Generation Interconnection
Facility Study Report

For

PJM Generation Interconnection Request
Queue Position AC2-088/AD1-136

South Bethel – Brown 69 kV
45.8 MW Capacity / 80 MW Energy

Fourth Revision March / 2020

Third Revision February / 2020

Second Revision: January / 2020

First Revision: October / 2019

Original Issue: December 2018

Introduction

This Facilities Study has been prepared in accordance with the PJM Open Access Transmission Tariff §207, as well as the Facilities Study Agreement between Nestlewood Solar I LLC, (Interconnection Customer (IC)) and PJM Interconnection, LLC (Transmission Provider (TP)). The Interconnected Transmission Owner (ITO) is Duke Energy Ohio and Kentucky (DEOK).

General

The Interconnection Customer (IC) has proposed a combined 80 MW solar photovoltaic generating facility located near Leonard Road, Brown County, Ohio. The facility is a combination of the AC2-088 – 70 MW project and the AD1-136 – 10 MW project. Both projects will be located at the same Interconnection Customer site and will connect as a single generation plant into the Duke Energy Ohio and Kentucky (DEOK) transmission system. AC2-088 was evaluated for compliance with reliability criteria for summer peak conditions in 2020. The combined projects, AC2-088 and AD1-136, were evaluated for compliance with reliability criteria for summer peak conditions in 2021.

The proposed in-service date is November 30, 2021. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection (POI)

AC2-088/AD1-136 will interconnect with the ITO transmission system via a new three breaker ring bus switching station tapping the South Bethel – Brown 69 kV line. The Point of interconnection will be located where Duke Energy's overhead conductors form the interconnection switching station terminate into the Interconnection Customer's structure mounted switch.

Cost Summary

The AC2-088/AD1-136 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities[1]	$ 29,553
Direct Connection Network Upgrades [2]	$ 181,514
Non Direct Connection Network Upgrades	$ 1,117,962
Allocation for New System Upgrades	$ 0
Contribution for Previously Identified Upgrades	$ 0
Total Costs	$ 1,329,029

[1] It is assumed that the Interconnection Customer will construct the Attachment Facilities from the Interconnection Substation to the POI pursuant to Option to Build. The Attachment Facilities cost above is for the supervision of the Attachment Facilities Scope to be performed by the IC pursuant to the Option to Build and the Transmission Owner costs for the supply, installation, testing and commissioning of the Revenue Meter.

[2] It is assumed that the Interconnection Customer has elected the Option to Build the Interconnection Substation. The estimated Direct Connection costs provided above are for the Transmission Owner supervision of the scope of work to be performed pursuant to the Option to Build. Please see Part B Section 3 of this report for details.

A. Transmission Owner Facilities Study Summary

1. Description of Project

Nestlewood Solar I LLC, the Interconnection Customer (IC) has proposed a combined 80 MW solar photovoltaic generating facility located near Leonard Road, Brown County, Ohio. The facility is a combination of the AC2-088 70 MW project and the AD1-136 10 MW project. Both projects will be located at the same Interconnection Customer site and will connect as a single generation plant into the Duke Energy Ohio and Kentucky (DEOK) 69 kV networked transmission system. AC2-088 was evaluated for compliance with reliability criteria for summer peak conditions in 2020. The combined projects, AC2-088 + AD1-136, were evaluated for compliance with reliability criteria for summer peak conditions in 2021.

The requested in-service date is November 30, 2021. **This study does not imply an ITO commitment to this in-service date.**

2. Amendments to the System Impact Study data or System Impact Study Results

The System Impact Study for AD1-136, the 10 MW uprate to AC2-088, identified an over dutied in line switch on the South Bethel-Brown transmission circuit. As a mitigation, the switch required replacement with a larger capacity switch and a new mounting structure. However, subsequent to that study and prior to the issuing of this Facilities Study report, the switch was replaced with a larger capacity switch and new mounting structure by DEOK during an asset management project. As a result, the mitigation measure and the associated costs have been excluded from the Facilities Study.

The following inputs to the cost estimate have changed:

- Larger footprint of overall substation to accommodate new minimum approach distance design criteria requires
    - additional stone
    - additional fencing
    - additional grounding grid
    - additional bus
- Addition of nine 69 kV CCVTs
- Contracted engineering labor will be used in place of internal labor
- Contracted construction labor will be used in place of internal labor

3. Interconnection Customer's Submitted Milestone Schedule

A project duration schedule has been provided as part of this report. The schedule assumes standard land use and environmental permitting and approval processes. The actual in-service

date will also be influenced by the ability to get an outage on the South Bethel-Brown feeder. This is generally limited to the spring and fall seasons.

4. Interconnection Customer's Scope of Work

The Interconnection Customer is responsible for all design and construction related activities on their side of the POI. Route selection, line design, and right-of-way acquisition for the IC's facilities are not included in this report and are the responsibility of the IC.

The IC will be required to meet the metering and communication requirements specified in the Metering and Communications section of this report.

The Interconnection Customer will procure land for the new interconnection switching substation. The property rights will be transferred to Duke Energy before construction of the substation will begin. The size of the property will be determined by Duke Energy during the engineering phase of the project. Duke Energy will determine the location of the substation on the property. The property shall have direct access to county or state maintained roadway. The constructed substation and surrounding land shall not require a retention or detention pond, or a retaining wall.

The Interconnection Customer will be required to engineer, procure, and construct a 69 kV circuit and communication circuits from the generating facility to the Point of Interconnection. At the interconnection switching substation, the 69 kV circuit shall have a terminating structure with a switch to act as the POI. This structure/switch shall be approximately 25 feet outside the new substation fence. The communications circuits will connect at a junction point near the terminating structure. The Interconnection Customer will be required to acquire all permits necessary to construct Interconnection Customer owned facilities on Duke Energy property.

The dynamic simulation study results show that the AD1-136 and AC2-088 have met the 0.95 leading power factor requirements. However, an additional 7.2 Mvar are required for the plant to meet the 0.95 lagging power factor requirements. Interconnection Customer is required to install necessary equipment on the Interconnection Customer's side of the Point of Interconnection to provide the 7.2 Mvar necessary to meet the 0.95 lagging power factor requirements.

The Interconnection Customer will be responsible for meeting all criteria as specified in the applicable sections of the Duke Energy Midwest Transmission Systems Facility Connection Requirements document. DEOK reserves the right to review the electrical protection design and relay settings for interconnecting customer facilities to ensure that the protective relaying equipment will be compatible with that installed at the new substation. DEOK personnel must be present at the time of commissioning to witness proper function of the protection scheme and related coordination.

All work to accommodate the interconnection of AC2-088/AD1-136 is dependent upon the IC obtaining all necessary permits. In addition, the IC shall be responsible for acquiring all real property rights and acquisitions, including but not limited to rights of way and easements. Any deferment in obtaining the necessary real property rights, acquisitions and permits required for this interconnection may delay the construction schedule.

Refer to Section B item (1) and item (3) of this report for information on Transmission Owner Facilities to be constructed by the Interconnection Customer pursuant to the Option to Build.

5. Description of Facilities Included in the Facilities Study

This Facilities Study assumes that the IC will construct a new substation with a 69 kV three-position ring bus on IC supplied land and the Attachment Facilities from the Interconnection Substation to the POI pursuant to Option to Build and transfer ownership to DEOK upon completion of the scope of work. DEOK will supply, install, test and commission the Revenue Meter. If the election of Option to Build is withdrawn or terminated, then DEOK will construct the new substation on IC supplied land and construct the Attachment Facilities.

Two of the positions on the ring bus will be transmission line terminals for the tie-in of the South Bethel-Brown transmission circuit. The third position will be a terminal configured for the interconnection of the AC2-088/AD1-136 80MW generating facility. The installation of the substation will require modifications to the South Bethel-Brown transmission circuit to loop it in and out of the new ring bus. The new ring bus substation will be located at the northeast corner of the Leonard Road and Bethel-Maple Road intersection, directly across Bethel-Maple Road from the South Bethel-Brown transmission circuit.

The IC is required to construct a 69 kV feeder circuit from the solar generating facility to within 25 feet of the new ring bus substation's fence. The feeder will terminate at an IC owned pole and pole mounted switch. The IC will construct the remainder of the feeder from the Switch to the interconnection substation pursuant to the Option to Build, but DEOK will own it. DEOK will supply, install, test and commission the Revenue Meter in the Attachment Facilities. The DEOK side of the switch will act as the Point of Interconnection. See Attachment #1.

6. Total Costs of Transmission Owner Facilities included in Facilities Study

Work Description	Total Cost
Attachment Facilities Supply, Installation, commissioning and testing of Revenue Meter (N6239)	$20,000
Attachment Facilities Supervision of Attachment Facilities Construction - From Interconnection Substation to POI (N6239)	$9,553
Attachment Facilities Construction of Attachment Facilities from the Interconnection Substation to the POI (N6239)	$0
Total Attachment Facilities Cost	$29,553
Direct Network Upgrade Interconnection Substation Construction (N5781) Transmission Owner Supervision of Interconnection Substation Engineering and Construction (N5781)	$181,514
Direct Network Upgrade Interconnection Substation Construction (N5781) (To be performed pursuant to the Option to Build)	$0
Total Direct Network Upgrade Costs	$181,514
Non-Direct Network Upgrade Transmission line Modifications (N5782)	$559,528
Non-Direct Network Upgrade Remote Relay (N6240)	$558,434
Total Non-Direct Network Upgrade Costs	$1,117,962
Total Network Upgrades	$1,299,476
Total Project Costs	$1,329,029

Cost Breakdown:

Category	Cost
Direct labor	$745,984
Direct Material	$156,789
Indirect labor	$401,196
Indirect Material	$25,060
Total	$1,329,029

7. Summary of Milestone Schedules for Completion of Work Included in Facilities Study:

The overall estimated timeline for DEOK to complete the Transmission Owner Interconnection facilities is approximately **18 months** after the ISA and CSA are fully executed. It is important to note that this project will be incorporated into the existing project work load at DEOK at the time of contract execution. If the work load of existing projects is extensive, resource constraints may extend the schedule duration.

The schedule of work for the Interconnected Transmission Owner work is:

Activity	Duration	Start Month	End Month
Engineering	11	1	12
Procurement	10	4	14
Construction	14	4	18

Month #1 corresponds to the first month after project's CSA is effective.

Duration Schedule Assumptions

- Standard land use and environmental permitting and approval processes
- No impacts from storm damage and restoration, time of year limitations, permitting issues, outage scheduling, system emergencies, and contractor and equipment availability

B. Transmission Owner Facilities Study Results

1. Attachment Facilities

PJM Network Upgrade # N6239: Metering and overhead conductors from the POI to the AC2-088/AD1-136 interconnection switching substation

This Facilities Study report assumes that the Interconnection Customer has elected the Option to Build the 69 kV overhead conductors and associated Attachment Facilities from the Interconnection Substation to the POI. The Transmission owner will supply, install, test and commission the Revenue Meter and will be responsible for the supervision of the Attachment Facilities scope to be performed by the IC pursuant to the Option to Build.

In the event that the Option to Build election is withdrawn or terminated, then the scope of work described in the "Alternate Scope" Section below shall apply.

The estimated costs for Transmission Owner Supervision of the Attachment Facilities scope of work to be performed pursuant to the Option to Build is provided below:

Category	Cost
Engineering Supervision	$5,464
Construction Supervision	$4,090
Total	$9,553[3]

Alternate Scope:

The following scope shall apply in the event that the Option to Build election is withdrawn or terminated:

The transmission Owner will design, engineer, purchase equipment and construct overhead conductors from the new three breaker ring bus substation to the Point of Interconnection at the Customer's pole mounted switch. The installation will include, but not limited to: overhead conductors, a takeoff structure, surge arresters, line disconnects, communication circuits, revenue metering, relaying and protection equipment.

2. Transmission Line – Upgrades

PJM Network Upgrade # N5782 – Reconfigure the South Bethel – Brown 69 kV line to loop through the interconnection switching substation and rework the distribution underbuild on that circuit path.

Scope of work includes:

- Install drilled piers for dead-end monopole structures
- Install galvanized steel dead-end monopole structures
- Install light duty monopole structures
- Remove the existing phase and static wires between the dead-end monopoles
- Install phase and static wires between each dead-end monopole and its associated substation take-off tower
- Rebuild distribution circuit cross arms and other distribution equipment on replaced poles
- Transfer distribution circuit conductors

Major Equipment Included in Transmission Line Estimate:

- Two (2) dead-end monopole structures, galvanized steel
- Two (2) light duty structures, galvanized steel
- 954 ACSR 45/7 conductor
- 7#8AW static wire

[3] The Transmission Owner supervision cost estimates assumes 40 hours of engineering supervision and 34 hours of construction supervision are required. The Interconnection Customer will be responsible for actual supervision costs incurred.

Transmission Line Estimate Assumptions:

- The new ring bus substation will be constructed close enough to the South Bethel-Brown circuit such that only two new light duty steel poles will be needed for the road crossing; no other structures will be required between the dead-end structures and the substation's take off towers.
- The new ring bus substation will be constructed on the northeast corner of the Leonard Road/Bethel Maple Road intersection.
- Required tree/vegetation clearing by IC.

3. New Substation/Switchyard Facilities

PJM Network Upgrade Number, N5781 – Build a three breaker AC2-088/AD1-136 69 kV interconnection switching substation

This Facilities Study report assumes that the Interconnection Customer has elected the Option to Build the Interconnection Switching Station. In the event that the Option to Build election is withdrawn or terminated, then the scope of work described in the "Alternate Scope" Section below shall apply.

Scope of Work to be Performed Pursuant to the Option to Build:

The Interconnection Customer will engineer and construct the Interconnection Substation. The Transmission Owner shall supervise the engineering and construction of the Interconnection Substation.

The estimated costs for Transmission Owner Supervision of the scope of work to be performed pursuant to the Option to Build is provided below:

Category	Cost
Engineering Supervision	$103,810
Construction Supervision	$77,704
Total	$181,514[4]

Alternate Scope:

The following scope shall apply in the event that the Option to Build election is withdrawn or terminated.

[4] The Transmission Owner supervision cost estimates assumes 840 hours of engineering supervision and 631 hours of construction supervision are required. The Interconnection Customer will be responsible for actual supervision costs incurred.

PJM Network Upgrade Number, N5781 – Build a three breaker AC2-088/AD1-136 69 kV interconnection switching substation

Purchase and install substation material – Direct Network Upgrade:

a. Remove and haul off the top 18" of soil followed by importing 18" of soil and compacting in lifts
b. Install two (2) concrete entrance aprons into the site
c. Install 18" RCP culvert at each entrance apron
d. Install ground mat and crushed stone surface
e. Install substation roadways and yard stone
f. Install fifty-four (54) drilled pier foundations for bus supports, CCVTs, wave traps, surge arresters and switch supports
g. Install twelve (12) drilled pier foundations for take-off towers
h. Install three (3) mat foundations for circuit breakers
i. Install ten (10) drilled pier foundations for a pre-manufactured control building
j. Install one hundred feet (100') of Trenwa
k. Install eleven hundred feet (1100') of fence and two (2) thirty-foot (30') gates
l. Install grounding to all station equipment
m. Install conduit for all aux and control cables
n. Install three (3) 69 kV A-frame take-off towers
o. Install three (3) 69 kV motor operated line disconnect switches
p. Install nine (9) 69 kV surge arresters
q. Install nine (9) 69 kV metering accuracy CCVTs with ST-54 structures
r. Install ten (10) 69 kV 3-phase bus support structures
s. Install sixteen (16) 69 kV 1-phase bus support structures
t. Install six (6) 69 kV breaker disconnect switches
u. Install three (3) 69 kV 40kA circuit breakers
v. Install five hundred feet (500') of 4-inch aluminum pipe bus
w. Install two (2) 69 kV power PTs with support structures and low side disconnect switches
x. Install two (2) station power fuses & two (2) single pole switches
y. Install one (1) automatic transfer switch for the station service
z. Install one (1) pre-manufactured control building complete with lighting, HVAC, battery system and AC panelboards
aa. Install three (3) 69 kV CT's
bb. Install one (1) primary revenue meter
cc. Install one (1) backup revenue meter
dd. Install one (1) 125VDC battery and filtered charger
ee. Install three (3) standard dual SEL421 relay packages for the three 69 kV lines
ff. Install three (3) standard SEL451 relay packages for the three 69 kV breakers
gg. Install one (1) manual synch panel
hh. Install one (1) 96-point annunciator
ii. Install three (3) SEL2411 controllers for the 69 kV line switches
jj. Install one (1) primary RTU for station control
kk. Install one (1) backup RTU for backup metering
ll. Install primary and backup interchange metering
mm. Install one (1) SEL-3610 serial server for engineering access

nn. Install two (2) Cisco CGS-2520 ethernet switches & power supplies
oo. Install one (1) Cisco CGR-2010 router & power supply
pp. Install two (2) full time communication channels with the necessary channel protections
qq. Install shielded control cable and fiber cables
rr. Install station security system
ss. Install two (2) lighting masts
tt. Install eight (8) lighting fixtures
uu. Install phase and static wires between the IC's POI switch and the ring bus substation's take-off tower

Major Equipment Included in Substation Estimate:

- Three (3) 69 kV A-frame take-off towers
- Three (3) 69 kV motor operated line disconnect switches
- Nine (9) 69 kV surge arresters
- Nine (9) 69 kV metering accuracy CCVTs with ST-54 structures
- Ten (10) 69 kV 3-phase bus support structures
- Sixteen (16) 69 kV 1-phase bus support structures
- Six (6) 69 kV breaker disconnect switches
- Three (3) 69 kV 40 kA circuit breakers
- Five hundred feet (500') of 4-inch aluminum pipe bus
- Two (2) 69 kV power PTs with support structures and low side disconnect switches
- Two (2) station power fuses & (2) single pole switches
- One (1) automatic transfer switch for station service
- One (1) pre-manufactured control building complete with lighting, HVAC, battery system and AC panelboards
- Three (3) 69 kV CT's
- One (1) primary revenue meter
- One (1) backup revenue meter
- One (1) 125VDC battery and filtered charger
- Three (3) standard dual SEL421 relay packages for the three 69 kV lines
- Three (3) standard SEL451 relay packages for the three 69 kV breakers
- One (1) manual synch panel
- One (1) 96-point annunciator
- Three (3) SEL2411 controllers for the 69 kV line switches
- One (1) primary RTU for station control
- One (1) backup RTU for backup metering
- One (1) SEL-3610 serial server for engineering access
- Two (2) Cisco CGS-2520 ethernet switches & power supplies
- One (1) Cisco CGR-2010 router & power supply
- Two (2) full time communication channels with the necessary channel protections
- One (1) station security system
- Two (2) Lightning masts
- Eight (8) Outdoor lighting fixtures

Substation Estimate Assumptions:

- Land for the substation purchased by IC.
- Soil conditions are such that driven piles will not be required, and standard drilled piers can be used. If soil borings reveal poor soil conditions, more expensive types of foundations may be required.
- The soil is not contaminated and does not require special handling and disposal.

4. Upgrades to Substation / Switchyard Facilities

PJM Network Upgrade # N6240 Remote Protection and Communication Work.

- Make relay settings changes at remote ends (South Bethel and Brown) as required
- Modify stuck breaker transfer trip schemes at remote ends to include the new ring bus substation
- Reconfigure existing communications paths between remote ends to include new ring bus substation.

5. Metering & Communications

PJM Requirements

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

ITO Requirements

The Interconnection Customer is also required to comply with all DEOK's revenue metering requirements for generation interconnection customers. The revenue metering requirements may be found within the "Duke Energy Midwest Transmission Systems Facility Connection Requirements," Version 7, effective October 31, 2018".

6. Environmental, Real Estate and Permitting Issues

This Facilities Study assumes that the Standard land use and environmental permitting and approval processes is applicable

7. Option to Build

This Facilities Study report assumes that the Interconnection Customer selected the Option to Build the Interconnection Substation and the Attachment Facilities from the Interconnection Substation to the POI. In order to exercise the Option to Build, the Interconnection Customer must comply with the Option to Build provisions outlined in Appendix 2, Section 3.2.3 in the Interconnection Construction Service Agreement of the AC2-088/AD1-136 queue project. If the Option to Build election is withdrawn or terminated, then following estimated costs shall apply:

Work Description	Total Cost
Attachment Facilities (N6239)	$418,826
Total Attachment Facilities Cost	$418,826
Direct Network Upgrade Interconnection Substation Construction (N5781)	$4,607,081
Total Direct Network Upgrade Costs	$4,607,081
Non-Direct Network Upgrade Transmission Line Reconfiguration (N5782)	$559,528
Non-Direct Network Upgrade Remote Protection and Communication (N6240)	$558,434
Total Non-Direct Network Upgrade Costs	$1,117,962
Total Network Upgrades	$5,725,043
Total Project Costs	$6,143,869

Attachment 1.
Single Line