# *Generation Interconnection*
# *System Impact Study Report*

## *For*

## *PJM Generation Interconnection Request*
## *Queue Position AB2-161*

## *Bakers Pond – Ivor 115kV*
## *19 MW Capacity / 50 MW Energy*

**June / 2017**

# Introduction

This System Impact Study (SIS) has been prepared in accordance with the PJM Open Access Transmission Tariff, Section 205, as well as the System Impact Study Agreement between First Solar Development, LLC, the Interconnection Customer (IC) and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Virginia Electric and Power Company (VEPCO).

# Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the IC. As a requirement for interconnection, the IC may be responsible for the cost of constructing Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an IC may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, 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 System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The IC 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 solar generating facility located in Waverly, VA (Sussex County). The installed facilities will have a total capability of 50 MW with 19 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 6/01/2019. **This study does not imply an ITO commitment to this in-service date.**

## Point of Interconnection

AB2-161 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Bakers Pond – Ivor 115kV line.

## Cost Summary

The AB2-161 interconnection request will be responsible for the following costs:

| Description | Total Cost |
|---|---|
| Attachment Facilities | $1,550,000 |
| Direct Connection Network Upgrades | $5,500,000 |
| Non Direct Connection Network Upgrades | $ 800,000 |
| Allocation for New System Upgrades | $0 |
| Contribution for Previously Identified Upgrades | $0 |
| **Total Costs** | **$7,850,000** |

## Attachment Facilities

Generation Substation: Install metering and associated protection equipment. Estimated Cost $550,000.

Transmission: Construct approximately one span of 115 kV Attachment line between the generation substation and a new AB2-161 Switching Station. The estimated cost for this work is $1,000,000.

The estimated total cost of the Attachment Facilities is $1,550,000. It is estimated to take 18-24 months to complete this work. These preliminary cost estimates are based on typical engineering costs. A more detailed engineering cost estimates are normally done when the IC provides an exact site plan location for the generation substation during the Facility Study phase. These costs do not include CIAC Tax Gross-up. The single line is shown below in Attachment 1.

## Direct Connection Cost Estimate

Substation: Establish the new 115 kV AB2-161 Switching Substation (interconnection substation). The estimated cost of this work scope is $5,500,000. It is estimated to take 24-36 months to complete this work.

## Non-Direct Connection Cost Estimate

Transmission: Install transmission structure in-line with transmission line to allow the proposed interconnection switching station to be interconnected with the transmission system. Estimated cost is $800,000 and is estimated to take 24-30 months to complete.

Remote Terminal Work: During the Facilities Study, ITO's System Protection Engineering Department will review transmission line protection as well as anti-islanding required to accommodate the new generation and interconnection substation. System Protection Engineering will determine the minimal acceptable protection requirements to reliably interconnect the proposed generating facility with the transmission system. The review is based on maintaining system reliability by reviewing ITO's protection requirements with the known transmission system configuration which includes generating facilities in the area. This review may determine that transmission line protection and communication upgrades are required at remote substations.

Outage scheduling and coordination will impact the actual completion dates for the various identified network upgrades.

## Interconnection Customer Requirements

ITO's Facility Interconnection Requirements as posted on PJM's website
http://www.pjm.com/~/media/planning/plan-standards/private-dominion/facility-connection-requirements1.ashx

Voltage Ride Through Requirements - The Customer Facility shall be designed to remain in service (not trip) for voltages and times as specified for the Eastern Interconnection in Attachment 1 of NERC Reliability Standard PRC-024-1, and successor Reliability Standards, for

both high and low voltage conditions, irrespective of generator size, subject to the permissive trip exceptions established in PRC-024-1 (and successor Reliability Standards).

Frequency Ride Through Requirements - The Customer Facility shall be designed to remain in service (not trip) for frequencies and times as specified in Attachment 2 of NERC Reliability Standard PRC-024-1, and successor Reliability Standards, for both high and low frequency condition, irrespective of generator size, subject to the permissive trip exceptions established in PRC-024-1 (and successor Reliability Standards).

Reactive Power - The Generation Interconnection Customer shall design its non-synchronous Customer Facility with the ability to maintain a power factor of at least 0.95 leading to 0.95 lagging measured at the generator's terminals.

Meteorological Data Reporting Requirement - The solar generation facility shall, at a minimum, be required to provide the Transmission Provider with site-specific meteorological data including:

- Temperature (degrees Fahrenheit)
- Atmospheric pressure (hectopascals)
- Irradiance
- Forced outage data

# 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.

## Interconnected Transmission Owner Requirements

Metering and SCADA/Communication equipment must meet the requirements outlined in section 3.1.6 Metering and Telecommunications of ITO's Facility Connection Requirement NERC Standard FAC-001 which is publically available at www.dom.com.

# Network Impacts

The Queue Project AB2-161 was evaluated as a 50.0 MW (Capacity 19.0 MW) injection tapping the Bakers Pond-Ivor 115kV line in the ITO area. Project AB2-161 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB2-161 was studied with a commercial probability of 100%. Potential network impacts were as follows:

## Contingency Descriptions

The following contingencies resulted in overloads:

| Contingency Name | Description |
|---|---|
| 562T563 | CONTINGENCY '562T563' /*CARSON<br>OPEN BRANCH FROM BUS 314902 TO BUS 314923 CKT 1 /*CARSON TO MIDLOTHIAN<br>OPEN BRANCH FROM BUS 314914 TO BUS 314902 CKT 1 /*CARSON 500.00 - 8SEPTA 500.00<br>END |
| BASIN 230 B#2 | CONTINGENCY 'BASIN 230 B#2' /*<br>OPEN BRANCH FROM BUS 314276 TO BUS 314339 CKT 1<br>OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1<br>OPEN BRANCH FROM BUS 314276 TO BUS 314274 CKT 2<br>END |
| LN 208-259 | CONTINGENCY 'LN 208-259'<br>OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1 /* 6CHSTF A 230.00 - 6IRON208 230.00<br>OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1 /* 6IRON208 230.00 - 6SOUWEST 230.00<br>OPEN BUS 314309 /* ISLAND<br>OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /* 6BASIN 230.00 - 6CHSTF B 230.00<br>END |
| LN 23_A | CONTINGENCY 'LN 23_A'<br>OPEN BRANCH FROM BUS 314206 TO BUS 314529 CKT 1 /* 3OAKRIDG 115.00 - 3KINGS F 115.00<br>OPEN BRANCH FROM BUS 314206 TO BUS 314532 CKT Z1 /* 3OAKRIDG 115.00 - 3OAKRI23 115.00<br>OPEN BRANCH FROM BUS 314532 TO BUS 314536 CKT 1 /* 3OAKRI23 115.00 - 3SUFFOLK 115.00<br>OPEN BRANCH FROM BUS 313879 TO BUS 314528 CKT 1 /* 3SADL_2 115.00 - 3IVOR106 115.00<br>OPEN BUS 314206 /* ISLAND<br>OPEN BUS 314261 /* ISLAND<br>OPEN BUS 314528 /* ISLAND<br>OPEN BUS 314529 /* ISLAND<br>OPEN BUS 314532 /* ISLAND<br>END |

| Contingency Name | Description |
|---|---|
| LN 259 | CONTINGENCY 'LN 259-2065'<br>OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /* 6BASIN 230.00 - 6CHSTF B 230.00<br>OPEN BRANCH FROM BUS 314276 TO BUS 314339 CKT 1 /* 6BASIN 230.00 - 6SPRUNCE 230.00<br>END |
| LN 259-2065 | CONTINGENCY 'LN 259-2065'<br>OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /* 6BASIN 230.00 - 6CHSTF B 230.00<br>OPEN BRANCH FROM BUS 314276 TO BUS 314339 CKT 1 /* 6BASIN 230.00 - 6SPRUNCE 230.00<br>END |
| LN 557 | CONTINGENCY 'LN 557'<br>OPEN BRANCH FROM BUS 314214 TO BUS 314903 CKT 1 /* 6CHCKAHM 230.00 - 8CHCKAHM 500.00<br>OPEN BRANCH FROM BUS 314903 TO BUS 314908 CKT 1 /* 8CHCKAHM 500.00 - 8ELMONT 500.00<br>END |
| LN 563 | CONTINGENCY 'LN 563'<br>OPEN BRANCH FROM BUS 314902 TO BUS 314914 CKT 1 /* 8CARSON 500.00 - 8MDLTHAN 500.00<br>END |
| T672B | CONTINGENCY 'T672B' /*_ BASIN<br>OPEN BRANCH FROM BUS 314276 TO BUS 314260 CKT 1 /*L284 BASIN VARINA<br>OPEN BRANCH FROM BUS 314275 TO BUS 314276 CKT 1 /*L2055 BASIN BELLMEADE<br>REMOVE MACHINE 1 FROM BUS 315053 /*BELMEADE GEN CT-1<br>REMOVE MACHINE 2 FROM BUS 315054 /*BELMEADE GEN CT-2<br>REMOVE MACHINE 3 FROM BUS 315055 /*BELMEADE GEN ST<br>OPEN BRANCH FROM BUS 314274 TO BUS 314276 CKT 1 /*BASIN TX5<br>OPEN BRANCH FROM BUS 314274 TO BUS 314276 CKT 2 /*BASIN TX6<br>OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /*L259 BASIN CHESTERFIELD<br>OPEN BRANCH FROM BUS 314276 TO BUS 314339 CKT 1 /*L2065 BASIN SPRUANCE NUG<br>END |

# Summer Peak Analysis – 2020

## Generator Deliverability

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

None

## Multiple Facility Contingency

*(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output).*

| # | Contingency Type | Contingency Name | Affected Area | Facility Description | Bus From | Bus To | Circuit | Power Flow | Loading % Initial | Loading % Final | Rating Type | Rating MVA | MW Contribution |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | LFFB | T672B | DVP - DVP | 6MESSER-6CHARCTY 230 kV line | 314228 | 314225 | 1 | AC | 100 | 101.69 | LD | 459 | 7.84 |
| 2 | DCTL | LN 259-2065 | DVP - DVP | 6MESSER-6CHARCTY 230 kV line | 314228 | 314225 | 1 | AC | 99.1 | 100.77 | LD | 459 | 7.78 |
| 3 | BUS | BASIN 230 B#2 | DVP - DVP | 6MESSER-6CHARCTY 230 kV line | 314228 | 314225 | 1 | AC | 98.85 | 100.52 | LD | 459 | 7.79 |
| 4 | DCTL | LN 259-2065 | DVP - DVP | 6CHSTF B-6MESSER 230 kV line | 314287 | 314228 | 1 | AC | 99.13 | 100.8 | LD | 459 | 7.78 |
| 5 | BUS | BASIN 230 B#2 | DVP - DVP | 6CHSTF B-6MESSER 230 kV line | 314287 | 314228 | 1 | AC | 98.88 | 100.55 | LD | 459 | 7.79 |

## 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

## 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)*

| | Contingency | | Affected | | Bus | | | Power | Loading % | | Rating | | MW | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Type | Name | Area | Facility Description | From | To | Cir. | Flow | Initial | Final | Type | MVA | Contribution | Ref |
| 6 | DCTL | LN 208-259 | DVP - DVP | 6CHARCTY-6LAKESD 230 kV line | 314225 | 314227 | 1 | AC | 114.57 | 116.34 | LD | 459 | 8.18 | 1 |
| 7 | DCTL | LN 208-259 | DVP - DVP | 6MESSER-6CHARCTY 230 kV line | 314228 | 314225 | 1 | AC | 125.7 | 127.46 | LD | 459 | 8.18 | 2 |
| 8 | LFFB | 562T563 | DVP - DVP | 6MESSER-6CHARCTY 230 kV line | 314228 | 314225 | 1 | AC | 102.72 | 104.03 | LD | 459 | 6.08 | |
| 9 | DCTL | LN 208-259 | DVP - DVP | 6CHSTF B-6MESSER 230 kV line | 314287 | 314228 | 1 | AC | 125.73 | 127.49 | LD | 459 | 8.18 | 3 |
| 10 | LFFB | 562T563 | DVP - DVP | 6CHSTF B-6MESSER 230 kV line | 314287 | 314228 | 1 | AC | 102.74 | 104.06 | LD | 459 | 6.08 | |
| 11 | LFFB | T672B | DVP - DVP | 6CHSTF B-6MESSER 230 kV line | 314287 | 314228 | 1 | AC | 100.03 | 101.72 | LD | 459 | 7.84 | |

## Steady-State Voltage Requirements

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

None

## Stability and Reactive Power Requirement for Low Voltage Ride Through

*(Summary of the VAR requirements based upon the results of the dynamic studies)*

No mitigations required

## New System Reinforcements

*(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this interconnection request)*

| Violation # | Overloaded Facility | Upgrade Description | Network Upgrade Number | Upgrade Cost | AB2-161 Allocation |
|---|---|---|---|---|---|
| # 1 - 3 | 6MESSER-6CHARCTY 230 kV line | Rebuild 21.32 miles of the Chesterfield - Lakeside 230kV transmission line by 6/1/2020 | b2745 | | |
| # 4, 5 | 6CHSTF B-6MESSER 230 kV line | | | | |
| | | | | **Total New Network Upgrades** | **$** |

## 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 is calculated and reported for in the Impact Study)*

| Violation # | Overloaded Facility | Upgrade Description | Network Upgrade Number | Upgrade Cost | AB2-161 Allocation |
|---|---|---|---|---|---|
| # 6 | 6CHARCTY-6LAKESD 230 kV line | Rebuild 21.32 miles of the Chesterfield - Lakeside 230kV transmission line by 6/1/2020 | b2745 | | |
| # 7, 8 | 6MESSER-6CHARCTY 230 kV line | | | | |
| # 9 - 11 | 6CHSTF B-6MESSER 230 kV line | | | | |

| Violation # | Overloaded Facility | Upgrade Description | Network Upgrade Number | Upgrade Cost | AB2-161 Allocation |
|---|---|---|---|---|---|
| | | | | **Total New Network Upgrades** | **$** |

## 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 interconnection request by addressing 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.*

| | Contingency | | Affected | | Bus | | | Power | Loading % | | Rating | | MW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Type | Name | Area | Facility Description | From | To | Circuit | Flow | Initial | Final | Type | MVA | Contribution |
| 12 | N-1 | LN 23_A | DVP - DVP | 3SADL_2-3BAKRS P 115 kV line | 313879 | 314273 | 1 | AC | 72.63 | 114.37 | ER | 111 | 50 |
| 13 | Non | Non | DVP - DVP | 3SADL_2-3BAKRS P 115 kV line | 313879 | 314273 | 1 | AC | 71.95 | 112.38 | NR | 111 | 50 |
| 14 | N-1 | LN 557 | DVP - DVP | 6CHARCTY-6LAKESD 230 kV line | 314225 | 314227 | 1 | AC | 110.61 | 112.22 | ER | 375 | 6.1 |
| 15 | N-1 | LN 259 | DVP - DVP | 6MESSER-6CHARCTY 230 kV line | 314228 | 314225 | 1 | AC | 120.81 | 122.86 | ER | 375 | 7.81 |
| 16 | N-1 | LN 23_A | DVP - DVP | 3BAKRS P-3NEWBOHE 115 kV line | 314273 | 314280 | 1 | AC | 68.77 | 100.86 | ER | 111 | 50 |
| 17 | N-1 | LN 259 | DVP - DVP | 6CHSTF B-6MESSER 230 kV line | 314287 | 314228 | 1 | AC | 120.84 | 122.9 | ER | 375 | 7.81 |

| # | Contingency Type | Contingency Name | Affected Area | Facility Description | Bus From | Bus To | Circuit | Power Flow | Loading % Initial | Loading % Final | Rating Type | Rating MVA | MW Contribution |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | N-1 | LN 563 | DVP - DVP | 6CHSTF B-6BASIN 230 kV line | 314287 | 314276 | 1 | AC | 127.91 | 129.73 | ER | 449 | 8.25 |

## Light Load Analysis in 2020

Not required

## ITO Analysis

ITO assessed the impact of the proposed Queue Project #AB2-161 interconnection of 50 MW of energy (Capacity 19 MW) for compliance with reliability criteria on ITO's Transmission System. The system was assessed using the summer 2020 RTEP case provided to ITO by PJM. When performing a generation analysis, ITO's main analysis will be load flow study results under single contingency and multiple facility contingency (both normal and stressed system conditions). ITO Criteria considers a transmission facility overloaded if it exceeds 94% of its emergency rating under normal and stressed system conditions. A full listing of ITO's Planning Criteria and interconnection requirements can be found in the ITO's Facility Connection Requirements which are publicly available at: http://www.dom.com.

The results of these studies evaluate the system under a limited set of operating conditions and do not guarantee the full delivery of the capacity and associated energy of this proposed interconnection request under all operating conditions. NERC Planning and Operating Reliability Criteria allow for the re-dispatch of generating units to resolve projected and actual deficiencies in real time and planning studies. Specifically NERC Category C Contingency Conditions ( Bus Fault, Tower Line, N-1-1, and Stuck Breaker scenarios) allow for re-dispatch of generating units to resolve potential reliability deficiencies. For ITO Planning Criteria the re-dispatch of generating units for these contingency conditions is allowed as long as the projected loading does not exceed 100% of a facility Load Dump Rating.

As part of its generation impact analysis ITO routinely evaluates the impact that a proposed new generation resource will have under maximum generation conditions, stress system conditions and import/export system conditions (greater than 20 MW). The results of these studies are discussed in more detail below.

Category B Analysis (Single Contingency):

- System Normal – Same as PJM analysis
- Critical System Condition (No Surry 230 kV Unit) – Same as PJM analysis.

Category C Analysis: (Multiple Facility Contingency)

- Bus Fault - No deficiencies identified
- Line Stuck Breaker - No deficiencies identified
- Tower Line – No deficiencies identified

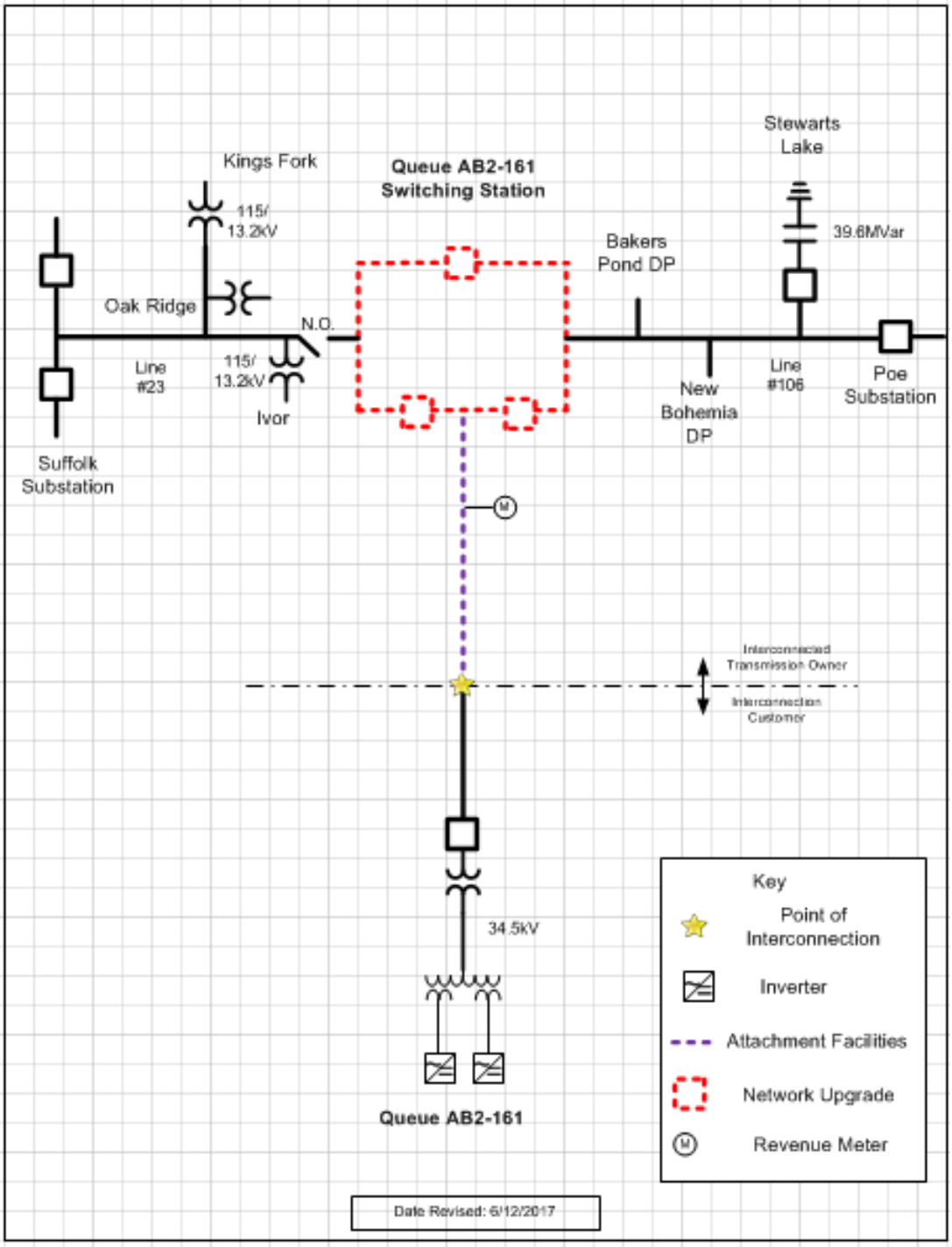
## Affected System Analysis & Mitigation

### Duke Energy:

None identified

# Attachment 1.

## *System Configuration*



# Appendices

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.

# Appendix 1

(DVP - DVP) The 6CHARCTY-6LAKESD 230 kV line (from bus 314225 to bus 314227 ckt 1) loads from 114.57% to 116.34% (AC power flow) of its load dump rating (459 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 8.18 MW to the thermal violation.

CONTINGENCY 'LN 208-259'
OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1 /* 6CHSTF A 230.00 - 6IRON208 230.00
OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1 /* 6IRON208 230.00 - 6SOUWEST 230.00
OPEN BUS 314309 /* ISLAND
OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /* 6BASIN 230.00 - 6CHSTF B 230.00
END

| Bus Number | Bus Name | Full Contribution |
|---|---|---|
| 315065 | 1CHESTF6 | 39.25 |
| 315077 | 1HOPHCF1 | 2.28 |
| 315078 | 1HOPHCF2 | 2.28 |
| 315079 | 1HOPHCF3 | 2.28 |
| 315080 | 1HOPHCF4 | 3.46 |
| 315076 | 1HOPPOLC | 1.95 |
| 315073 | 1STONECA | 5.71 |
| 314784 | 1WEYRHSB | 0.65 |
| 314539 | 3UNCAMP | 0.81 |
| 314541 | 3WATKINS | 0.23 |
| 314229 | 6MT R221 | -0.33 |
| 315074 | CIR_AB2-152 | 8.03 |
| 315075 | CIR_AB2-152 | 5.65 |
| 292791 | U1-032 E | 2.98 |
| 900672 | V4-068 E | 0.1 |
| 901082 | W1-029E | 13.18 |
| 902241 | W2-022 C OP1 | 0.49 |
| 902242 | W2-022 E OP1 | 3.26 |
| 907092 | X1-038 E | 2.02 |
| 914231 | Y2-077 | 0.92 |
| 916042 | Z1-036 E | 13.32 |
| 917332 | Z2-043 E | 0.34 |
| 917342 | Z2-044 E | 0.18 |
| 917592 | Z2-099 E | 0.15 |
| 921163 | AA1-063AE | 1.48 |
| 918512 | AA1-065 E OP | 1.46 |

| | | |
|---|---|---|
| 918562 | AA1-072 E | 0.06 |
| 921552 | AA1-134 C | 2.83 |
| 921553 | AA1-134 E | 1.21 |
| 921562 | AA1-135 C | 2.91 |
| 921563 | AA1-135 E | 1.25 |
| 921572 | AA1-138 C | 2.92 |
| 921573 | AA1-138 E | 1.25 |
| 921752 | AA2-053 C | 3.22 |
| 921753 | AA2-053 E | 1.38 |
| 921762 | AA2-057 C | 2.33 |
| 921763 | AA2-057 E | 1.16 |
| 921772 | AA2-059 C | 0.7 |
| 921773 | AA2-059 E | 0.32 |
| 921862 | AA2-068 C | 0.75 |
| 921863 | AA2-068 E | 0.35 |
| 920022 | AA2-086 E | 0.08 |
| 921982 | AA2-088 C | 2.25 |
| 921983 | AA2-088 E | 3.67 |
| 922442 | AA2-165 C | 0.32 |
| 922443 | AA2-165 E | 0.15 |
| 922472 | AA2-169 C | 0.7 |
| 922473 | AA2-169 E | 0.32 |
| 922512 | AA2-174 C | 0.15 |
| 922513 | AA2-174 E | 0.16 |
| 922522 | AA2-177 C | 6.13 |
| 922523 | AA2-177 E | 2.63 |
| 922532 | AA2-178 C | 2.91 |
| 922533 | AA2-178 E | 1.25 |
| 922602 | AB1-013 C | 0.88 |
| 922603 | AB1-013 E | 5.87 |
| 922722 | AB1-053 C | 0.44 |
| 922723 | AB1-053 E | 0.25 |
| 923262 | AB1-132 C OP | 5.95 |
| 923263 | AB1-132 E OP | 2.55 |
| 923572 | AB1-173 C OP | 0.98 |
| 923573 | AB1-173 E OP | 0.46 |
| 923582 | AB1-173AC OP | 0.98 |
| 923583 | AB1-173AE OP | 0.46 |
| 923801 | AB2-015 C OP | 2.9 |
| 923802 | AB2-015 E OP | 2.38 |
| 923851 | AB2-025 C | 1.64 |
| 923852 | AB2-025 E | 0.74 |
| 923911 | AB2-031 C OP | 0.98 |
| 923912 | AB2-031 E OP | 0.48 |
| 923981 | AB2-039 C OP | 7.69 |

| | | |
|---|---|---|
| 923982 | AB2-039 E OP | 6.21 |
| 923991 | AB2-040 C OP | 3.2 |
| 923992 | AB2-040 E OP | 2.62 |
| 924071 | AB2-051 C OP | 38.51 |
| 924381 | AB2-087 C | 0.19 |
| 924382 | AB2-087 E | 0.09 |
| 924501 | AB2-099 C | 0.2 |
| 924502 | AB2-099 E | 0.09 |
| 924511 | AB2-100 C | 6.24 |
| 924512 | AB2-100 E | 3.07 |
| 924761 | AB2-128 C | 5.34 |
| 924762 | AB2-128 E | 2.1 |
| 924811 | AB2-134 C OP | 8.23 |
| 924812 | AB2-134 E OP | 8.09 |
| 924931 | AB2-147 C | 1.21 |
| 924932 | AB2-147 E | 1.97 |
| 924941 | AB2-149 C OP | 1.54 |
| 924942 | AB2-149 E OP | 2.51 |
| 924951 | AB2-150 C OP | 1.21 |
| 924952 | AB2-150 E OP | 1.97 |
| 925051 | AB2-160 C OP | 4.25 |
| 925052 | AB2-160 E OP | 6.94 |
| 925061 | AB2-161 C OP | 3.11 |
| 925062 | AB2-161 E OP | 5.07 |
| 925122 | AB2-169 E | 1.77 |
| 925141 | AB2-171 C OP | 1.67 |
| 925142 | AB2-171 E OP | 2.72 |
| 925171 | AB2-174 C OP | 3.17 |
| 925172 | AB2-174 E OP | 2.87 |
| 925281 | AB2-186 C | 0.18 |
| 925282 | AB2-186 E | 0.08 |
| 925291 | AB2-188 C OP | 0.72 |
| 925292 | AB2-188 E OP | 0.32 |
| 925331 | AB2-190 C | 12.25 |
| 925332 | AB2-190 E | 5.25 |

# Appendix 2

(DVP - DVP) The 6MESSER-6CHARCTY 230 kV line (from bus 314228 to bus 314225 ckt 1) loads from 125.7% to 127.46% (AC power flow) of its load dump rating (459 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 8.18 MW to the thermal violation.

CONTINGENCY 'LN 208-259'
 OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1 /* 6CHSTF A 230.00 - 6IRON208 230.00
 OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1 /* 6IRON208 230.00 - 6SOUWEST 230.00
 OPEN BUS 314309 /* ISLAND
 OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /* 6BASIN 230.00 - 6CHSTF B 230.00
 END

| Bus Number | Bus Name | Full Contribution |
|---|---|---|
| 315065 | 1CHESTF6 | 39.25 |
| 315077 | 1HOPHCF1 | 2.28 |
| 315078 | 1HOPHCF2 | 2.28 |
| 315079 | 1HOPHCF3 | 2.28 |
| 315080 | 1HOPHCF4 | 3.46 |
| 315076 | 1HOPPOLC | 1.95 |
| 315073 | 1STONECA | 5.71 |
| 314784 | 1WEYRHSB | 0.65 |
| 314539 | 3UNCAMP | 0.81 |
| 314541 | 3WATKINS | 0.23 |
| 314229 | 6MT R221 | -0.33 |
| 315074 | CIR_AB2-152 | 8.03 |
| 315075 | CIR_AB2-152 | 5.65 |
| 292791 | U1-032 E | 2.98 |
| 900672 | V4-068 E | 0.1 |
| 901082 | W1-029E | 13.18 |
| 902241 | W2-022 C OP1 | 0.49 |
| 902242 | W2-022 E OP1 | 3.26 |
| 907092 | X1-038 E | 2.02 |
| 914231 | Y2-077 | 0.92 |
| 916042 | Z1-036 E | 13.32 |
| 917332 | Z2-043 E | 0.34 |
| 917342 | Z2-044 E | 0.18 |
| 917592 | Z2-099 E | 0.15 |

| | | |
|---|---|---|
| 921163 | AA1-063AE | 1.48 |
| 918512 | AA1-065 E OP | 1.46 |
| 918562 | AA1-072 E | 0.06 |
| 921552 | AA1-134 C | 2.83 |
| 921553 | AA1-134 E | 1.21 |
| 921562 | AA1-135 C | 2.91 |
| 921563 | AA1-135 E | 1.25 |
| 921572 | AA1-138 C | 2.92 |
| 921573 | AA1-138 E | 1.25 |
| 921752 | AA2-053 C | 3.22 |
| 921753 | AA2-053 E | 1.38 |
| 921762 | AA2-057 C | 2.33 |
| 921763 | AA2-057 E | 1.16 |
| 921772 | AA2-059 C | 0.7 |
| 921773 | AA2-059 E | 0.32 |
| 921862 | AA2-068 C | 0.75 |
| 921863 | AA2-068 E | 0.35 |
| 920022 | AA2-086 E | 0.08 |
| 921982 | AA2-088 C | 2.25 |
| 921983 | AA2-088 E | 3.67 |
| 922442 | AA2-165 C | 0.32 |
| 922443 | AA2-165 E | 0.15 |
| 922472 | AA2-169 C | 0.7 |
| 922473 | AA2-169 E | 0.32 |
| 922512 | AA2-174 C | 0.15 |
| 922513 | AA2-174 E | 0.16 |
| 922522 | AA2-177 C | 6.13 |
| 922523 | AA2-177 E | 2.63 |
| 922532 | AA2-178 C | 2.91 |
| 922533 | AA2-178 E | 1.25 |
| 922602 | AB1-013 C | 0.88 |
| 922603 | AB1-013 E | 5.87 |
| 922722 | AB1-053 C | 0.44 |
| 922723 | AB1-053 E | 0.25 |
| 923262 | AB1-132 C OP | 5.95 |
| 923263 | AB1-132 E OP | 2.55 |
| 923572 | AB1-173 C OP | 0.98 |
| 923573 | AB1-173 E OP | 0.46 |
| 923582 | AB1-173AC OP | 0.98 |
| 923583 | AB1-173AE OP | 0.46 |
| 923801 | AB2-015 C OP | 2.9 |
| 923802 | AB2-015 E OP | 2.38 |
| 923851 | AB2-025 C | 1.64 |
| 923852 | AB2-025 E | 0.74 |
| 923911 | AB2-031 C OP | 0.98 |

| | | |
|---|---|---|
| 923912 | AB2-031 E OP | 0.48 |
| 923981 | AB2-039 C OP | 7.69 |
| 923982 | AB2-039 E OP | 6.21 |
| 923991 | AB2-040 C OP | 3.2 |
| 923992 | AB2-040 E OP | 2.62 |
| 924071 | AB2-051 C OP | 38.51 |
| 924381 | AB2-087 C | 0.19 |
| 924382 | AB2-087 E | 0.09 |
| 924501 | AB2-099 C | 0.2 |
| 924502 | AB2-099 E | 0.09 |
| 924511 | AB2-100 C | 6.24 |
| 924512 | AB2-100 E | 3.07 |
| 924761 | AB2-128 C | 5.34 |
| 924762 | AB2-128 E | 2.1 |
| 924811 | AB2-134 C OP | 8.23 |
| 924812 | AB2-134 E OP | 8.09 |
| 924931 | AB2-147 C | 1.21 |
| 924932 | AB2-147 E | 1.97 |
| 924941 | AB2-149 C OP | 1.54 |
| 924942 | AB2-149 E OP | 2.51 |
| 924951 | AB2-150 C OP | 1.21 |
| 924952 | AB2-150 E OP | 1.97 |
| 925051 | AB2-160 C OP | 4.25 |
| 925052 | AB2-160 E OP | 6.94 |
| 925061 | AB2-161 C OP | 3.11 |
| 925062 | AB2-161 E OP | 5.07 |
| 925122 | AB2-169 E | 1.77 |
| 925141 | AB2-171 C OP | 1.67 |
| 925142 | AB2-171 E OP | 2.72 |
| 925171 | AB2-174 C OP | 3.17 |
| 925172 | AB2-174 E OP | 2.87 |
| 925281 | AB2-186 C | 0.18 |
| 925282 | AB2-186 E | 0.08 |
| 925291 | AB2-188 C OP | 0.72 |
| 925292 | AB2-188 E OP | 0.32 |
| 925331 | AB2-190 C | 12.25 |
| 925332 | AB2-190 E | 5.25 |

# Appendix 3

(DVP - DVP) The 6CHSTF B-6MESSER 230 kV line (from bus 314287 to bus 314228 ckt 1) loads from 125.73% to 127.49% (AC power flow) of its load dump rating (459 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 8.18 MW to the thermal violation.

CONTINGENCY 'LN 208-259'
OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1 /* 6CHSTF A 230.00 - 6IRON208 230.00
OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1 /* 6IRON208 230.00 - 6SOUWEST 230.00
OPEN BUS 314309 /* ISLAND
OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /* 6BASIN 230.00 - 6CHSTF B 230.00
END

| Bus Number | Bus Name | Full Contribution |
|---|---|---|
| 315065 | 1CHESTF6 | 39.25 |
| 315077 | 1HOPHCF1 | 2.28 |
| 315078 | 1HOPHCF2 | 2.28 |
| 315079 | 1HOPHCF3 | 2.28 |
| 315080 | 1HOPHCF4 | 3.46 |
| 315076 | 1HOPPOLC | 1.95 |
| 315073 | 1STONECA | 5.71 |
| 314784 | 1WEYRHSB | 0.65 |
| 314539 | 3UNCAMP | 0.81 |
| 314541 | 3WATKINS | 0.23 |
| 314229 | 6MT R221 | -0.33 |
| 315074 | CIR_AB2-152 | 8.03 |
| 315075 | CIR_AB2-152 | 5.65 |
| 292791 | U1-032 E | 2.98 |
| 900672 | V4-068 E | 0.1 |
| 901082 | W1-029E | 13.18 |
| 902241 | W2-022 C OP1 | 0.49 |
| 902242 | W2-022 E OP1 | 3.26 |
| 907092 | X1-038 E | 2.02 |
| 914231 | Y2-077 | 0.92 |
| 916042 | Z1-036 E | 13.32 |
| 917332 | Z2-043 E | 0.34 |
| 917342 | Z2-044 E | 0.18 |
| 917592 | Z2-099 E | 0.15 |

| | | |
|---|---|---|
| 921163 | AA1-063AE | 1.48 |
| 918512 | AA1-065 E OP | 1.46 |
| 918562 | AA1-072 E | 0.06 |
| 921552 | AA1-134 C | 2.83 |
| 921553 | AA1-134 E | 1.21 |
| 921562 | AA1-135 C | 2.91 |
| 921563 | AA1-135 E | 1.25 |
| 921572 | AA1-138 C | 2.92 |
| 921573 | AA1-138 E | 1.25 |
| 921752 | AA2-053 C | 3.22 |
| 921753 | AA2-053 E | 1.38 |
| 921762 | AA2-057 C | 2.33 |
| 921763 | AA2-057 E | 1.16 |
| 921772 | AA2-059 C | 0.7 |
| 921773 | AA2-059 E | 0.32 |
| 921862 | AA2-068 C | 0.75 |
| 921863 | AA2-068 E | 0.35 |
| 920022 | AA2-086 E | 0.08 |
| 921982 | AA2-088 C | 2.25 |
| 921983 | AA2-088 E | 3.67 |
| 922442 | AA2-165 C | 0.32 |
| 922443 | AA2-165 E | 0.15 |
| 922472 | AA2-169 C | 0.7 |
| 922473 | AA2-169 E | 0.32 |
| 922512 | AA2-174 C | 0.15 |
| 922513 | AA2-174 E | 0.16 |
| 922522 | AA2-177 C | 6.13 |
| 922523 | AA2-177 E | 2.63 |
| 922532 | AA2-178 C | 2.91 |
| 922533 | AA2-178 E | 1.25 |
| 922602 | AB1-013 C | 0.88 |
| 922603 | AB1-013 E | 5.87 |
| 922722 | AB1-053 C | 0.44 |
| 922723 | AB1-053 E | 0.25 |
| 923262 | AB1-132 C OP | 5.95 |
| 923263 | AB1-132 E OP | 2.55 |
| 923572 | AB1-173 C OP | 0.98 |
| 923573 | AB1-173 E OP | 0.46 |
| 923582 | AB1-173AC OP | 0.98 |
| 923583 | AB1-173AE OP | 0.46 |
| 923801 | AB2-015 C OP | 2.9 |
| 923802 | AB2-015 E OP | 2.38 |
| 923851 | AB2-025 C | 1.64 |
| 923852 | AB2-025 E | 0.74 |
| 923911 | AB2-031 C OP | 0.98 |

| | | |
|---|---|---|
| 923912 | AB2-031 E OP | 0.48 |
| 923981 | AB2-039 C OP | 7.69 |
| 923982 | AB2-039 E OP | 6.21 |
| 923991 | AB2-040 C OP | 3.2 |
| 923992 | AB2-040 E OP | 2.62 |
| 924071 | AB2-051 C OP | 38.51 |
| 924381 | AB2-087 C | 0.19 |
| 924382 | AB2-087 E | 0.09 |
| 924501 | AB2-099 C | 0.2 |
| 924502 | AB2-099 E | 0.09 |
| 924511 | AB2-100 C | 6.24 |
| 924512 | AB2-100 E | 3.07 |
| 924761 | AB2-128 C | 5.34 |
| 924762 | AB2-128 E | 2.1 |
| 924811 | AB2-134 C OP | 8.23 |
| 924812 | AB2-134 E OP | 8.09 |
| 924931 | AB2-147 C | 1.21 |
| 924932 | AB2-147 E | 1.97 |
| 924941 | AB2-149 C OP | 1.54 |
| 924942 | AB2-149 E OP | 2.51 |
| 924951 | AB2-150 C OP | 1.21 |
| 924952 | AB2-150 E OP | 1.97 |
| 925051 | AB2-160 C OP | 4.25 |
| 925052 | AB2-160 E OP | 6.94 |
| 925061 | AB2-161 C OP | 3.11 |
| 925062 | AB2-161 E OP | 5.07 |
| 925122 | AB2-169 E | 1.77 |
| 925141 | AB2-171 C OP | 1.67 |
| 925142 | AB2-171 E OP | 2.72 |
| 925171 | AB2-174 C OP | 3.17 |
| 925172 | AB2-174 E OP | 2.87 |
| 925281 | AB2-186 C | 0.18 |
| 925282 | AB2-186 E | 0.08 |
| 925291 | AB2-188 C OP | 0.72 |
| 925292 | AB2-188 E OP | 0.32 |
| 925331 | AB2-190 C | 12.25 |
| 925332 | AB2-190 E | 5.25 |