail its output to prevent non-compliance with voltage criteria.

8. The specified inverter to be used for this project, Parker 890 GTB, shall meet UL 1741 standards otherwise anti-islanding direct transfer trip facilities to remote substations will be required.

9. The 34.5 kV side of the step up transformer shall be either ungrounded wye or delta in order to avoid possible miscoordination which triggers the need for a substation ring bus connection rather than a tap connection.

The above requirements are in addition to any metering or other requirements imposed by PJM.

Design Requirements

Interconnection Customer is responsible for specifying appropriate equipment and facilities such that the parallel generation is compatible with Transmission Owner's Transmission System. Interconnection Customer is also responsible for meeting any applicable federal, state, and local codes.

System Relay and Protection Requirements

- Standard 34.5 kV line protection for the Carroll - Monocacy 34.5 kV line and AB1-124 34.5 kV line.

- A Parker 890 GTB is specified as the inverter to be used for this application. As of the Parker publication date of December 2014 for this device, a UL 1741 certification was listed as pending. The customer will provide further information to ensure the Parker 890 GTB inverter meets the requirements of UL 1741 without requiring the addition of transfer trip facilities, or provide an alternate inverter. If the UL 1741 standard is met in such a manner, then anti-islanding direct transfer trip to the remote substations will not be required.

The 34.5kV interconnection proposal will require Interconnection Customer to meet applicable "Technical Requirements" as outlined in First Energy's document titled *Requirements for Transmission Connected Facilities.* This document is located at either of the following links:

www.firstenergycorp.com/feconnect
www.pjm.com/planning/design-engineering/to-tech-standards.aspx

Metering, SCADA and Communications

PJM Requirements

The Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for Interconnection Customer's generating Resource. Reference PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

Interconnection Customer will be responsible for designing, furnishing and installing Supervisory Control and Data Acquisition (SCADA) Remote Terminal Unit (RTU) equipment in its generation substation, and for obtaining the telecommunication circuits and data transfer from the RTU to the Transmission Owner Data Center.

Transmission Owner (Potomac Edison) Requirements

Transmission Owner will provide 34.5 kV interconnection metering equipment and shall be installed in AB1-124 facilities by the Transmission Owner. Transmission Owner will provide the ratio and accuracy specifications based upon the customer load and generator levels.

Interconnection Customer to provide 34.5 kV revenue metering equipment poles/foundations, mounting structures, and telecommunications per Transmission Owner specifications.

More information on the Transmission Owner's Revenue Metering Requirements may be found in the *FirstEnergy Requirements for Transmission Connected Facilities* document located at the following links:

www.firstenergycorp.com/feconnect

www.pjm.com/planning/design-engineering/to-tech-standards.aspx

Environmental, Real Estate and Permitting Issues

The following are possible environmental, real estate and permitting issues:

- Interconnection Customer will be responsible for acquiring all right of ways, easements, permits, access, and grading for new Transmission Owner 34.5 kV line facilities.
- Interconnection Customer to provide a permanent easement to Transmission Owner for access to Interconnection Customer's POI and metering interconnection (Ref. Figure 2).
- It is not anticipated that any environmental permits for the Transmission Owner's portion of the project will be required.

Back-up Service Agreement

The execution of a back-up service agreement with the electric distribution company will be necessary to serve the customer load supplied from AB1-124 generation project interconnection point when the units are out-of-service. This assumes the intent of the Interconnection Customer is to net the generation with the load.

Assumptions/Qualifiers

The accomplishment of the work on the Transmission Owner system to support the estimated costs and proposed schedule is dependent on the following:

- Obtaining the necessary transmission line outages. Transmission line outages are typically not granted from June to September and are discouraged during extreme winter conditions. PJM and FirstEnergy TSO requires 6 to 12-month notice for greater than 5-day and 30-day outages respectively.
- Interconnection Customer provides rough grade of property for the TRANSMISSION OWNER 34.5 kV facilities and an access road of the delivery of equipment to this site to help prevent any equipment delivery, environmental, or regulatory delays.
- Estimates assume no significant rock encountered during construction, and suitable soil conditions exist to accommodate digging for new poles. This could affect costs and timing and equipment requirements.
- No equipment delivery, environmental, permitting, regulatory or real estate delays.
- No extreme weather.
- No force majeure.

ATTACHMENTS

Figure 1
PJM Queue AB1-124
Project Location

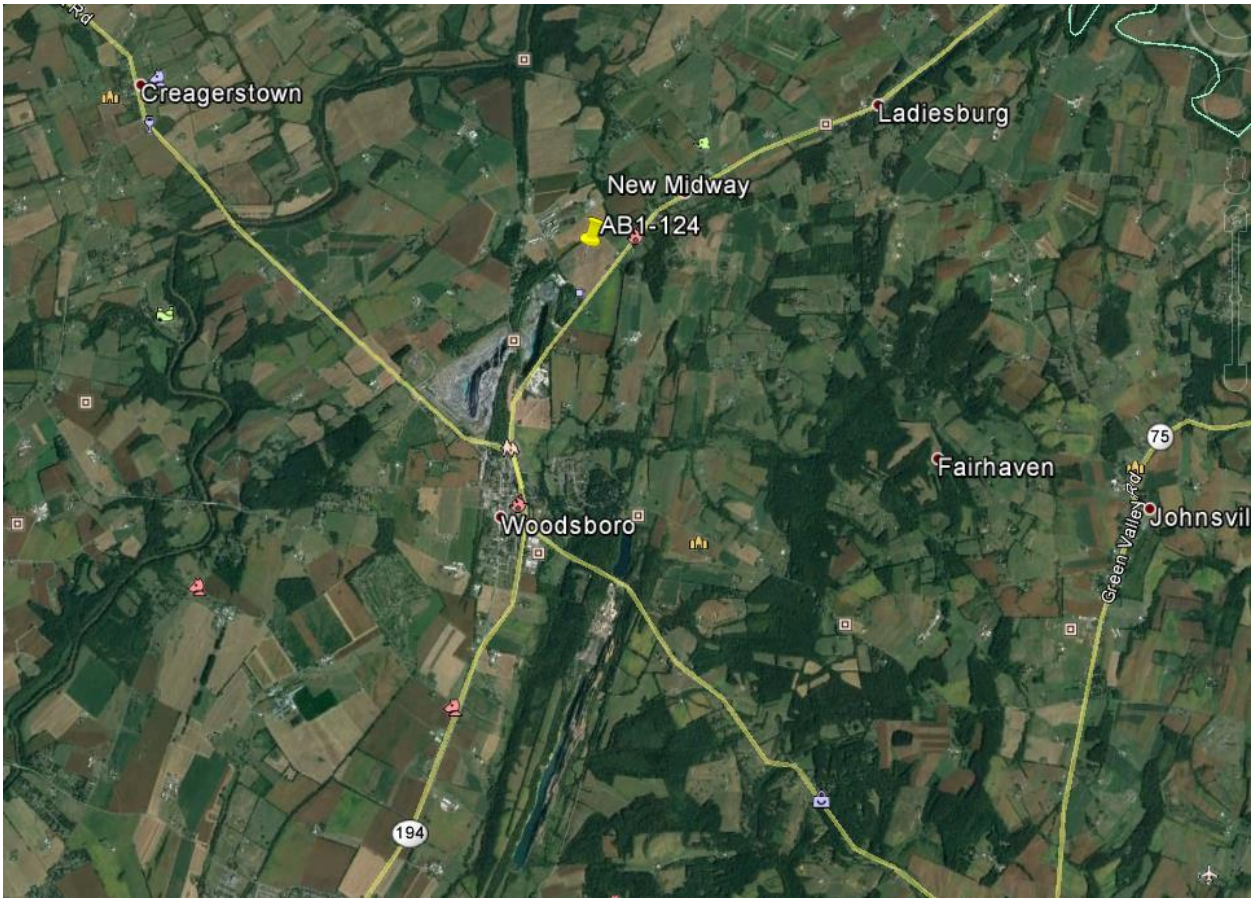

Figure 2
PJM Queue AB1-124
Interconnection Single-Line Diagram