# *Generation Interconnection Feasibility Study Report*

***For***

# *PJM Generation Interconnection Request Queue Position AE1-059*

# *Stanton-Summit #4 230kV line*

# *500 MW Energy / 250 MW Capacity*

February 2019

# Introduction

This Feasibility Study has been prepared in accordance with the PJM Open Access Transmission Tariff, 36.2, as well as the Feasibility Study Agreement between the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is PPL Electric Utilities (PPL EU).

# Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the feasibility study, but the actual allocation will be deferred until the impact study is performed.

An Interconnection Customer with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

PJM utilizes manufacturer models to ensure the performance of turbines is properly captured during the simulations performed for stability verification and, where applicable, for compliance with low voltage ride through requirements. Turbine manufacturers provide such models to their customers. The list of manufacturer models PJM has already validated is contained in Attachment B of Manual 14G. Manufacturer models may be updated from time to time, for various reasons such as to reflect changes to the control systems or to more accurately represent the capabilities turbines and controls which are currently available in the field. Additionally, as new turbine models are developed, turbine manufacturers provide such new models which must be used in the conduct of these studies. PJM needs adequate time to evaluate the new models in order to reduce delays to the System Impact Study process timeline for the Interconnection Customer as well as other Interconnection Customers in the study group. Therefore, PJM will require that any Interconnection Customer with a new manufacturer model must supply that model to PJM, along with a $10,000 fully refundable deposit, no later than three (3) months prior to the starting date of the System Impact Study (See Section 4.3 for starting dates) for the Interconnection Request which shall specify the use of the new model. The Interconnection Customer will be required to submit a completed dynamic model study request form (Attachment B-1 of Manual 14G) in order to document the request for the study.

The Feasibility Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

# General

The IC has proposed a hydro (pumped storage) generating facility located in Luzerne County, Pennsylvania. The installed facilities will have a total capability of 500 MW with 250 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is December 15, 2022. **This study does not imply a PPL EU commitment to this in-service date.**

## Point of Interconnection (POI)

AE1-059 will interconnect with the PPL EU transmission system via one of the following:

Option 1: via a tap of the Stanton – Summit #4 230 kV line. The Point of Interconnection will be where the Customer Interconnection Facilities interconnect with the Transmission Owner Interconnection Facilities. POI specifications can be found below under the Interconnection Customer Requirements.

Option 2: via a direct connection into the Stanton 230kV substation

### Cost Summary

AE1-059 will be responsible for the following estimated costs:

| Description | Total Cost |
|---|---|
| Attachment Facilities | $0 |
| Direct Connection Network Upgrades | $19,147,000 |
| Non Direct Connection Network Upgrades | $2,416,000 |
| **Total Costs** | **$21,563,000** |

In addition, the AE1-059 project may be responsible for a contribution to the following costs:

| Description | Total Cost |
|---|---|
| System Upgrades | $135,259,000 |

Cost allocations for these upgrades will be provided in the System Impact Study Report.

### Estimated Schedule

The estimated time to complete the scope of work is 24-36 months after the PJM three-party Interconnection Service Agreement (ISA) and Interconnection Construction Service Agreement (ICSA) are signed and PPL EU receives Notice to Proceed from the IC.

**Assumptions**

- Availability of optimal transmission line route
- Outage feasibility not assessed until Facilities Study
- No major environmental, real estate, or permitting issues

# Transmission Owner Scope of Work

# Attachment Facilities

None

# Direct Connection Network Upgrades

*New Switchyard*

- Construct one new standard switchyard at the location specified during the Feasibility Study Kick Off Call.
- Construct one (1) new standard two bay (Breaker and a Half arrangement) 230kV switchyard.
- The Stanton - Summit #4 230 kV line and the new IC generator lead line-2 will terminate in bay one (1) and the 230 kV Stanton & the new IC generator lead line-1 will terminate in bay two (2) of the new switchyard.

The total preliminary cost estimate for the Direct Connection network Upgrades is given in the table below. These costs do not include CIAC Tax Gross-up.

| Description | Total Cost |
|---|---|
| New Switchyard | $19,147,000 |
| **Total Direct Connection Costs** | **$19,147,000** |

# Non Direct Connection Network Upgrades

*Transmission Line Tap*

- Tap the existing Stanton-Summit #4 230kV line. Install two dead-end tap poles and route the lines into the new 230kV switchyard.
- Install conductor using1590 ACSR and dual OPGW.
- Install tangent tension structure on the Stanton-Summit switchyard location assumed to be adjacent to the 230kv corridor

*Remote End Work*

Develop all engineering packages including BOM, construction support and close-out in compliance with PPL EU Standards and Specs:

- Model IC in CAPE and conduct a wide area short-circuit study at least two busses away from the IC facilities. Identify affected relays and revise settings as needed.
- Revise protective relay settings at both Stanton and Summit Substations to evaluate the effects of infeed from the IC.

- Revise DTT schemes at both Stanton and Summit Substations to reflect new IC switchyard.
- At Stanton Substation, update all Summit line designations on equipment, panels, and drawings. Items associated with this line should be updated to reference the new IC Switchyard.
- At Summit Substation, update all Stanton line designations on equipment, panels, and drawings. Items associated with this line should be updated to reference the new IC Switchyard.

*Transmission Fiber*

- Install dual OPGW on taps to new switchyard
- Install (2) splice boxes and bring fiber into new switchyard dead-ends
- Break the existing OPGW on the Shickshinny-Lackawanna 500kV line and install new splice boxes on (2) structures on that line.
- Re-install OPGW on Shickshinny-Lackawanna 500kV
- Install underbuilt OPGW and tie splice boxes together.

The total preliminary cost estimate for the Non Direct Connection Upgrades is given in the table below. These costs do not include CIAC Tax Gross-up.

| Description | Total Cost |
|---|---|
| Transmission Line Tap | $2,000,000 |
| Remote End Work – Stanton Substation | $108,000 |
| Remote End Work – Summit Substation | $108,000 |
| Transmission Fiber | $200,000 |
| **Total Non-Direct Connection Facility Costs** | **$2,416,000** |

# Interconnection Customer Requirements

Requirement from the PJM Open Access Transmission Tariff:

1. An Interconnection Customer entering the New Services Queue on or after October 1, 2012 with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.

**PPL EU Interconnection Requirements**

PPL EU applicable technical standards that address requirements for interconnection of generation, transmission, and end user facilities can be found at the following link:

https://pjm.com/planning/design-engineering/to-tech-standards/private-ppl.aspx

**PPL EU Point(s) of Interconnection (POI) Requirements**

The IC will interconnect with the PPL EU transmission system into the new 230kV switchyard on the Stanton – Summit 230kV line. The POI will be where the IC generator lead line terminates (with insulators) at the first dead-end structure inside the PPL EU switchyard. The scope of work provided in this Feasibility Study is for facilities to be constructed on the PPL EU side of the POI.

# Revenue Metering and SCADA Requirements

**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 IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

**PPL EU Requirements**

Installation of revenue grade Bi-directional Metering Equipment will be required in the vicinity of the POI to measure kWh and kVARh. PPL EU will design and supply the required metering equipment; all installation costs would be borne by the IC including CTs/PTs. All metering equipment must meet applicable PPL EU tariff requirements as well as being compliant with all applicable requirements of the PJM agreements. The equipment must provide bidirectional revenue metering (kWh and kVARh) and real-time data (kW, kVAR, circuit breaker status, and generator bus voltages) for the IC's generating resource. The metering equipment should be housed in a control cabinet or similar enclosure and must be accessible to PPL EU metering personnel.

# OPTION 1

## Network Impacts

The Queue Project AE1-059 was evaluated as a 500 MW (Capacity 250 MW) injection tapping the Stanton-Summit #4 230 kV line in the PPL area. Project AE1-059 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-059 was studied with a commercial probability of 53%. Potential network impacts were as follows:

## Summer Peak Analysis – 2022

### Generator Deliverability

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

None

### Multiple Facility Contingency

*(Double Circuit Tower Line contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)*

None

### 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)*

| ID | FROM BUS# | FROM BUS | FROM BUS AREA | TO BUS# | TO BUS | TO BUS AREA | CKT ID | CONT NAME | Type | Rating MVA | PRE PROJECT LOADING % | POST PROJECT LOADING % | AC\|DC | MW IMPACT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **94114** | 200021 | SUNBURY | PJM | 200009 | JUNIATA | PJM | 1 | PL:28:P12:000080 | single | 3112.0 | 102.58 | 103.9 | DC | 87.45 |
| **93862** | 200675 | 26E.TWANDA | PENELEC | 130763 | HILSD230 | NYISO | 1 | PS_P1-2_5063 | single | 531.0 | 129.51 | 130.63 | DC | 12.82 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **94229** | 200675 | 26E.TWANDA | PENELEC | 130763 | HILSD230 | NYISO | 1 | PL:03:P71:001017 | tower | 531.0 | 142.97 | 145.43 | DC | 28.53 |
| **93449** | 208009 | LACK | PPL | 200074 | LACKAW | PJM | 3 | PL:02:P42:001057 | breaker | 1165.0 | 104.84 | 111.62 | DC | 173.76 |

## Steady-State Voltage Requirements

*(Summary of the VAR requirements based upon the results of the steady-state voltage studies)*

To be determined during Impact Study

## Short Circuit

*(Summary of impacted circuit breakers)*

New circuit breakers found to be over-duty:
None

Contributions to previously identified circuit breakers found to be over-duty:
None

## 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

## Potential Congestion due to Local Energy Deliverability

*PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The IC can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.*

*Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which shall study all overload conditions associated with the overloaded element(s) identified.*

| ID | FROM BUS# | FROM BUS | FROM BUS AREA | TO BUS# | TO BUS | TO BUS AREA | CKT ID | CONT NAME | Type | Rating MVA | PRE PROJECT LOADING % | POST PROJECT LOADING % | AC\|DC | MW IMPACT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **94115** | 200021 | SUNBURY | PJM | 200009 | JUNIATA | PJM | 1 | PL:28:P12:000080 | operation | 3112.0 | 101.34 | 103.89 | DC | 174.9 |

## Light Load Analysis

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B)

## System Reinforcements

| ID | Index | Facility | Upgrade Description | Cost |
|---|---|---|---|---|
| **93449** | 3 | **LACK 230.0 kV - LACKAW 500.0 kV Ckt 3** | **PPL**<br>Description:<br>• Build new 500/230kV substation adjacent to the existing Lackawanna substation.<br>• Install two 500/230kV transformers equivalent to the existing Lackawanna transformers.<br>• Break in the Lackawanna-Hopakong 500kV Line and terminate into the new substation.<br>• Terminate Lackawanna Energy (LAEN) lead line into this new 500/230kV substation.<br>Time Estimate : 36-42 Months<br>Cost : $ 75,000,000 | $75,000,000 |
| **94114** | 1 | **SUNBURY 500.0 kV - JUNIATA 500.0 kV Ckt 1** | Description: No violation. PPL applicable rating is 3732 MVA. No upgrade required. | $0 |
| **94229,93862** | 2 | **26E.TWANDA 230.0 kV - HILSD230 230.0 kV Ckt 1** | **NYISO**<br>Description: The external (i.e. Non-PJM) Transmission Owner, NYISO, will evaluate this violation during the impact study phase.<br><br>**PENELEC**<br>Description: Re-conductor line and upgrade terminal equipment at East Towanda substation.<br>Time Estimate : 27 Months<br>Cost : $60,259,000 | $60,259,000 |
| | | | **TOTAL COST** | **$135,259,000** |

# OPTION 2

## Network Impacts

The Queue Project AE1-059 was evaluated as a 500 MW (Capacity 250 MW) injection into the Stanton 230 kV Substation in the PPL area. Project AE1-059 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-059 was studied with a commercial probability of 53%. Potential network impacts were as follows:

## Summer Peak Analysis – 2022

### Generator Deliverability

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

None

### Multiple Facility Contingency

*(Double Circuit Tower Line contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)*

None

### 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)*

| ID | FROM BUS# | FROM BUS | FROM BUS AREA | TO BUS# | TO BUS | TO BUS AREA | CKT ID | CONT NAME | Type | Rating MVA | PRE PROJECT LOADING % | POST PROJECT LOADING % | AC\|DC | MW IMPACT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **94465** | 200021 | SUNBURY | PJM | 200009 | JUNIATA | PJM | 1 | PL:28:P12:000080 | single | 3112.0 | 102.58 | 103.9 | DC | 87.65 |
| **94211** | 200675 | 26E.TWANDA | PENELEC | 130763 | HILSD230 | NYISO | 1 | PS_P1-2_5063 | single | 531.0 | 129.51 | 130.62 | DC | 12.76 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **94571** | 200675 | 26E.TWANDA | PENELEC | 130763 | HILSD230 | NYISO | 1 | PL:03:P71:001017 | tower | 531.0 | 142.97 | 145.42 | DC | 28.39 |
| **93770** | 208009 | LACK | PPL | 200074 | LACKAW | PJM | 3 | PL:02:P42:001057 | breaker | 1165.0 | 104.84 | 111.54 | DC | 171.8 |

## Steady-State Voltage Requirements

*(Summary of the VAR requirements based upon the results of the steady-state voltage studies)*

To be determined during Impact Study

## Short Circuit

*(Summary of impacted circuit breakers)*

New circuit breakers found to be over-duty:
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Contributions to previously identified circuit breakers found to be over-duty:
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## New System Reinforcements

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## 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)*

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## Potential Congestion due to Local Energy Deliverability

*PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The IC can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.*

*Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which shall study all overload conditions associated with the overloaded element(s) identified.*

| ID | FROM BUS# | FROM BUS | FROM BUS AREA | TO BUS# | TO BUS | TO BUS AREA | CKT ID | CONT NAME | Type | Rating MVA | PRE PROJECT LOADING % | POST PROJECT LOADING % | AC\|DC | MW IMPACT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **94466** | 200021 | SUNBURY | PJM | 200009 | JUNIATA | PJM | 1 | PL:28:P12:000080 | operation | 3112.0 | 101.34 | 103.9 | DC | 175.3 |

## Light Load Analysis

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B)

## Flow Gate Details

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact. It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

## OPTION 1

## Index 1

| ID | FROM BUS# | FROM BUS | FROM BUS AREA | TO BUS# | TO BUS | TO BUS AREA | CKT ID | CONT NAME | Type | Rating MVA | PRE PROJECT LOADING % | POST PROJECT LOADING % | AC\|DC | MW IMPACT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **94114** | 200021 | SUNBURY | PJM | 200009 | JUNIATA | PJM | 1 | PL:28:P12:000080 | single | 3112.0 | 102.58 | 103.9 | DC | 87.45 |

| Bus # | Bus | MW Impact |
|---|---|---|
| **200038** | SUSQ 2 | 74.35 |
| **200083** | FRPO 1 | 38.5 |
| **200084** | FRPO 2 | 38.5 |
| **200823** | 26MHP_X3-003 | 11.2 |
| **208911** | MONT G1 | 63.57 |
| **208912** | MONT G2 | 64.4 |
| **208930** | SNBY 6 | 24.21 |
| **208931** | SNBY 7 | 26.27 |
| **208932** | SNBY 5 | 24.21 |
| **208933** | SNBY 8 | 42.99 |
| **208945** | LOHA CT | 1.24 |
| **208948** | WILL CT | 2.41 |
| **208981** | FOWH IPP | 3.55 |
| **209018** | SUNBIPCT | 3.42 |
| **209021** | WEST IPP | 2.7 |
| **210706** | HOLD | 6.53 |
| **212099** | BRMO IPP | 1.08 |
| **212174** | INGE | 0.66 |
| **212369** | PATRIOT 1 | 32.82 |
| **212370** | PATRIOT 2 | 32.82 |
| **916051** | Z1-038 | 3.78 |
| **918431** | AA1-057 | 8.66 |
| **920711** | AA2-182 C | 616.12 |
| **924291** | AB2-074 C | 31.53 |
| **925951** | AC1-071 C | 2.76 |
| **926081** | AC1-087 C | 1.21 |
| **926681** | AC1-151 C | 2.75 |
| **930641** | AB1-108 | 164.72 |
| **932691** | AC2-092 | 29.67 |
| **935071** | AD1-143 C1 | 1.85 |

| Bus # | Bus | MW Impact |
|---|---|---|
| **935081** | AD1-143 C2 | 0.06 |
| **935091** | AD1-143 C3 | 1.82 |
| **935101** | AD1-143 C4 | 0.06 |
| **938331** | AE1-051 | 1.74 |
| **938391** | AE1-058 C | 104.2 |
| **938401** | AE1-059 C O1 | 87.45 |
| **BAYOU** | BAYOU | 4.9 |
| **BIG_CAJUN1** | BIG_CAJUN1 | 7.53 |
| **BIG_CAJUN2** | BIG_CAJUN2 | 15.16 |
| **BLUEG** | BLUEG | 23.82 |
| **CALDERWOOD** | CALDERWOOD | 2.53 |
| **CANNELTON** | CANNELTON | 1.44 |
| **CATAWBA** | CATAWBA | 1.58 |
| **CBM-N** | CBM-N | 8.21 |
| **CHEOAH** | CHEOAH | 2.31 |
| **CHILHOWEE** | CHILHOWEE | 0.83 |
| **CHOCTAW** | CHOCTAW | 5.02 |
| **COFFEEN** | COFFEEN | 2.51 |
| **COTTONWOOD** | COTTONWOOD | 19.44 |
| **DEARBORN** | DEARBORN | 4.19 |
| **DUCKCREEK** | DUCKCREEK | 5.47 |
| **EDWARDS** | EDWARDS | 2.5 |
| **ELMERSMITH** | ELMERSMITH | 2.48 |
| **FARMERCITY** | FARMERCITY | 1.65 |
| **G-007A** | G-007A | 20.38 |
| **GIBSON** | GIBSON | 0.98 |
| **HAMLET** | HAMLET | 5.15 |
| **NEWTON** | NEWTON | 6.56 |
| **NYISO** | NYISO | 35.43 |
| **O-066A** | O-066A | 12.21 |
| **PRAIRIE** | PRAIRIE | 12.2 |
| **SANTEETLA** | SANTEETLA | 0.68 |
| **SMITHLAND** | SMITHLAND | 0.97 |
| **TATANKA** | TATANKA | 2.98 |
| **TILTON** | TILTON | 3.0 |
| **TRIMBLE** | TRIMBLE | 2.65 |
| **TVA** | TVA | 8.15 |
| **UNIONPOWER** | UNIONPOWER | 3.62 |
| **VFT** | VFT | 64.93 |

## Index 2

| ID | FROM BUS# | FROM BUS | FROM BUS AREA | TO BUS# | TO BUS | TO BUS AREA | CKT ID | CONT NAME | Type | Rating MVA | PRE PROJECT LOADING % | POST PROJECT LOADING % | AC\|DC | MW IMPACT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **94229** | 200675 | 26E.TWANDA | PENELEC | 130763 | HILSD230 | NYISO | 1 | PL:03:P71:001017 | tower | 531.0 | 142.97 | 145.43 | DC | 28.53 |

| Bus # | Bus | MW Impact |
|---|---|---|
| **200823** | 26MHP_X3-003 | 7.66 |
| **200894** | 26K02 | 9.27 |
| **200949** | 26X1-109 | 32.74 |
| **203283** | 26MANOR_T86 | 0.04 |
| **210706** | HOLD | 1.28 |
| **294573** | P-028 E | 15.5 |
| **916051** | Z1-038 | 2.63 |
| **916541** | Z1-110 | 0.45 |
| **917072** | Z2-011 | 0.45 |
| **917661** | WAYM E | 3.57 |
| **918602** | AA1-077 E | 5.08 |
| **918682** | AA1-082 E | 14.3 |
| **918871** | AA1-106 | 2.61 |
| **919201** | AA1-144 O1 | 39.52 |
| **919491** | AA2-000 | 40.18 |
| **920351** | AA2-133 | 0.5 |
| **925951** | AC1-071 C | 0.56 |
| **925952** | AC1-071 E | 3.72 |
| **930511** | AB1-092 | 1.48 |
| **930641** | AB1-108 | 25.48 |
| **934801** | AD1-108 | 0.03 |
| **934811** | AD1-109 | 0.02 |
| **936421** | AD2-055 | 3.04 |
| **938331** | AE1-051 | 0.34 |
| **938401** | AE1-059 C O1 | 14.26 |
| **938402** | AE1-059 E O1 | 14.26 |
| **AA2-200** | AA2-200 | 47.57 |
| **AA2-300** | AA2-300 | 7.92 |
| **AA2-400** | AA2-400 | 11.33 |
| **BAYOU** | BAYOU | 0.81 |
| **BIG_CAJUN1** | BIG_CAJUN1 | 1.25 |
| **BIG_CAJUN2** | BIG_CAJUN2 | 2.51 |

| Bus # | Bus | MW Impact |
|---|---|---|
| **BLUEG** | BLUEG | 4.27 |
| **CALDERWOOD** | CALDERWOOD | 0.4 |
| **CANNELTON** | CANNELTON | 0.26 |
| **CARR** | CARR | 2.26 |
| **CATAWBA** | CATAWBA | 0.23 |
| **CHEOAH** | CHEOAH | 0.37 |
| **CHILHOWEE** | CHILHOWEE | 0.13 |
| **CHOCTAW** | CHOCTAW | 0.82 |
| **COFFEEN** | COFFEEN | 0.45 |
| **COTTONWOOD** | COTTONWOOD | 3.24 |
| **DEARBORN** | DEARBORN | 0.91 |
| **DUCKCREEK** | DUCKCREEK | 1.0 |
| **EDWARDS** | EDWARDS | 0.46 |
| **ELMERSMITH** | ELMERSMITH | 0.44 |
| **FARMERCITY** | FARMERCITY | 0.29 |
| **G-007A** | G-007A | 2.48 |
| **GIBSON** | GIBSON | 0.18 |
| **HAMLET** | HAMLET | 0.69 |
| **NEWTON** | NEWTON | 1.18 |
| **O-066A** | O-066A | 1.14 |
| **PRAIRIE** | PRAIRIE | 2.15 |
| **RENSSELAER** | RENSSELAER | 1.82 |
| **SANTEETLA** | SANTEETLA | 0.11 |
| **SMITHLAND** | SMITHLAND | 0.17 |
| **TATANKA** | TATANKA | 0.54 |
| **TILTON** | TILTON | 0.55 |
| **TRIMBLE** | TRIMBLE | 0.47 |
| **TVA** | TVA | 1.34 |
| **UNIONPOWER** | UNIONPOWER | 0.59 |
| **VFT** | VFT | 6.57 |

## Index 3

| ID | FROM BUS# | FROM BUS | FROM BUS AREA | TO BUS# | TO BUS | TO BUS AREA | CKT ID | CONT NAME | Type | Rating MVA | PRE PROJECT LOADING % | POST PROJECT LOADING % | AC\|DC | MW IMPACT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **93449** | 208009 | LACK | PPL | 200074 | LACKAW | PJM | 3 | PL:02:P42:001057 | breaker | 1165.0 | 104.84 | 111.62 | DC | 173.76 |

| Bus # | Bus | MW Impact |
|---|---|---|
| **200823** | 26MHP_X3-003 | 17.38 |
| **200894** | 26K02 | 9.79 |
| **203999** | P-047 E | 14.14 |
| **208055** | LAEN | 106.9 |
| **209009** | PEIP 2 | 3.41 |
| **210706** | HOLD | 9.02 |
| **294573** | P-028 E | 35.16 |
| **916051** | Z1-038 | 5.86 |
| **916202** | Z1-069 E | 6.92 |
| **916351** | Z1-091 | 4.83 |
| **917661** | WAYM E | 25.2 |
| **918601** | AA1-077 C | 2.65 |
| **918602** | AA1-077 E | 35.81 |
| **918682** | AA1-082 E | 13.51 |
| **918871** | AA1-106 | 3.76 |
| **919201** | AA1-144 O1 | 37.59 |
| **919491** | AA2-000 | 52.68 |
| **920341** | AA2-132 | 4.29 |
| **930511** | AB1-092 | 1.93 |
| **931092** | AB1-160 E | 1.98 |
| **931942** | AB1-182 E | 4.7 |
| **932571** | AC2-077 | 2.48 |
| **936421** | AD2-055 | 3.98 |
| **938331** | AE1-051 | 2.4 |
| **938401** | AE1-059 C O1 | 86.88 |
| **938402** | AE1-059 E O1 | 86.88 |
| **AA2-500** | AA2-500 | 150.01 |
| **CBM-N** | CBM-N | 0.33 |
| **CBM-S1** | CBM-S1 | 0.77 |
| **CBM-S2** | CBM-S2 | 0.04 |
| **CBM-W1** | CBM-W1 | 2.33 |
| **CBM-W2** | CBM-W2 | 6.46 |

| Bus # | Bus | MW Impact |
|---|---|---|
| **CIN** | CIN | 0.84 |
| **G-007** | G-007 | 4.67 |
| **HAMLET** | HAMLET | 0.02 |
| **IPL** | IPL | 0.55 |
| **LGEE** | LGEE | 0.23 |
| **MEC** | MEC | 1.52 |
| **MECS** | MECS | 1.83 |
| **NYISO** | NYISO | 1.22 |
| **O-066** | O-066 | 16.99 |
| **WEC** | WEC | 0.24 |

| Contingency Name | Contingency Definition |
|---|---|
| **PL:03:P71:001017** | CONTINGENCY 'PL:03:P71:001017' /* LACK-HOPA 500KV & PAUP-BLGR 230KV<br>DISCONNECT BRANCH FROM BUS 200074 TO BUS 200098 CKT 1 /* LACKAW-LACHOP_T 500<br>DISCONNECT BRANCH FROM BUS 200091 TO BUS 200098 CKT 1 /* HOPAKONG-LACHOP_T 500<br>DISCONNECT BRANCH FROM BUS 208049 TO BUS 207919 CKT 1 /* PAUP-BLGR TR2 230<br>DISCONNECT BRANCH FROM BUS 207919 TO BUS 211394 CKT 2 /* BLGR-BLGR 230/69KV T2<br>END |
| **PL:28:P12:000080** | CONTINGENCY 'PL:28:P12:000080' /* SUSQ-WESC 500KV LINE<br>DISCONNECT BRANCH FROM BUS 200022 TO BUS 200023 CKT 1 /* SUSQHANA-WESCOVLE 500<br>END |
| **PL:02:P42:001057** | CONTINGENCY 'PL:02:P42:001057' /* LACK-PAUP 230KV; PAUP_E CB @ LACK<br>DISCONNECT BRANCH FROM BUS 208009 TO BUS 925950 CKT 1 /* LACK-AC1-071 TAP 230 /*<br>CONTINGENCY LINE ADDED FOR AE1 BUILD<br>DISCONNECT BRANCH FROM BUS 208009 TO BUS 211681 CKT 2 /* LACK-LACK 230/69KV T2<br>DISCONNECT BRANCH FROM BUS 208009 TO BUS 200074 CKT 4 /* LACK-LACKAW 500/230KV T4<br>END |
| **PS_P1-2_5063** | CONTINGENCY 'PS_P1-2_5063'<br>DISCONNECT BUS 200098 /* LACKAWANNA HOPATCONG_T<br>END |

## OPTION 2:

## Index 1

| ID | FROM BUS# | FROM BUS | FROM BUS AREA | TO BUS# | TO BUS | TO BUS AREA | CKT ID | CONT NAME | Type | Rating MVA | PRE PROJECT LOADING % | POST PROJECT LOADING % | AC\|DC | MW IMPACT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **94465** | 200021 | SUNBURY | PJM | 200009 | JUNIATA | PJM | 1 | PL:28:P12:000080 | single | 3112.0 | 102.58 | 103.9 | DC | 87.65 |

| Bus # | Bus | MW Impact |
|---|---|---|
| **200038** | SUSQ 2 | 74.35 |
| **200083** | FRPO 1 | 38.5 |
| **200084** | FRPO 2 | 38.5 |
| **200823** | 26MHP_X3-003 | 11.2 |
| **208911** | MONT G1 | 63.57 |
| **208912** | MONT G2 | 64.4 |
| **208930** | SNBY 6 | 24.21 |
| **208931** | SNBY 7 | 26.27 |
| **208932** | SNBY 5 | 24.21 |
| **208933** | SNBY 8 | 42.99 |
| **208945** | LOHA CT | 1.24 |
| **208948** | WILL CT | 2.41 |
| **208981** | FOWH IPP | 3.55 |
| **209018** | SUNBIPCT | 3.42 |
| **209021** | WEST IPP | 2.7 |
| **210706** | HOLD | 6.53 |
| **212099** | BRMO IPP | 1.08 |
| **212174** | INGE | 0.66 |
| **212369** | PATRIOT 1 | 32.82 |
| **212370** | PATRIOT 2 | 32.82 |
| **916051** | Z1-038 | 3.78 |
| **918431** | AA1-057 | 8.66 |
| **920711** | AA2-182 C | 616.12 |
| **924291** | AB2-074 C | 31.53 |
| **925951** | AC1-071 C | 2.76 |
| **926081** | AC1-087 C | 1.21 |
| **926681** | AC1-151 C | 2.75 |
| **930641** | AB1-108 | 164.72 |
| **932691** | AC2-092 | 29.67 |

| Bus # | Bus | MW Impact |
|---|---|---|
| **935071** | AD1-143 C1 | 1.85 |
| **935081** | AD1-143 C2 | 0.06 |
| **935091** | AD1-143 C3 | 1.82 |
| **935101** | AD1-143 C4 | 0.06 |
| **938331** | AE1-051 | 1.74 |
| **938391** | AE1-058 C | 104.2 |
| **938401** | AE1-059 C O2 | 87.65 |
| **BAYOU** | BAYOU | 4.9 |
| **BIG_CAJUN1** | BIG_CAJUN1 | 7.53 |
| **BIG_CAJUN2** | BIG_CAJUN2 | 15.16 |
| **BLUEG** | BLUEG | 23.82 |
| **CALDERWOOD** | CALDERWOOD | 2.53 |
| **CANNELTON** | CANNELTON | 1.44 |
| **CATAWBA** | CATAWBA | 1.58 |
| **CBM-N** | CBM-N | 8.21 |
| **CHEOAH** | CHEOAH | 2.31 |
| **CHILHOWEE** | CHILHOWEE | 0.83 |
| **CHOCTAW** | CHOCTAW | 5.02 |
| **COFFEEN** | COFFEEN | 2.51 |
| **COTTONWOOD** | COTTONWOOD | 19.44 |
| **DEARBORN** | DEARBORN | 4.19 |
| **DUCKCREEK** | DUCKCREEK | 5.47 |
| **EDWARDS** | EDWARDS | 2.5 |
| **ELMERSMITH** | ELMERSMITH | 2.48 |
| **FARMERCITY** | FARMERCITY | 1.65 |
| **G-007A** | G-007A | 20.38 |
| **GIBSON** | GIBSON | 0.98 |
| **HAMLET** | HAMLET | 5.15 |
| **NEWTON** | NEWTON | 6.56 |
| **NYISO** | NYISO | 35.43 |
| **O-066A** | O-066A | 12.21 |
| **PRAIRIE** | PRAIRIE | 12.2 |
| **SANTEETLA** | SANTEETLA | 0.68 |
| **SMITHLAND** | SMITHLAND | 0.97 |
| **TATANKA** | TATANKA | 2.98 |
| **TILTON** | TILTON | 3.0 |
| **TRIMBLE** | TRIMBLE | 2.65 |
| **TVA** | TVA | 8.15 |
| **UNIONPOWER** | UNIONPOWER | 3.62 |
| **VFT** | VFT | 64.93 |

## Index 2

| ID | FROM BUS# | FROM BUS | FROM BUS AREA | TO BUS# | TO BUS | TO BUS AREA | CKT ID | CONT NAME | Type | Rating MVA | PRE PROJECT LOADING % | POST PROJECT LOADING % | AC\|DC | MW IMPACT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **94571** | 200675 | 26E.TWANDA | PENELEC | 130763 | HILSD230 | NYISO | 1 | PL:03:P71:001017 | tower | 531.0 | 142.97 | 145.42 | DC | 28.39 |

| Bus # | Bus | MW Impact |
|---|---|---|
| **200823** | 26MHP_X3-003 | 7.66 |
| **200894** | 26K02 | 9.27 |
| **200949** | 26X1-109 | 32.74 |
| **203283** | 26MANOR_T86 | 0.04 |
| **210706** | HOLD | 1.28 |
| **294573** | P-028 E | 15.5 |
| **916051** | Z1-038 | 2.63 |
| **916541** | Z1-110 | 0.45 |
| **917072** | Z2-011 | 0.45 |
| **917661** | WAYM E | 3.57 |
| **918602** | AA1-077 E | 5.08 |
| **918682** | AA1-082 E | 14.3 |
| **918871** | AA1-106 | 2.61 |
| **919201** | AA1-144 O1 | 39.52 |
| **919491** | AA2-000 | 40.18 |
| **920351** | AA2-133 | 0.5 |
| **925951** | AC1-071 C | 0.56 |
| **925952** | AC1-071 E | 3.72 |
| **930511** | AB1-092 | 1.48 |
| **930641** | AB1-108 | 25.48 |
| **934801** | AD1-108 | 0.03 |
| **934811** | AD1-109 | 0.02 |
| **936421** | AD2-055 | 3.04 |
| **938331** | AE1-051 | 0.34 |
| **938401** | AE1-059 C O2 | 14.19 |
| **938402** | AE1-059 E O2 | 14.19 |
| **AA2-200** | AA2-200 | 47.57 |
| **AA2-300** | AA2-300 | 7.92 |
| **AA2-400** | AA2-400 | 11.33 |
| **BAYOU** | BAYOU | 0.81 |
| **BIG_CAJUN1** | BIG_CAJUN1 | 1.25 |

| Bus # | Bus | MW Impact |
|---|---|---|
| **BIG_CAJUN2** | BIG_CAJUN2 | 2.51 |
| **BLUEG** | BLUEG | 4.27 |
| **CALDERWOOD** | CALDERWOOD | 0.4 |
| **CANNELTON** | CANNELTON | 0.26 |
| **CARR** | CARR | 2.26 |
| **CATAWBA** | CATAWBA | 0.23 |
| **CHEOAH** | CHEOAH | 0.37 |
| **CHILHOWEE** | CHILHOWEE | 0.13 |
| **CHOCTAW** | CHOCTAW | 0.82 |
| **COFFEEN** | COFFEEN | 0.45 |
| **COTTONWOOD** | COTTONWOOD | 3.24 |
| **DEARBORN** | DEARBORN | 0.91 |
| **DUCKCREEK** | DUCKCREEK | 1.0 |
| **EDWARDS** | EDWARDS | 0.46 |
| **ELMERSMITH** | ELMERSMITH | 0.44 |
| **FARMERCITY** | FARMERCITY | 0.29 |
| **G-007A** | G-007A | 2.48 |
| **GIBSON** | GIBSON | 0.18 |
| **HAMLET** | HAMLET | 0.69 |
| **NEWTON** | NEWTON | 1.18 |
| **O-066A** | O-066A | 1.13 |
| **PRAIRIE** | PRAIRIE | 2.15 |
| **RENSSELAER** | RENSSELAER | 1.82 |
| **SANTEETLA** | SANTEETLA | 0.11 |
| **SMITHLAND** | SMITHLAND | 0.17 |
| **TATANKA** | TATANKA | 0.54 |
| **TILTON** | TILTON | 0.55 |
| **TRIMBLE** | TRIMBLE | 0.47 |
| **TVA** | TVA | 1.34 |
| **UNIONPOWER** | UNIONPOWER | 0.59 |
| **VFT** | VFT | 6.57 |

## Index 3

| ID | FROM BUS# | FROM BUS | FROM BUS AREA | TO BUS# | TO BUS | TO BUS AREA | CKT ID | CONT NAME | Type | Rating MVA | PRE PROJECT LOADING % | POST PROJECT LOADING % | AC\|DC | MW IMPACT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **93770** | 208009 | LACK | PPL | 200074 | LACKAW | PJM | 3 | PL:02:P42:001057 | breaker | 1165.0 | 104.84 | 111.54 | DC | 171.8 |

| Bus # | Bus | MW Impact |
|---|---|---|
| **200823** | 26MHP_X3-003 | 17.38 |
| **200894** | 26K02 | 9.79 |
| **203999** | P-047 E | 14.14 |
| **208055** | LAEN | 106.9 |
| **209009** | PEIP 2 | 3.41 |
| **210706** | HOLD | 9.02 |
| **294573** | P-028 E | 35.16 |
| **916051** | Z1-038 | 5.86 |
| **916202** | Z1-069 E | 6.92 |
| **916351** | Z1-091 | 4.83 |
| **917661** | WAYM E | 25.2 |
| **918601** | AA1-077 C | 2.65 |
| **918602** | AA1-077 E | 35.81 |
| **918682** | AA1-082 E | 13.51 |
| **918871** | AA1-106 | 3.76 |
| **919201** | AA1-144 O1 | 37.59 |
| **919491** | AA2-000 | 52.68 |
| **920341** | AA2-132 | 4.29 |
| **930511** | AB1-092 | 1.93 |
| **931092** | AB1-160 E | 1.98 |
| **931942** | AB1-182 E | 4.7 |
| **932571** | AC2-077 | 2.48 |
| **936421** | AD2-055 | 3.98 |
| **938331** | AE1-051 | 2.4 |
| **938401** | AE1-059 C O2 | 85.9 |
| **938402** | AE1-059 E O2 | 85.9 |
| **AA2-500** | AA2-500 | 150.01 |
| **CBM-N** | CBM-N | 0.33 |
| **CBM-S1** | CBM-S1 | 0.77 |
| **CBM-S2** | CBM-S2 | 0.04 |
| **CBM-W1** | CBM-W1 | 2.33 |
| **CBM-W2** | CBM-W2 | 6.46 |

| Bus # | Bus | MW Impact |
|---|---|---|
| **CIN** | CIN | 0.84 |
| **G-007** | G-007 | 4.67 |
| **HAMLET** | HAMLET | 0.02 |
| **IPL** | IPL | 0.55 |
| **LGEE** | LGEE | 0.23 |
| **MEC** | MEC | 1.52 |
| **MECS** | MECS | 1.83 |
| **NYISO** | NYISO | 1.22 |
| **O-066** | O-066 | 16.99 |
| **WEC** | WEC | 0.24 |

| Contingency Name | Contingency Definition |
|---|---|
| **PL:03:P71:001017** | CONTINGENCY 'PL:03:P71:001017' /* LACK-HOPA 500KV & PAUP-BLGR 230KV<br>DISCONNECT BRANCH FROM BUS 200074 TO BUS 200098 CKT 1 /* LACKAW-LACHOP_T 500<br>DISCONNECT BRANCH FROM BUS 200091 TO BUS 200098 CKT 1 /* HOPAKONG-LACHOP_T 500<br>DISCONNECT BRANCH FROM BUS 208049 TO BUS 207919 CKT 1 /* PAUP-BLGR TR2 230<br>DISCONNECT BRANCH FROM BUS 207919 TO BUS 211394 CKT 2 /* BLGR-BLGR 230/69KV T2<br>END |
| **PL:28:P12:000080** | CONTINGENCY 'PL:28:P12:000080' /* SUSQ-WESC 500KV LINE<br>DISCONNECT BRANCH FROM BUS 200022 TO BUS 200023 CKT 1 /* SUSQHANA-WESCOVLE 500<br>END |
| **PL:02:P42:001057** | CONTINGENCY 'PL:02:P42:001057' /* LACK-PAUP 230KV; PAUP_E CB @ LACK<br>DISCONNECT BRANCH FROM BUS 208009 TO BUS 925950 CKT 1 /* LACK-AC1-071 TAP 230 /*<br>CONTINGENCY LINE ADDED FOR AE1 BUILD<br>DISCONNECT BRANCH FROM BUS 208009 TO BUS 211681 CKT 2 /* LACK-LACK 230/69KV T2<br>DISCONNECT BRANCH FROM BUS 208009 TO BUS 200074 CKT 4 /* LACK-LACKAW 500/230KV T4<br>END |
| **PS_P1-2_5063** | CONTINGENCY 'PS_P1-2_5063'<br>DISCONNECT BUS 200098 /* LACKAWANNA HOPATCONG_T<br>END |