PJM Merchant Transmission Request
Queue #S57/S58
Collins 765kV
(1200MW Non-Firm and 300MW Firm/1600MW Non-Firm and 400MW Firm)
Retool System Impact Study Report

Updated September 2014

Preface

The intent of this System Impact Study is to determine a plan, with 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.

The PJM Reliability Planning Process utilizes PJM planning criteria, NERC Planning Standards, NERC Regional Council planning criteria, and the individual Transmission Owner FERC filed planning criteria. In all cases, PJM applies the most conservative of all applicable planning criteria when identifying reliability problems and determining the need for system upgrades on the PJM system. The application of the NERC Planning Standards is adapted to the specific needs of the PJM system.

In some instances an interconnection customer 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. All facilities required for interconnection of a generation interconnection project must be designed in compliance with the technical specifications (on PJM web site) for the appropriate Transmission Owner.

After the System Impact Study Agreement is executed and prior to execution of the Interconnection Service Agreement, an Interconnection Customer may modify its project to reduce the electrical output (MW) (in the case of a Generation Interconnection Request) of the proposed project by up to the larger of 20 percent of the capability considered in the System Impact Study or 50 MW.

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 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

Rock Island Clean Line LLC (Transmission Interconnection Customer) has proposed a 1200MW Non-firm (300MW Firm) Merchant Transmission project and a 1600 MW Non-firm (400 MW Firm) Merchant Transmission project to be interconnected to the ComEd transmission system at the Station 23 Collins Substation. The proposed in-service date for these projects is **January 1, 2017**.

The Transmission Interconnection Customer proposes to construct a Merchant HVDC line from the generating site to the proposed point of interconnection. It is proposed to interconnect both S57 and S58 into the existing 765kV ring bus at Station 23 Collins as depicted in **Figure #1**.

Notwithstanding the studies already performed, additional studies will be completed during the Facilities Study to address analysis being performed at the PJM connection point as well as the MISO connection point in order to fully document all reinforcement requirements and simulations performed. These additional studies will involve all necessary analysis, including but not limited to dynamic stability studies, small signal stability studies, harmonics analyses, a full trip of the entire facility, all additional studies for HVDC projects identified in PJM Manual 14E, etc. It is possible that additional upgrades, not identified in this impact study, may be required as a result of these additional studies performed during the Facilities Study.

Because this study found numerous reliability violations (discussed below in detail) where the HVDC line delivers energy at levels above the 700 MW firm level requested, PJM cannot at this time determine how often and under what, if any conditions the Transmission Interconnection Customer can deliver energy above the 700 MW firm level requested. These conditions will be determined in the future based on (1) the Facilities Study; (2) development of operating guides and procedures that will ensure reliability and are mutually acceptable to PJM and the Midcontinent Independent System Operator; and (3) the assumption that the Transmission Interconnection Customer is able to implement such operating guides and procedures at the direction of PJM by reducing the energy injected into Collins 765kV in the times specified. All such operating guides and procedures will be documented in the Interconnection Service Agreement and will be a condition of interconnection.

Attachment Facilities

The proposed interconnection of S57 and S58 into the existing 765kV ring bus at Station 23 Collins is depicted in **Figure #1**. This proposed interconnection would consist of the addition of two 765kV circuit breakers (BT1-7) and (BT5-6) in the existing 765kV ring bus, and the installation of two new line positions at buses 1 and 5.

It is possible that physical and geographical obstructions may prohibit implementation of the interconnection shown in **Figure #1**, due to the routing of the customer's 765 kV leads from the converter station. A re-evaluation of the interconnection may be required

during the Facilities Study that may result in additional scope to the Direct Connection Cost Estimate.

The Transmission Interconnection Customer proposes to construct a Merchant HVDC line from Iowa to a site close to Collins Substation, install a converter station at the site and install two 345kV circuits from the convertor station to a transformer substation where the voltage will be stepped up to 765kV. From the transformer substation two 765kV lines will connect to ComEd's Collins Substation, the Interconnection Substation. The termination of these two lines at the Interconnection Substation will serve as the Point of Interconnection between Transmission Interconnection Customer and ComEd.

The Transmission Interconnection Customer is responsible for constructing all of the facilities on the Transmission Interconnection Customer side of the Point of Interconnection. It will be the Interconnection Customer's responsibility to obtain any required right-of-way between the Convertor Substation and Interconnection Substation.

Direct Connection Cost Estimate

This includes the cost of connecting to the Interconnection Substation (Station 23 Collins), including the installation of two 765kV circuit breakers and two line positions. The estimated cost of this upgrade is approximately $**15,000,000.** See the cost breakdown in the following table.

Description	Estimated Cost
At Collins Station 23: Install two 765kV circuit breakers, two line terminations with MDs, and two revenue meters (PJM Network Upgrade Number #N**1758**)	**$12,800,000**
At Collins Station 23: Upgrade relay, SCADA & Communications equipment (PJM Network Upgrade Number #N**1759**)	**$3,200,000**
Total	**$15,000,000**

Cost Estimate Notes:

1) These Estimates are Order-of-Magnitude estimates of the costs that ComEd would bill to the customer for this interconnection and are 2014 dollars. These estimates are based on a one-line electrical diagram of the project and the information provided to PJM and ComEd by the Transmission Interconnection Customer.

2) These cost estimates do not include cost of acquiring right-of-way for the transmission line and purchasing any additional land, if needed, for the line terminations. The need and cost of acquiring property and associated legal costs will be investigated during Facilities Study for this project.

3) There were no site visits performed for these estimates. There may be costs related to specific site related issues that are not identified in these estimates. The site reviews will be performed during the Facilities Study or during detailed engineering.

4) These estimates are not a guarantee of the maximum amount payable by the Transmission Interconnection Customer and the actual costs of ComEd's work may differ significantly from these estimates. Per the PJM Tariff, Transmission Interconnection Customer will be responsible for paying all actual costs of ComEd's work.

5) The Transmission Interconnection Customer is responsible for all engineering, procurement, testing and construction of all equipment on the Transmission Interconnection Customer's side of the Point of Interconnection (POI).

Project Schedule Notes:

The total timeframe to complete engineering, procurement, and construction for the ComEd portion of this project is approximately 30-36 months after the Interconnection Service Agreement (ISA) and Construction Service Agreement (CSA) are executed. Due to the required construction time, the customer is advised that the requested in service date cannot be met and the schedule for placing the project in service will be further defined in the Facilities Study phase.

Scope and Cost Estimate of Non-Direct Connection Work

A complete stability study will be performed as part of Facilities Study using the most current data. An initial stability study performed as part of this re-tool study has identified stability criteria violations that may require upgrades to maintain system reliability and integrity. The cost of these potential upgrades has not been estimated. The Transmission Interconnection Customer is responsible for all actual costs needed to alleviate any potential stability issues identified in the Facilities Study.

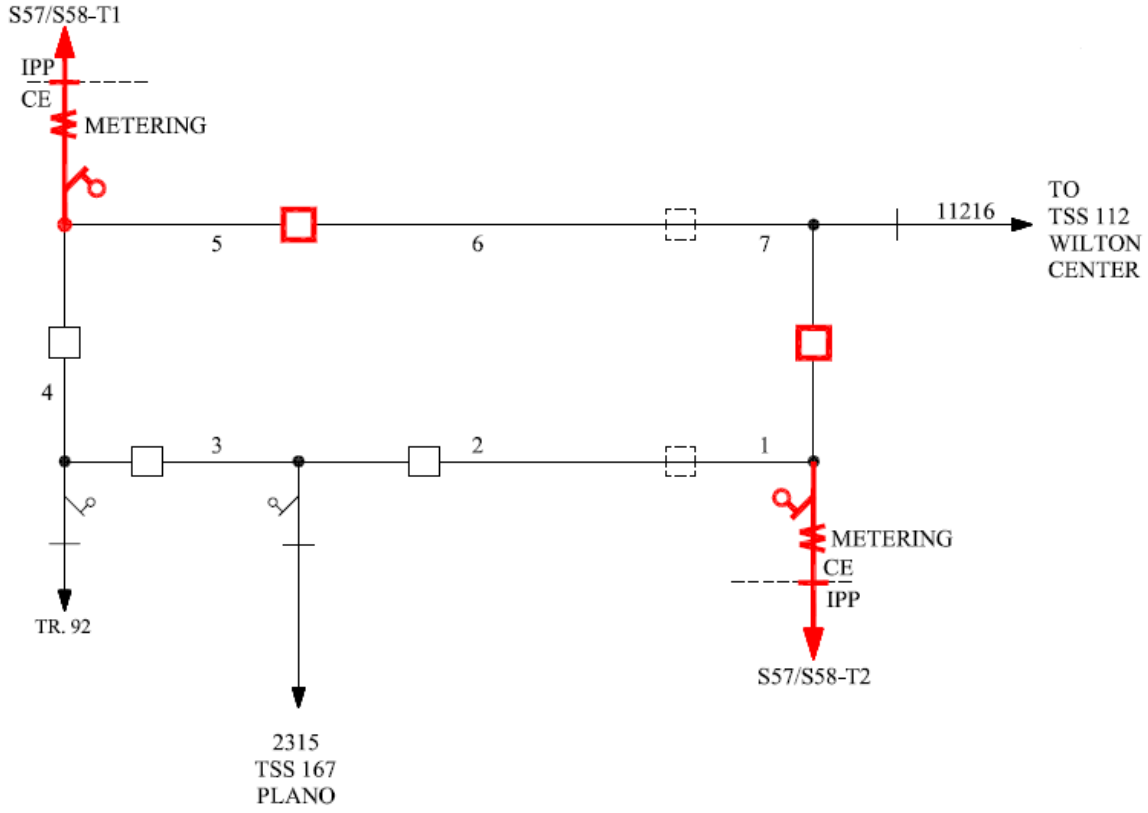


Figure 1. Interconnection Single Line Diagram

Revenue Metering and SCADA Requirements

For PJM: The Transmission Interconnection Customer will install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for the Transmission Interconnection Customer's merchant transmission facility. See PJM Manuals M-01 and M-14D, and PJM Tariff Section 24.1 to 24.2.

For ComEd: The Interconnection Customer will install equipment necessary to provide bi-directional Revenue Metering (KWH, KVARH) and real time data (KW, KVAR, circuit breaker status, and 765 kV voltage) for IC's merchant transmission facility. See ComEd Applicable Standards available on the PJM website ("TO Standards") – "ComEd Interconnection Guidelines (For Generators Greater than 20 MW)".

SUMMER PEAK ANALYSIS

Network Impacts

The S57 and S58 projects were studied as 3500MW (Firm 700MW) injection into Station 23 Collins 765 kV substation. Projects S57 and S58 were evaluated for compliance with reliability criteria for **Summer Peak conditions** in 2012. Potential network impacts were as follows:

Generator Deliverability

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

No problems were identified.

Multiple Facility Contingency

(Double Circuit Tower Line, Line with Failed Breaker and Bus Fault contingencies for the full energy output)

Table 1. Multiple Facility Contingency

Item	Contribution MVA	Overloaded Element	Overload %		Rating		Contingency Element
			From	To	Type	MVA	
1a	70.48	Plano 138/345 kV transformer TR 81 (36372 to 36076)	89.28	100.83	ALDR	610	bus fault outage of "111_EJ-345B__2'

Please refer to Appendix 1 for a table containing the generators having contribution to this flowgate.

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

No problems were identified.

Short Circuit
(Summary of impacted circuit breakers)

PJM and ComEd have performed Short Circuit studies for these projects and have found no overdutied breakers as a result.

Steady-State Voltage Requirements
(Summary of VAR requirements based upon the results of the steady-state voltage studies.)

For all steady-state voltage studies, the following system modeling assumptions were utilized:

- The S57/S58 converters consume 1750 MVAR (at a 3500 MW level). The reactive consumption of the converters is assumed to be 50% of the real power MW level.
- 3, +/-125 MVAR SVCs were modeled and are being provided by the Interconnection Customer in their design of the HVDC line and converter station.
- 15 capacitor banks, each rated 217 MVAR, were modeled and are being provided by the Interconnection Customer in their design of the HVDC line and converter station.

Under these assumptions, no additional reactive compensation is required to meet steady-state voltage criteria.

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

For Item 1a, the overload of the Plano 138/345 kV transformer TR 81 can be relieved by installing a 2nd Plano 345/138kV autotransformer. The cost estimate is **$15,000,000** (PJM Network Upgrade Number #n**3469**) and will take approximately 30-36 months to complete the work.

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

N-1 High Voltage Study (for single, tower, bus, stuck breaker contingencies)

No high voltage violations were identified for N-1 (single) contingencies at 700 MW, 1192 MW, and 3500 MW.

No high voltage violations were identified for N-1 (tower, bus, stuck breaker) contingencies at 3500 MW.

N-1 Common Mode Voltage Study (for tower, bus, stuck breaker contingencies)

At 3500 MW injection into Collins: No violations identified.

N-1-1 Thermal and Voltage Study (using the 2017 RTEP case)

- Thermal Results at 700 MW Firm:
  - No violations identified.
- Thermal Results at 3500 MW:

Fr Bus	Fr Name	To Bus	To Name	CKT	KVs	Areas	Rating	AC Ld(%)	Contingency 1	Contingency 2
270607	COLLINS	275168	COLLINS	1	765/345	222/222	1379	253.32	'765-L2315___-S'	'765-L11216__-S'
270607	COLLINS	275168	COLLINS	1	765/345	222/222	1379	253.41	'765-L11216__-S'	'765-L2315___-S'
270607	COLLINS	275168	COLLINS	1	765/345	222/222	1379	253.32	'765-L2315___-S'	'765-L11216__-S'
270607	COLLINS	275168	COLLINS	1	765/345	222/222	1379	113.79	'345-L16704_B-S'	'765-L11216__-S'
270607	COLLINS	275168	COLLINS	1	765/345	222/222	1379	128.41	'TR94_PLANO_B-S'	'765-L11216__-S'
270607	COLLINS	275168	COLLINS	1	765/345	222/222	1379	122.22	'345-L16703_R-S_1'	'765-L11216__-S'
270607	COLLINS	275168	COLLINS	1	765/345	222/222	1379	126.14	'TR93_PLANO_R-S'	'765-L11216__-S'
270630	PLANO	275207	PLANO	1	765/345	222/222	1341	133.02	'TR94_PLANO_B-S'	'765-L11216__-S'
270630	PLANO	275207	PLANO	1	765/345	222/222	1341	129.16	'TR92_COLLI_B-S'	'765-L11216__-S'
270630	PLANO	275207	PLANO	1	765/345	222/222	1341	101.74	'345-L16703_R-S_1'	'765-L11216__-S'
270630	PLANO	275208	PLANO	1	765/345	222/222	1341	135.69	'TR92_COLLI_B-S'	'765-L11216__-S'
270630	PLANO	275208	PLANO	1	765/345	222/222	1341	135.41	'TR93_PLANO_R-S'	'765-L11216__-S'
270697	COLLINS	270716	DRESDEN	1	345/345	222/222	1528	116.61	'765-L2315___-S'	'765-L11216__-S'
270697	COLLINS	274703	KENDALL	1	345/345	222/222	1528	111.95	'765-L2315___-S'	'765-L11216__-S'
270716	DRESDEN	275179	DRESDEN	1	345/138	222/222	442	100.92	'138-L1210__B-S'	'345-L14321TB-N'
270716	DRESDEN	275179	DRESDEN	1	345/138	222/222	442	100.62	'138-L1210__B-S'	'345-L1221__B-S'
270716	DRESDEN	275179	DRESDEN	1	345/138	222/222	442	106.11	'765-L2315___-S'	'765-L11216__-S'
270716	DRESDEN	275179	DRESDEN	1	345/138	222/222	442	103.31	'345-L1223_TR-S'	'345-L14321TB-N'
270716	DRESDEN	275179	DRESDEN	1	345/138	222/222	442	102.76	'345-L1223_TR-S'	'345-L1221__B-S'
270716	DRESDEN	275179	DRESDEN	1	345/138	222/222	442	101.49	'345-L14321TB-N'	'345-L1223_TR-S'
270716	DRESDEN	275179	DRESDEN	1	345/138	222/222	442	103.76	'345-L10806_R-S'	'345-L1223_TR-S'
270716	DRESDEN	275179	DRESDEN	1	345/138	222/222	442	102.58	'345-L10806_R-S'	'345-L14321TB-N'
270716	DRESDEN	275179	DRESDEN	1	345/138	222/222	442	102.29	'345-L10806_R-S'	'345-L1221__B-S'
270810	LOCKPORT	274702	KENDALL	1	345/345	222/222	1201	103.82	'345-L10806_R-S'	'BASE CASE'
270820	MCCOOK	275202	MCCOOK	1	345/138	222/222	400	102.8	'TR82_CRAWF_R-C'	'BASE CASE'
270846	PLANO	270730	ELECTRIC JCT	1	345/345	222/222	1341	105.55	'TR92_COLLI_B-S'	'765-L11216__-S'
271074	BEDFORD TAP	272012	Metropolitan Sanitary District	1	138/138	222/222	449	112.27	'TR82_CRAWF_R-C'	'345-L10803TB-S'
271074	BEDFORD TAP	272012	Metropolitan Sanitary District	1	138/138	222/222	449	112.27	'TR82_CRAWF_R-C'	'TR84_MCCOO_R-S'
271406	ELMHURST	271490	FRANKLIN PARK	1	138/138	222/222	300	140.85	'TR81_ELMHU_B-C'	'TR84_ELMHU_R-C'

271406	ELMHURST	271490	FRANKLIN PARK	1	138/138	222/222	300	131.65	'TR81_ELMHU_B-C'	'345-L12004TR-C'
271406	ELMHURST	271490	FRANKLIN PARK	1	138/138	222/222	250	111.32	'TR81_ELMHU_B-C'	'BASE CASE'
271406	ELMHURST	271490	FRANKLIN PARK	1	138/138	222/222	300	140.72	'TR84_ELMHU_R-C'	'TR81_ELMHU_B-C'
271406	ELMHURST	271490	FRANKLIN PARK	1	138/138	222/222	250	111.4	'TR84_ELMHU_R-C'	'BASE CASE'
271988	MCCOOK	272352	RIDGELAND	1	138/138	222/222	310	139.51	'TR82_CRAWF_R-C'	'BASE CASE'
271988	MCCOOK	272352	RIDGELAND	1	138/138	222/222	397	114.71	'TR82_CRAWF_R-C'	'345-L10808_B-S'
271988	MCCOOK	272352	RIDGELAND	1	138/138	222/222	397	114.66	'TR82_CRAWF_R-C'	'345-L10801AB-S'
271988	MCCOOK	272352	RIDGELAND	1	138/138	222/222	397	114.53	'TR82_CRAWF_R-C'	'345-L1312__B-C'
271988	MCCOOK	272352	RIDGELAND	1	138/138	222/222	397	113.07	'TR82_CRAWF_R-C'	'345-L4621_TB-N'
272012	Metropolitan Sanitary District	271988	MCCOOK	1	138/138	222/222	449	113.28	'TR82_CRAWF_R-C'	'345-L10803TB-S'
272012	Metropolitan Sanitary District	271988	MCCOOK	1	138/138	222/222	449	113.27	'TR82_CRAWF_R-C'	'TR84_MCCOO_R-S'
274702	KENDALL	270810	LOCKPORT	1	345/345	222/222	1479	102.18	'345-L10806_R-S'	'765-L11216__-S'
275168	COLLINS	270697	COLLINS	1	345/345	222/222	1379	253.29	'765-L2315___-S'	'765-L11216__-S'
275168	COLLINS	270697	COLLINS	1	345/345	222/222	1379	253.3	'765-L11216__-S'	'765-L2315___-S'
275168	COLLINS	270697	COLLINS	1	345/345	222/222	1379	253.29	'765-L2315___-S'	'765-L11216__-S'
275168	COLLINS	270697	COLLINS	1	345/345	222/222	1379	113.73	'345-L16704_B-S'	'765-L11216__-S'
275168	COLLINS	270697	COLLINS	1	345/345	222/222	1379	128.19	'TR94_PLANO_B-S'	'765-L11216__-S'
275168	COLLINS	270697	COLLINS	1	345/345	222/222	1379	122.13	'345-L16703_R-S_1'	'765-L11216__-S'
275168	COLLINS	270697	COLLINS	1	345/345	222/222	1379	126.14	'TR93_PLANO_R-S'	'765-L11216__-S'
275179	DRESDEN	271337	DRESDEN	1	138/138	222/222	442	106.09	'765-L2315___-S'	'765-L11216__-S'
275179	DRESDEN	271337	DRESDEN	1	138/138	222/222	442	101.39	'345-L10806_R-S'	'345-L1223_TR-S'
275179	DRESDEN	271337	DRESDEN	1	138/138	222/222	442	100.62	'345-L10806_R-S'	'345-L14321TB-N'
275179	DRESDEN	271337	DRESDEN	1	138/138	222/222	442	100.34	'345-L10806_R-S'	'345-L1221__B-S'
275202	MCCOOK	271988	MCCOOK	1	138/138	222/222	400	102.56	'TR82_CRAWF_R-C'	'BASE CASE'
275207	PLANO	270846	PLANO	1	345/345	222/222	1341	133.02	'TR94_PLANO_B-S'	'765-L11216__-S'
275207	PLANO	270846	PLANO	1	345/345	222/222	1341	129.16	'TR92_COLLI_B-S'	'765-L11216__-S'
275207	PLANO	270846	PLANO	1	345/345	222/222	1341	100.58	'345-L16703_R-S_1'	'765-L11216__-S'
275208	PLANO	270847	PLANO	1	345/345	222/222	1341	135.69	'TR92_COLLI_B-S'	'765-L11216__-S'
275208	PLANO	270847	PLANO	1	345/345	222/222	1341	135.41	'TR93_PLANO_R-S'	'765-L11216__-S'

- Voltage Results at 700 MW Firm:
    - No violations identified.
- Voltage Results at 3500 MW:
    - With the Collins – Plano 765 kV line out of service, there is a voltage collapse for the loss of the Collins – Wilton Center 765 kV line.

- With the Collins – Wilton Center 765 kV line out of service, there is a voltage collapse for the loss of the Collins – Plano 765 kV line.
- With the Collins 765/345 kV transformer out of service, there is a voltage collapse for the loss of the Collins – Wilton Center 765 kV line.
- With the Collins – Wilton Center 765 kV line out of service, there is a voltage collapse for the loss of the Collins 765/345 kV transformer.
- With the Plano 765/345 kV transformer 'TR93' out of service, there is a voltage collapse for the loss of the Collins – Wilton Center 765 kV line.
- With the Plano 765/345 kV transformer 'TR94' out of service, there is a voltage collapse for the loss of the Collins – Wilton Center 765 kV line.
- With the Plano – Electric Junction 345 kV 'R' line, Plano 345 kV bus tie, and Plano 345/138 kV XFMR 'R' out of service, the loss of the Collins – Wilton Center 765 kV line causes a voltage drop greater than 10% at the Collins and Plano 765 kV buses.
- With the Collins - Kendal 345 kV 'R' line out of service, the loss of the Collins – Wilton Center 765 kV line causes a voltage drop greater than 10% at the Collins and Plano 765 kV buses.
- With the 3, S57/S58/U3-026 SVCs out of service, the loss of the Collins – Wilton Center 765 kV line causes a voltage drop greater than 10% at the Collins and Plano 765 kV buses.
- With the S57/S58/U3-026 capacitor bank #1 out of service, the loss of the Collins – Wilton Center 765 kV line causes a voltage drop greater than 10% at the Collins and Plano 765 kV buses.
- With the S57/S58/U3-026 capacitor bank #2 out of service, the loss of the Collins – Wilton Center 765 kV line causes a voltage drop greater than 10% at the Collins and Plano 765 kV buses.
- With the S57/S58/U3-026 capacitor bank #3 out of service, the loss of the Collins – Wilton Center 765 kV line causes a voltage drop greater than 10% at the Collins and Plano 765 kV buses.

Contingencies involving the loss of the Collins – Plano 765kV and Collins – Wilton Center 765kV circuits, above approximately 2100 MWs output for the S57 & S58 facilities, results in voltage collapse following the second contingency. The S57 & S58 facility output must be curtailed immediately following the first contingency, loss of either the Collins – Plano 765kV or Collins – Wilton Center 765kV circuits, in order to alleviate this condition. It should be noted that following the loss of either element, Collins – Plano 765kV or Collins – Wilton Center 765kV circuits, the N-1 dispatch will require curtailment of the S57 & S58 facility below 1379MWs in order to avoid overload of the Collins 765/345kV transformer.

The mitigation for these identified severe voltage conditions at 3500 MW injection will be via an operating procedure where the S-057/S-058 DC line will need to be curtailed down to a 700 MW Firm injection level after any of the identified first contingencies in preparation for the identified second contingencies. Generation redispatch will require coordination with MISO (and possibly other operating entities) to reduce flow on the DC line to 700 MW within a certain time limit.

ComEd, as Transmission Owner for this interconnection, has indicated that they do not accept the assumption that, in this circumstance, an operating guide can be relied upon as a means to re-dispatch this facility from 3500MW to 700MW within a reasonable time to avoid system collapse and/or cascading failure. ComEd notes, for example, that certain contingencies result in voltage collapse and reliability violations result in post-contingency voltages far exceeding the Emergency Low Voltage Limits (95%) and the Load Dump Voltage Limits (90%) for which PJM Manual 3 requires 15 minutes and 5 minutes to correct, respectively, after the first contingency occurs. If applicable operating procedures cannot be developed, additional network upgrades would be necessary.

Light Load Reliability Analysis

*(Summary of any reinforcements required to mitigate system reliability issues during light load periods. This light load study was evaluated for compliance with reliability criteria for **Light Load conditions** in 2014.)*

The S57 and S58 projects were studied as 700MW injection into Collins 765kV substation. Projects S57 and S58 were evaluated for compliance with reliability criteria for Light Load Conditions in 2014. However, ComEd, the Transmission Owner for this interconnection, has indicated they do not accept the study assumptions and methodology. As the S57 and S58 projects were not studied at levels above 700 MW for Light Load Conditions, all flows above 700 MW will be curtailed within 30 minutes when system conditions indicate that the next contingency can cause a reliability violation. The requirement for redispatch will be documented in the Interconnection Service Agreement. Any redispatch arrangement is subject to PJM and the Midcontinent ISO agreeing to an acceptable redispatch protocol that would ensure curtailment of the facility to 700 MW in 30 minutes or less. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

No violations were identified in the Light Load analysis performed with the DC line operating at 700 MW as described above.

N-1 Common Mode Voltage Study (for tower, bus, stuck breaker contingencies)

At 3500 MW injection into Collins: No violations identified.

N-1-1 Voltage Study

Contingencies involving the loss of the Collins – Plano 765kV and Collins – Wilton Center 765kV circuits, above approximately 1870 MWs output for the S57 & S58 facilities, results in voltage collapse following the second contingency. The S57 & S58 facility output must be curtailed immediately following the first contingency, loss of either the Collins – Plano 765kV or Collins – Wilton Center 765kV circuits, in order to alleviate this condition. It should be noted that following the loss of either element, Collins – Plano 765kV or Collins – Wilton Center 765kV circuits, the N-1 dispatch will require curtailment of the S57 & S58 facility below 1379MWs in order to avoid overload of the Collins 765/345kV transformer.

Facility re-dispatch will be required to mitigate the above violations. Current review indicates that the facility dispatch from 3500 MWs to 700 MWs would be necessary under conditions that would require the successful and rapid implementation of operating procedures to address various system conditions which may result in these voltage violations. Analysis will be performed during the Facilities Study phase to determine at what system load level the non-firm portion of the S57 & S58 project (2800 MWs) would need to be curtailed, resulting in only allowing a dispatch to inject the firm portion of the request (700 MWs). Moreover, curtailment in this circumstance will be required under ALL conditions (normal and contingency) at or below the load level determined. Provisions relating to this need to re-dispatch the facility and curtail the non-firm portion of the request will be incorporated into an operating guide and referenced in the ISA for the project should the project proceed to interconnection.

ComEd, as Transmission Owner for this interconnection, has indicated that they do not accept the assumption that, in this circumstance, an operating guide can be relied upon as a means to re-dispatch this facility from 3500MW to 700MW within a reasonable time to avoid system collapse and/or cascading failure. Any operating procedure must explicitly address how PJM will be able to ensure reliability for these contingencies, especially give the risk of voltage collapse or cascading failures. Additional study will be required during the Facilities Study to verify the customer facility response can mitigate the violations and effective operating procedures can be developed, the requirement for redispatch will be documented in the Interconnection Service Agreement. Any redispatch arrangement is also subject to

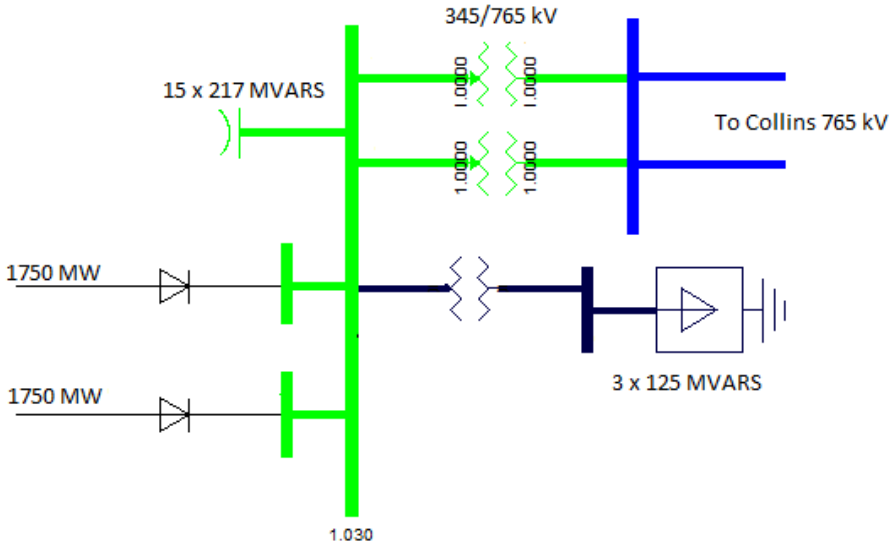
PJM and the Midcontinent ISO agreeing to an acceptable redispatch protocol that would ensure curtailment of the facility to 700 MW in 30 minutes or less.

Assuming effective operating procedures can be developed, the developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request. Additional studies would be needed to determine which upgrades would be necessary in the event (1) effective operating procedures cannot be developed; or (2) if operating procedures can be developed, if the developer wishes to eliminate the operational restrictions.

Stability and Reactive Power Requirements for Low Voltage Ride Through
(Summary of VAR requirements based upon the results of the dynamic studies.)

S57/S58 is a 3500 MW injection into the PJM system in ComEd. The project consists of one bipolar HVDC line originating in MISO territory connecting to Collins 765 kV substation in ComEd. Each pole is designed to carry 1750 MW for a total injection of 3500 MW. Firm interconnection rights for the DC line are 700 MW for **S57/S58**.

At the PJM side, the DC line will filter the inverter at 345 kV and connect to Collins through two 345/765 transformers and two 765 kV lines. In addition, the project has been described to include 375 MVARS of dynamic compensation through three Statcoms and fifteen 217 MVAR capacitors (3255 MVAR total). The diagram below describes the proposed project on the inverter side.



Case Setup:

For this evaluation, the following dispatch considerations were adopted:

1. Main ComEd generators are online at maximum output and suggested target voltage based on ComEd SPOG 1-1. Detailed values for the Main ComEd generators are shown below:

Main ComEd generators dispatch

Bus Name	ID	Vsched	Pgen
KINCA;1U 20.000	1	1.0406	625
KINCA;2U 20.000	2	1.0406	625
BRAID;1U 25.000	1	1.0348	1269.2
BRAID;2U 25.000	2	1.0348	1242.9
BYRON;1U 25.000	1	1.0261	1269.2
BYRON;2U 25.000	2	1.0261	1265
DRESD;2U 18.000	2	1.0203	1009
DRESD;3U 18.000	3	1.0203	1009
LASCO;1U 25.000	1	1.0406	1183
LASCO;2U 25.000	2	1.0406	1183
QUAD ;1U 18.000	1	1.0319	1009
QUAD ;2U 18.000	2	1.0319	1009
POWER;5U 25.000	5	1.0406	851
POWER;6U 25.000	6	1.0406	846

2. Nearby Queue projects are online at maximum output. The list of queue projects is provided below.

Required Queue projects dispatch

Bus Name	ID	Vsched	Pgen
GRNDR;BU 0.5750	W1	1.029	150
S27 0.6000	W1	1.000	198
S28 0.6000	W2	1.000	198
TCROP;1U 0.6900	W1	1.029	102
TCROP;2U 0.6900	W2	1.000	198
GRNDR;2U 0.5750	W2	1.030	190.5
MINONK;W1 0.6900	W1	1.000	200
S36_GEN 0.6900	1	0.9903	174
S37_GEN 0.5750	1	0.9901	174
R30_3 0.5750	1	1.0107	166.5
R30_2 0.5750	1	1.0107	166.5
R30_1 0.5750	1	1.0107	166.5

Additional units were added to the dispatch based on proximity to project under study (Collins 765 kV). All additional units under this item were dispatched at full output.

Note that due to load profile differences between the summer peak case and the light load case, the final dispatch may be different. The full dispatch used for this study is provided as part of the full stability report.

Modeling considerations associated with **S57/S58** project are provided below:

Net real power injection at Raun 345 kV (MISO) substation	2 x 1848 = **3696** MW
Net real power injection at Collins 765 kV (ComEd/PJM) substation	2 x 1750 = **3500** MW
Reactive Power Compensation at Raun 345 kV (MISO)	12x126 = 1512 MVAR Caps 2 x 125 = 250 MVAR Statcom
Voltage controlled at Rectifier side	1.048 p.u. at 345 kV
Reactive Power Compensation at Collins 765 kV (ComEd/PJM)	15 x 217 = 3255 Mvar Caps 3 x 125 = 375 MVAR Statcom
Voltage controlled at Inverter side	1.03 p.u. at 345 kV

Contingency Scenarios:

The stability study for this project was performed using the RTEP 2017 topology with two operating conditions: summer light load and summer peak. In addition, the RTEP 2017 case was modified to include applicable queue projects. The range of contingencies evaluated was limited to those necessary to assess compliance with NERC, PJM and other applicable criteria.

Five main fault types were considered:

1. Three-phase fault (3ph) with primary clearing time.
2. Three-phase fault (3ph) with delayed clearing time to simulate partial loss of relaying communications.
3. Three-phase fault (3ph) fault for duration of primary clearing time persisting as a single-line-to-ground fault cleared in delayed time as a result of breaker failure (stuck breaker) for both independent pole operated (IPO) breakers.
4. Three-phase fault (3ph) fault for duration of primary clearing time persisting as a 3ph fault cleared in delayed time as a result of breaker failure (stuck breaker) for gang operated breakers, only.
5. Three-phase fault (3ph) fault with multiple simultaneous line trips to simulate the loss of a transmission tower with multiple lines.

To assess stability, the system was subjected to fault at the following locations:

1. Collins 765 kV (Light Load and Summer Peak)
2. Wilton Center 765 kV (Light Load and Summer Peak)
3. Dresden 345 kV (Light Load only)
4. LaSalle County 345 kV (Light Load only)
5. Braidwood 345 kV (Light Load only)
6. Powerton 345 kV (Light Load only)

For each of the above locations, the system was tested for an intact condition and also relevant outages. Specific fault descriptions and breaker clearing times used for this study are provided in the full report.

Simulation Results:

Dynamics and stability was tested using Siemens-PTI PSS/E Version 32, the 2017 case with two load conditions (Light Load and Summer Peak) and the data supplied by the developer.

Based on the contingencies tested:

1. At the full power output of 3500 MW, **S57/S58** was found to be unstable for a number of scenarios for both the Light Load and Summer Peak conditions. All of the issues arise during **outages** and are directly attributable to the 3500 MW injection. Outages that result in an unstable condition are:

    a. Collins – Wilton Center 765 kV line
    b. Wilton Center – Dumont 765 kV line
    c. Collins – Plano 765 kV line

    The issues identified during the simulation are detailed below:
    - For the Light Load condition, case setup/initialization was not successful.
        - **Power Flow solution diverged** or was not sufficiently robust for any outage involving line Collins to Wilton Center or line Wilton Center Dumont. In the light load condition, the flow west to east across these lines is in excess of 3800 MW, with most of the injection sinking in the Eastern PJM system. Loss of this main outlet, causes the powerflow to diverge or for its solution to be very difficult and often, not suitable for dynamics and stability studies.
        - **Execution of activity TYSL** was not successful. Cases related with the above outages often were very difficult to converge when executing activity TYSL of PSS/E required for dynamics and stability. Activity TYSL was executed for the entire range of acceleration factors to improve convergence.

- For the Light Load condition, scenarios that were capable of initializing failed to run through the dynamic simulation for the additional contingency. The additional contingency corresponds to the loss of the other 765 kV outlet with or without a fault.
- The Summer Peak condition initializes properly at 3500 MW, but fails to run through the dynamic simulation for the additional contingency (N-1-1). The additional contingency corresponds to the loss of the other 765 kV outlet at Collins with or without a fault.

To mitigate the issues described above, the DC line was curtailed to its S57/S58 firm value of **700 MW** for those specific outages. At the power output of **700 MW**, scenarios involving the aforementioned outages were capable of running successfully with no additional issues being identified.

2. Pole block contingencies were unsuccessful with the simulations failing to run due to a DC line model issue. Pole block testing will be carried out once the model is corrected and resubmitted to PJM.
3. All other contingencies tested exhibit an adequate behavior, with the system withstanding the fault and returning to a new acceptable steady state condition.

Mitigations:

1. The DC line is required to curtail to firm value of 700 MW for the following outages:

    a. Collins – Wilton Center 765 kV line
    b. Wilton Center – Dumont 765 kV line
    c. Collins – Plano 765 kV line.

2. The model has to be resubmitted to complete the simulation concerning Pole block contingencies.

Additional Recommendations:

1. All simulations were tested using a voltage at the inverter side of the DC line of 1.03 p.u. based on PJM Manual 03. This is the recommended voltage setpoint for this bus.

2. Switching studies are recommended, to understand if the Transient Overvoltages observed during the dynamics study may lead to other concerns in the system.

ComEd, as Transmission Owner for this interconnection, has indicated that they do not accept the assumption that an operating guide can be relied upon as a means to re-dispatch this facility from 3500MW to 700MW within a reasonable time to avoid system collapse and/or cascading failure.

Potential Issues to Adjacent RTO's

Additional impacts may be defined in the Facilities Study.

Delivery of Energy Portion of Interconnection Request

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 developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Only the most severely overloaded conditions are listed. 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 will study all overload conditions associated with the overloaded element(s) identified.

1. (CE - CE) The WILTO; R-B ISL;RT 345 kV line (from bus 36415 to bus 36271 ckt 1) loads from 87.74% to 100.88% (AC power flow) of its normal rating (1231 MVA) for non-contingency condition. This project contributes approximately 161.8 MW to the thermal violation.

2. (CE - CE) The WILTO; B-B ISL;BT 345 kV line (from bus 36414 to bus 36270 ckt 1) loads from 100.37% to 115.1% (AC power flow) of its emergency rating (1470 MVA) for the single line contingency outage of '345-L11614AR-S'. This project contributes approximately 217.4 MW to the thermal violation.

   CONTINGENCY '345-L11614AR-S'
   TRIP BRANCH FROM BUS 36335 TO BUS 36271 CKT 1 /* GOODI;2R 345 B ISL;RT 345
   TRIP BRANCH FROM BUS 36271 TO BUS 36273 CKT 1 /* B ISL;RT 345 B ISL; R 345
   TRIP BRANCH FROM BUS 36271 TO BUS 36415 CKT 1 /* B ISL;RT 345 WILTO; R 345
   END

3. (CE - CE) The PLANO; R-ELECT;4R 345 kV line (from bus 36373 to bus 36311 ckt 1) loads from 94.29% to 111.87% (AC power flow) of its emergency rating (1739 MVA) for the single line contingency outage of '345-L16704_B-S'. This project contributes approximately 307 MW to the thermal violation.

   CONTINGENCY '345-L16704_B-S' /* MODIFIED BY S. THIEL 3-16-10
   TRIP BRANCH FROM BUS 36372 TO BUS 36310 CKT 1 /* PLANO; B 345 ELECT; B 345
   DISCONNECT BUS 36076 /* PLANO;1M 138
   END

4. (CE - CE) The WILTO; R-B ISL;RT 345 kV line (from bus 36415 to bus 36271 ckt 1) loads from 104.42% to 119.88% (AC power flow) of its emergency rating (1470

MVA) for the single line contingency outage of '345-L11613AB-S'. This project contributes approximately 228.0 MW to the thermal violation.

```
CONTINGENCY '345-L11613AB-S'
  TRIP BRANCH FROM BUS 36336 TO BUS 36270 CKT 1              /*
GOODI;4B 345 B ISL;BT 345
  TRIP BRANCH FROM BUS 36270 TO BUS 36272 CKT 1              /* B
ISL;BT 345 B ISL; B 345
  TRIP BRANCH FROM BUS 36270 TO BUS 36414 CKT 1              /* B
ISL;BT 345 WILTO; B 345
  END
```

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

(CE - CE) The PLANO; B 345/138 kV transformer (from bus 36372 to bus 36076 ckt 1) loads from 89.28% to 100.83% (AC power flow) of its applicable load dump rating (610 MVA) for the bus fault outage of '111_EJ-345B__2'. This project contributes approximately 70.48 MW to the thermal violation.

CONTINGENCY '111_EJ-345B__2' / CONTINGENCY # 77; MODIFIED BY S. THIEL 3-16-10; MODIFIED BY S. THIEL 9/3/13, REMOVE PLANO TR81 SPS
TRIP BRANCH FROM BUS 36310 TO BUS 36372 CKT 1 / ELECT; B 345 PLANO; B 345
TRIP BRANCH FROM BUS 36310 TO BUS 36404 CKT 1 / ELECT; B 345 WAYNE; B 345
TRIP BRANCH FROM BUS 36310 TO BUS 36416 CKT 1 / ELECT; B 345 WOLFS; B 345
DISCONNECT BUS 36092 / ELECT;2M 138
DISCONNECT BUS 37912 /* WOLFS; B 345 WOLFS; B 138 WOLFS;1C34.5 - SPS AT TSS 111 TRIPS WOLFS TR81 FOR BUS 2 FAULT AT EJ
END

Bus Number	Bus Name	Full Contribution
90726	S-057 C	7.05
90727	S-057 E	28.2
90731	S-058 C	7.05
90732	S-058 E	28.2

PJM Merchant Transmission Request
Queue #S57/S58
Collins 765kV
(1500MW Non-Firm and 300MW Firm/2000MW Non-Firm and 400MW Firm)
Retool System Impact Study Report

Updated August 2013
DOCS#: 558054v18

Preface

The intent of this System Impact Study is to determine a plan, with 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.

The PJM Reliability Planning Process utilizes PJM planning criteria, NERC Planning Standards, NERC Regional Council planning criteria, and the individual Transmission Owner FERC filed planning criteria. In all cases, PJM applies the most conservative of all applicable planning criteria when identifying reliability problems and determining the need for system upgrades on the PJM system. The application of the NERC Planning Standards is adapted to the specific needs of the PJM system.

In some instances an interconnection customer 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. All facilities required for interconnection of a generation interconnection project must be designed in compliance with the technical specifications (on PJM web site) for the appropriate Transmission Owner.

After the System Impact Study Agreement is executed and prior to execution of the Interconnection Service Agreement, an Interconnection Customer may modify its project to reduce the electrical output (MW) (in the case of a Generation Interconnection Request) of the proposed project by up to the larger of 20 percent of the capability considered in the System Impact Study or 50 MW.

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 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

Rock Island Clean Line LLC (Transmission Interconnection Customer) has proposed a 1200MW Non-firm (300MW Firm) Merchant Transmission project and a 1600 MW Non-firm (400 MW Firm) Merchant Transmission project to be interconnected to the ComEd transmission system at the Station 23 Collins Substation. The proposed in-service date for these projects is **January 1, 2017**.

The Transmission Interconnection Customer proposes to construct a Merchant HVDC line from the generating site to the proposed point of interconnection. It is proposed to interconnect both S57 and S58 into the existing 765kV ring bus at Station 23 Collins as depicted in **Figure #1**.

Notwithstanding the studies already performed, additional studies will be completed during the Facilities Study to address analysis being performed at the PJM connection point as well as the MISO connection point in order to fully document all reinforcement requirements and simulations performed. These additional studies will involve all necessary analysis, including but not limited to dynamic stability studies, small signal stability studies, harmonics analyses, a full trip of the entire facility, all additional studies for HVDC projects identified in PJM Manual 14E, etc. It is possible that additional upgrades, not identified in this impact study, may be required as a result of these additional studies performed during the Facilities Study.

Because this study found numerous reliability violations (discussed below in detail) where the HVDC line delivers energy at levels above the 700 MW firm level requested, PJM cannot at this time determine how often and under what, if any conditions the Transmission Interconnection Customer can deliver energy above the 700 MW firm level requested. These conditions will be determined in the future based on (1) the Facilities Study; (2) development of operating guides and procedures that will ensure reliability and are mutually acceptable to PJM and the Midcontinent Independent System Operator; and (3) the assumption that the Transmission Interconnection Customer is able to implement such operating guides and procedures at the direction of PJM by reducing the energy injected into Collins 765kV in the times specified. All such operating guides and procedures will be documented in the Interconnection Service Agreement and will be a condition of interconnection.

Attachment Facilities

The proposed interconnection of S57 and S58 into the existing 765kV ring bus at Station 23 Collins is depicted in **Figure #1**. This diagram is based on the PJM assumption that 700MW would be dispatched during light load conditions. However, ComEd, the Transmission Owner for this interconnection, has indicated that they do not accept this assumption. This proposed interconnection would consist of the addition of two 765kV circuit breakers (BT1-7) and (BT5-6) in the existing 765kV ring bus, and the installation of two new line positions at buses 1 and 5.

It is possible that physical and geographical obstructions may prohibit implementation of the interconnection shown in **Figure #1**, due to the routing of the customer's 765 kV leads from the converter station. A re-evaluation of the interconnection may be required during the Facilities Study that may result in additional scope to the Direct Connection Cost Estimate.

The Transmission Interconnection Customer proposes to construct a Merchant HVDC line from Iowa to a site close to Collins Substation, install a converter station at the site and install two 765kV transmission lines directly between the converter station and Collins Substation to connect his generator output to the Interconnection Substation. The termination of these two lines at the Interconnection Substation will serve as the Point of Interconnection between Transmission Interconnection Customer and ComEd.

The Transmission Interconnection Customer is responsible for constructing all of the facilities on the Transmission Interconnection Customer side of the Point of Interconnection. It will be the Interconnection Customer's responsibility to obtain any required right-of-way between the Collector Substation and Interconnection Substation.

Direct Connection Cost Estimate

This includes the cost of connecting to the Interconnection Substation (Station 23 Collins), including the installation of two 765kV circuit breakers and two line positions. The estimated cost of this upgrade is approximately $**14,000,000.** See the cost breakdown in the following table.

Description	Direct Material	Indirect Material	Direct Labor	Indirect Labor	Total Cost
At Collins Station 23: Install two 765kV circuit breakers, two line terminations with MDs, and two revenue meters (PJM Network Upgrade Number #N**1758**)	$3,720,000	$840,000	$5,640,000	$1,800,000	**$12,000,000**
At Collins Station 23: Upgrade relay, SCADA & Communications equipment (PJM Network Upgrade Number #N**1759**)	$500,000	$100,000	$1,000,000	$400,000	**$2,000,000**
Total	$4,200,000	$933,333	$6,650,000	$2,216,667	**$14,000,000**

Cost Estimate Notes:

1) These Estimates are Order-of-Magnitude estimates of the costs that ComEd would bill to the customer for this interconnection and are 2012 dollars. These estimates are based on a one-line electrical diagram of the project and the information provided to PJM and ComEd by the Transmission Interconnection Customer.

2) These cost estimates do not include cost of acquiring right-of-way for the transmission line and purchasing any additional land, if needed, for the line terminations. The need and cost of acquiring property and associated legal costs will be investigated during Facilities Study for this project.

3) There were no site visits performed for these estimates. There may be costs related to specific site related issues that are not identified in these estimates. The site reviews will be performed during the Facilities Study or during detailed engineering.

4) These estimates are not a guarantee of the maximum amount payable by the Transmission Interconnection Customer and the actual costs of ComEd's work may differ significantly from these estimates. Per the PJM Tariff, Transmission Interconnection Customer will be responsible for paying all actual costs of ComEd's work.

5) The Transmission Interconnection Customer is responsible for all engineering, procurement, testing and construction of all equipment on the Transmission Interconnection Customer's side of the Point of Interconnection (POI).

Project Schedule Notes:

The total timeframe to complete engineering, procurement, and construction for the ComEd portion of this project is approximately 18 – 24 months after the Interconnection Service Agreement (ISA) and Construction Service Agreement (CSA) are executed.

Scope and Cost Estimate of Non-Direct Connection Work

A complete stability study will be performed as part of Facilities Study using the most current data. An initial stability study performed as part of this re-tool study has identified stability criteria violations that may require upgrades to maintain system reliability and integrity. The cost of these potential upgrades has not been estimated. The Transmission Interconnection Customer is responsible for all actual costs needed to alleviate any potential stability issues identified in the Facilities Study.

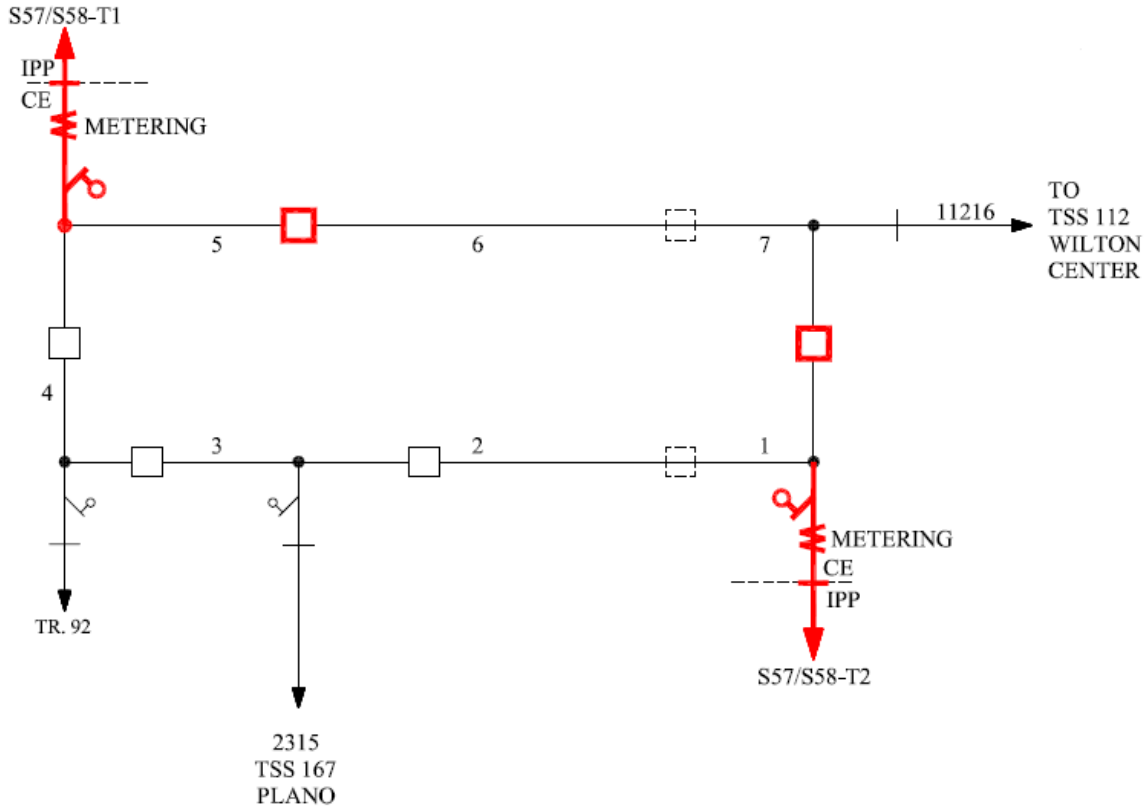


Figure 1. Interconnection Single Line Diagram

Revenue Metering and SCADA Requirements

For PJM: The Transmission Interconnection Customer will install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for the Transmission Interconnection Customer's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Section 24.1 to 24.2.

For ComEd: The Interconnection Customer will install equipment necessary to provide bi-directional Revenue Metering (KWH, KVARH) and real time data (KW, KVAR, circuit breaker status, and 765 kV voltage) for IC's generating Resource. See ComEd Applicable Standards available on the PJM website ("TO Standards") – "Exelon Energy Delivery Interconnection Guidelines (Generators Greater than 20 MW)".

SUMMER PEAK ANALYSIS

Network Impacts

The S57 and S58 projects were studied as 3500MW **(525MVAr)** injection into Station 23 Collins 765 kV substation. Projects S57 and S58 were evaluated for compliance with reliability criteria for **Summer Peak conditions** in 2012. Potential network impacts were as follows:

Generator Deliverability

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

No problems were identified.

Multiple Facility Contingency

(Double Circuit Tower Line contingencies were studied for the full energy output.)

Table 1. Multiple Facility Contingency

Item	Contribution MVA	Overloaded Element	Overload %		Rating		Contingency Element
			From	To	Type	MVA	
1a	82.7	Plano 138/345 kV transformer TR 81 (36372 to 36076)	88.71	102.31	ALDR	609.5	tower outage of '138-L11104_R-R_+_345-L16704_B-S'

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

No problems were identified

Short Circuit
(Summary of impacted circuit breakers)

ComEd has performed the Short Circuit study for these projects and has found no overdutied breakers as a result.

Steady-State Voltage Requirements
(Summary of VAR requirements based upon the results of the steady-state voltage studies.)

For the steady-state voltage study, it was assumed that the 525 MVAr reactive compensation is installed to operate the HVDC line and is being provided by the Interconnection Customer in their design of the converter station. Under these assumptions, no reactive compensation is required to meet steady-state voltage criteria.

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

For Item 1a, the overload of the Plano 138/345 kV transformer TR 81 can be relieved by installing a 2nd Plano 345/138kV autotransformer. The cost estimate is **$10,000,000** (PJM Network Upgrade Number #n**3469**) and will take approximately 18 – 24 months to complete the work.

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

N-1-1 Results

Results assume re-dispatch of the customer facility from 3500MWs to 700MWs in less than 30 minutes. The requirement for redispatch will be documented in the Interconnection Service Agreement

Fr Bus	Fr Name	To Bus	To Name	CKT	KVs	Areas	Rating	Contingency 1	Contingency 2	AC Ld(%)
36372	PLANO; B	36076	PLANO;1M	1	345/138	363/363	480	345-L16703_R-S	345-L16704_B-S	139.8
36076	PLANO;1M	35976	PLANO;1I	1	138/138	363/363	480	345-L16703_R-S	345-L16704_B-S	134.8

The reinforcement provided for Generation Deliverability studies also fixes these N-1-1 overloads.

Potential N-1 Violations

Following are N-1 thermal violations observed for S57/S58 project at 3500 MW on 2012 Summer peak case

FG #	Fr Bus	Fr Name	To Bus	To Name	CKT	KVs	Areas	Rating	AC Ld(%)	Cont Type	Contingency
1	36299	DAVIS; R	36026	DAVIS;2M	1	345/138	363/363	480	111.9	Single	'EXT_10'
2	36026	DAVIS;2M	36661	DAVIS; R	1	138/138	363/363	480	109.4	Single	'EXT_10'
3	36660	DAVIS; B	36670	K3192;5T	1	138/138	363/363	317	103.7	Single	'138-L8603__R-S'
4	37633	AUROR;RP	36517	BATAV;RT	1	138/138	363/363	445	102.4	Single	'345-L14419AR-R'
5	36298	DAVIS; B	36027	DAVIS;3M	1	345/138	363/363	480	101.7	Single	'EXT_11'

These violations can be mitigated by redispatch of the customer facility from 3500 MW to 700 MW in less than 30 minutes when system conditions show that the N-1 contingency can cause the overload, i.e., before the contingency occurs. The requirement for redispatch will be documented in the Interconnection Service Agreement. Any redispatch arrangement is subject to PJM and the Midcontinent ISO agreeing to an acceptable redispatch protocol that would ensure curtailment of the facility to 700 MW in 30 minutes or less. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Potential N-1-1 Violations

Following are a few N-1-1 thermal violations observed for S57/S58 project at 3500 MW on 2012 Summer peak case

FG	Fr Bu	Fr Nam	To Bu	To Nam	C	KVs	Area	Ratir	Contingency 1	Contingency 2	AC Ld(%
1	36372	PLANO; B	36076	PLANO;1M	1	345/138	363/363	480	345-L16703_R-S	345-L16704_B-S	156.1
2	36076	PLANO;1M	35976	PLANO;1I	1	138/138	363/363	480	345-L16703_R-S	345-L16704_B-S	149.7
3	36815	HANOV; R	37297	TOLLW; R	1	138/138	363/363	372	345-L11120_R-N	345-L14401_R-N	148
4	36036	ELECT;3M	36697	ELECT;3R	1	138/138	363/363	465	345-L14419AR-R	TR84_ELECT_R-N	139.4
5	36349	ELECT;3R	36036	ELECT;3M	1	345/138	363/363	465	345-L14419AR-R	TR84_ELECT_R-N	139.3
6	36255	COLLI;	36021	COLLI;2M	1	765/345	363/363	1380	TR93_PLANO_B-S	765-L11216__-S	138.8
7	36021	COLLI;2M	36291	COLLI; R	1	345/345	363/363	1380	TR93_PLANO_B-S	765-L11216__-S	138.8
8	36037	ELECT;4M	36709	ELECT;4R	1	138/138	363/363	465	345-L14419AR-R	TR83_ELECT_R-N	137.8
9	36311	ELECT;4R	36037	ELECT;4M	1	345/138	363/363	465	345-L14419AR-R	TR83_ELECT_R-N	137.6
10	36299	DAVIS; R	36026	DAVIS;2M	1	345/138	363/363	480	EXT_10	345-L17704AR-S	134.9
11	37634	AUROR;BP	36516	BATAV;BT	1	138/138	363/363	445	345-L11126_B-N	138-L14403_R-N	134.8
12	36298	DAVIS; B	36027	DAVIS;3M	1	345/138	363/363	480	345-L17907TB-S	EXT_11	134.6
13	37633	AUROR;RP	36517	BATAV;RT	1	138/138	363/363	445	345-L14419AR-R	345-L11120_R-N	134
14	36060	PLANO;3M	36258	PLANO;	1	345/765	363/363	1380	TR92_COLLI_R-S	765-L11216__-S	131.71
15	36060	PLANO;3M	36372	PLANO; B	1	345/345	363/363	1380	TR92_COLLI_R-S	765-L11216__-S	131.66
16	36026	DAVIS;2M	36661	DAVIS; R	1	138/138	363/363	480	EXT_10	345-L17704AR-S	131.5
17	36027	DAVIS;3M	36660	DAVIS; B	1	138/138	363/363	480	345-L17907TB-S	EXT_11	131.5
18	36311	ELECT;4R	36349	ELECT;3R	1	345/345	363/363	1339	345-L14419AR-R	BASE CASE	130.6
19	37255	SPAUL; R	36815	HANOV; R	1	138/138	363/363	445	345-L11120_R-N	345-L14401_R-N	130.5
20	36082	WAYNE;4M	37329	WAYNE; R	1	138/138	363/363	465	345-L11120_R-N	345-L14401_R-N	128.1
21	36405	WAYNE; R	36082	WAYNE;4M	1	345/138	363/363	465	345-L11120_R-N	345-L14401_R-N	127.8
22	36258	PLANO;	36060	PLANO;3M	1	765/345	363/363	1380	TR94_PLANO_R-S	765-L11216__-S	125.5
23	37372	WOLFS; B	36766	FRONT; B	1	138/138	363/363	225	345-L16704_B-S	345-L14321TB-N	123.2
24	36061	PLANO;4M	36258	PLANO;	1	345/765	363/363	1380	TR92_COLLI_R-S	765-L11216__-S	121.45
25	36061	PLANO;4M	36373	PLANO; R	1	345/345	363/363	1380	TR92_COLLI_R-S	765-L11216__-S	121.4

These violations can be mitigated by redispatch of the customer facility from 3500 MW to 700 MW in less than 30 minutes immediately after the first contingency occurs when system conditions indicate that the next contingency can cause an overload. Any redispatch arrangement is subject to PJM and the Midcontinent ISO agreeing to an acceptable redispatch protocol that would ensure curtailment of the

facility to 700 MW in 30 minutes or less. The requirement for redispatch will be documented in the Interconnection Service Agreement. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Light Load Reliability Analysis

The S57 and S58 projects were studied as 700MW **(525MVAr)** injection into Collins 765 kV substation. Projects S57 and S58 were evaluated for compliance with reliability criteria for **Light Load conditions** in 2014. However, ComEd, the Transmission Owner for this interconnection, has indicated they do not accept the study assumptions and methodology. As the S57 and S58 projects were not studied at levels above 700 MW for Light Load Conditions, all flows above 700 MW will be curtailed within 30 minutes when system conditions indicate that the next contingency can cause a reliability violation. The requirement for redispatch will be documented in the Interconnection Service Agreement. Any redispatch arrangement is subject to PJM and the Midcontinent ISO agreeing to an acceptable redispatch protocol that would ensure curtailment of the facility to 700 MW in 30 minutes or less. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request. Potential network impacts were as follows:

Steady-State Voltage Requirements

No violations were identified.

Generator Deliverability

No violations were identified.

Multiple Facility Contingency

No violations were identified.

Contribution to Previously Identified Overloads

No violations were identified.

Potential Congestion issues (Customer Facility operation at 3500MW)

Item 2a. The S57 and S58 queue projects increase the loading on the BURNH; B - 17SHEFLD 345kV line (from bus 270674 to bus 255111 ckt 1) increases from 78.95% to 104.17% (rating 1441MVA) for the single contingency '765-L11215__-S'.

Item 2b. The S57 and S58 queue projects increase the loading on the 17STLWEL - 05DUMONT 345kV line (from bus 255113 to bus 243219 ckt 1) increases from 96.06% to 130.12% (rating 1598MVA) for the single contingency '765-L11215__-S'.

Item 2c. The S57 and S58 queue projects increase the loading on the CRETE;BP - 17STJOHN 345kV line (from bus 274750 to bus 255112 ckt 1) increases from 99.065% to 131.92% (rating 1334MVA) for the single contingency '765-L11215__-S'.

Item 2d. The S57 and S58 queue projects increase the loading on the E FRA; B - CRETE;BP 345kV line (from bus 270728 to bus 274750 ckt 1) increases from 80.588% to 103.54% (rating 1334MVA) for the single contingency '765-L11216__-S'.

Item 2e. The S57 and S58 queue projects increase the loading on the BURNH;0R - 17MUNSTR 345kV line (from bus 270677 to bus 255109 ckt 1) increases from 95.66% to 130.32% (rating 1195MVA) for the single contingency '765-L11215__-S'.

Item 2f. The S57 and S58 queue projects increase the loading on the E FRA; R - UPNOR;RP 345kV line (from bus 270729 to bus 274804 ckt 1) increases from 95.75% to 128.75% (rating 1091MVA) for the single contingency '765-L11215__-S'.

Item 2g. The S57 and S58 queue projects increase the loading on the UPNOR;RP - 05OLIVE 345kV line (from bus 274804 to bus 243229 ckt 1) increases from 95.76% to 128.62% (rating 1091MVA) for the single contingency '765-L11215__-S'.

Item 2h. The S57 and S58 queue projects increase the loading on the R60_S72_TAP - T130 POI 345kV line (from bus 99202 to bus 90986 ckt 1) increases from 97.452% to 120.55% (rating 878MVA) for the single contingency '361_B2A'.

Item 2i. The S57 and S58 queue projects increase the loading on the T130 POI - 05E LIMA 345kV line (from bus 90986 to bus 242935 ckt 1) increases from 97.452% to 120.55% (rating 878MVA) for the single contingency '361_B2A'.

Item 2j. The S57 and S58 queue projects increase the loading on the 17STJOHN - S JOH; T 345kV line (from bus 255112 to bus 270886 ckt 1) increases from 86.73% to 118.48% (rating 1091MVA) for the single contingency '765-L11215__-S'.

Item 2k. The S57 and S58 queue projects increase the loading on the S JOH; T - 17GRNACR 345kV line (from bus 270886 to bus 255104 ckt 1) increases from 86.73% to 118.46% (rating 1091MVA) for the single contingency '765-L11215__-S'.

Item 2l. The S57 and S58 queue projects increase the loading on the 17GRNACR - G ACR; T 345kV line (from bus 255104 to bus 270771 ckt 1) increases from 84.89% to 115.34% (rating 1091MVA) for the single contingency '765-L11215__-S'.

Item 2m. The S57 and S58 queue projects increase the loading on the G ACR; T - 05OLIVE 345kV line (from bus 270771 to bus 243229 ckt 1) increases from 84.89% to 115.32% (rating 1091MVA) for the single contingency '765-L11215__-S'.

Item 2n. The S57 and S58 queue projects increase the loading on the 05OLIVE - 05DUMONT 345kV line (from bus 243229 to bus 243219 ckt 1) increases from 89.34% to 110.83% (rating 1272MVA) for the single contingency '765-L11215__-S'.

Item 2o. The S57 and S58 queue projects increase the loading on the WILTO; - 05DUMONT 765kV line (from bus 270644 to bus 243206 ckt 2) increases from 71.136% to 105.33% (rating 4047MVA) for the single contingency Base Case.

Item 2p. The S57 and S58 queue projects increase the loading on the WILTO; - 05DUMONT 765kV line (from bus 270644 to bus 243206 ckt 1) increases from 72.232% to 104.44% (rating 4444MVA) for the single contingency '238_B3'.

Potential Voltage Issues (3500MW)

The study case with S57/58 dispatched at 3500MW could not be reliably converged for the following scenarios:

Contingency Name	Cont. Type	Analysis Type	Error Type
765-L11215__-S	Single	Voltage Drop	Blown Up
2978	Line_FB	Voltage Drop	Blown Up
1750	Line_FB	Voltage Drop	Blown Up
112-65-BT3-4__	Line_FB	Voltage Drop	Blown Up
112-65-BT4-5__	Line_FB	Voltage Drop	Blown Up
765-L11215__-S	Single	Voltage Magnitude	Blown Up
2978	Line_FB	Voltage Magnitude	Blown Up
1750	Line_FB	Voltage Magnitude	Blown Up

112-65-BT3-4__	Line_FB	Voltage Magnitude	Blown Up
112-65-BT4-5__	Line_FB	Voltage Magnitude	Blown Up

Facility re-dispatch required to mitigate the above violations. Current review indicates that the facility dispatch from 3500 MWs to 700MWs would be necessary under conditions that would require the successful and rapid implementation of operating procedures to address various system conditions which may result in these voltage violations. Analysis will be performed during the Facilities Study phase to determine at what system load level the non-firm portion of the S57 & S58 project (2800 MWs) would need to be curtailed, resulting in only allowing a dispatch to inject the firm portion of the request (700MWs). Moreover, curtailment in this circumstance will be required under ALL conditions (normal and contingency) at or below the load level determined. Provisions relating to this need to re-dispatch the facility and curtail the non-firm portion of the request will be incorporated into an operating guide and referenced in the ISA for the project should the project proceed to interconnection.

ComEd, as Transmission Owner for this interconnection, has indicated that they do not accept the assumption that, in this circumstance, an operating guide can be relied upon as a means to re-dispatch this facility from 3500MW to 700MW within a reasonable time to avoid system collapse and/or cascading failure. ComEd notes, for example, that PJM does not monitor breaker failure contingencies in real-time, ComEd does not understand how an operating procedure can even be established to ensure voltage stability and prevent voltage collapse or cascading failures as the results above show the power flows did not converge. Any operating procedure must explicitly address how PJM will be able to ensure reliability for these contingencies, especially given the risk of voltage collapse or cascading failures. Additional study will be required during the Facilities Study to verify the customer facility response. If the additional studies indicate customer facility response can mitigate the violations and effective operating procedures can be developed, the requirement for redispatch will be documented in the Interconnection Service Agreement. Any redispatch arrangement is also subject to PJM and the Midcontinent ISO agreeing to an acceptable redispatch protocol that would ensure curtailment of the facility to 700 MW in 30 minutes or less.

Assuming effective operating procedures can be developed, the developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request. Additional studies would be needed to determine which upgrades would be necessary in the event (1) effective operating procedures cannot be developed; or (2) if operating procedures can be developed, if the developer wishes to eliminate the operational restriction.

Stability and Reactive Power Requirements for Low Voltage Ride Through
(Summary of VAR requirements based upon the results of the dynamic studies.)

This report evaluates the system dynamics related to the proposed PJM queue position S57/S58. Projects S57/S58 are a request to inject a total of 3500 MW into the ComEd system via a +/- 500 kV bipolar HVDC line, which is to be connected at the ComEd Collins 765 kV substation. The objective of this study is to assess the impact on PJM/ComEd system stability of this 3500 MW injection at Collins.

Study Assumptions

Project Initial conditions:

Net real power injection at Raun 345 kV (MISO) substation	3685 MW
Net real power injection at Collins 765 kV (ComEd/PJM) substation	3500 MW
Capacitive shunt at Raun 345 kV (MISO) HVDC rectifier substation	2500 Mvar
Capacitive shunt at Collins 765 kV (ComEd/PJM) HVDC inverter substation	2275 Mvar
Additional Compensation* at Collins 765 kV (ComEd/PJM) substation	308 MVAR

*Note that a +/- 600 Mvar switched shunt was added to the power flow model Raun 345 kV and Collins 765 kV ends of the HVDC to regulate the corresponding bus voltage. This was added by PJM for the study and not provided as part of the original design.

The study was performed using the RTEP 2013 Light Load stability base case with no additional reinforcements into the case.

Contingency Scenarios

The dynamic simulations of the proposed S57/S58 queue project were assessed for compliance with NERC and ComEd criteria. The range of contingencies evaluated was limited to those necessary to meet these criteria.

Five main fault types were considered:

1. Three-phase fault (3ph) with primary clearing time.
2. Three-phase fault (3ph) with delayed clearing time to simulate partial loss of relaying communications.
3. Three-phase fault (3ph) fault for duration of primary clearing time persisting as a single-line-to-ground fault cleared in delayed time as a result of breaker failure (stuck breaker) for both independent pole operated (IPO) breakers and gang operated breakers.

4. Three-phase fault (3ph) fault for duration of primary clearing time persisting as a 3ph fault cleared in delayed time as a result of breaker failure (stuck breaker) for gang operated breakers, only.
5. Three-phase fault (3ph) fault with multiple simultaneous line trips to simulate the loss of a transmission tower with multiple lines.

The complete list of contingencies evaluated is provided in the complete dynamics and stability report. The set of faults studied involve the following substations:

- Braidwood 345 kV
- Collins 765 kV
- Collins 345 kV
- Dresden 345 kV
- Elwood 345 kV
- Kincaid 345 kV
- LaSalle County 345 kV
- Powerton 345 kV
- Dumont 765 kV (AEP)
- Greentown 765 kV (AEP)
- Cook 765 kV (AEP)
- Marysville 765 kV (AEP)

Results

Following the addition of the proposed PJM queue project S57/S58, the system dynamic performance **failed** to meet applicable NERC, PJM and ComEd standards.

Reliability violations occur for the following contingencies:

Outage Unstable Scenarios

- Outage of Collins-Plano 765 kV L2315; Trip of Collins-Wilton Center 765 kV L11216 with or without fault.
- Outage of Collins- Wilton Center 765 kV L11216; Trip of Collins- Plano 765 kV L2315 with or without fault.

Breaker Failure Unstable Scenarios

- LaSalle Co. Red – Plano Red 345 kV L0102; Failed 1-2 breaker and loss of LaSalle Co. 345/138 kV Transformer 81 & LaSalle Co. Red/Blue bus tie.

Mitigation

To address the aforementioned stability issues the following has been identified:

1. Unstable Scenarios due to Outage: Restricting the power injected at Collins to 700 MW for any outage (emergency or maintenance) of any of the 765 kV lines terminating at Collins (Collins-Wilton Center Line 11216 or Collins Plano L2315) to mitigate the unstable outage scenarios.
2. Unstable Scenarios due to Breaker Failure: Replacement of two existing 3 cycle, 345 kV breakers at the ComEd LaSalle Co. plant with faster 2 cycle IPO breakers to mitigate unstable breaker failure scenarios.

Conclusions

- S57/S58 **failed** to meet NERC/PJM and ComEd standards resulting in three unstable scenarios.
- Unstable scenarios are addressed by:
  - Curtailment of S57 & S58 generation to 700 MW total pre-contingency for any outage (emergency or maintenance) of the Collins-Wilton Center 765 kV Line 11216 or the Collins-Plano 765 kV Line 2315.
  - Replacement of two existing 3 cycle, 345 kV breakers at the ComEd LaSalle Co. plant with faster 2 cycle IPO breakers.
- The simulations utilized **2275 MVAR of shunt compensation** at the Collins/PJM end of the HVDC line. This is required or expected to be provided by the developer to allow adequate operation of the DC line.
- Additional MVARS were needed to achieve an adequate voltage profile. This added up to 308 MVARS.

The stability violations can be mitigated by redispatch of the customer facility from 3500 MW to 700 MW in less than 30 minutes immediately after the first contingency occurs. Any redispatch arrangement is subject to PJM and the Midcontinent ISO agreeing to an acceptable redispatch protocol that would ensure curtailment of the facility to 700 MW in 30 minutes or less. The requirement for redispatch will be documented in the Interconnection Service Agreement. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Appendix: DC line dynamic model

```
** CDC6T  **  DC#  RECBUS X-- NAME --X BASEKV  INVBUS X-- NAME --X BASEKV
               48  800000 ROCK IS     345.00   36255 COLLI;       765.00

              C O N S     S T A T E S     V A R S      I C O N S
            249403-249434  95139-95141   25095-25112   10847-10849

  ALFDY  GAMDY   TVDC   TIDC VBLOCK  VUNBL  TBLOCK VBYPAS  VUNBY  TBYPAS  RSVOLT
   5.00  10.00  0.010  0.010 0.1500 0.9000   0.010    0.0 0.9500   0.010    0.00

  RSCUR  VRAMP  CRAMP     C0      V1      C1      V2      C2      V3      C3
   0.00  3.000  5.000   300.0   210.0  1500.0   270.0  3000.0   390.0  3300.0

 TCMODE  VDEBLK  TDEBLK  TREBLK  VINBLK   TCOMB  VACBYP  TDEBYP  TINBLK  TINBYP
  0.010  0.1500   0.010   0.020  0.0000  0.0000  0.7000   0.000   0.000   0.000

                        TVRDC
```

```
                    0.100

** CDC6T  **  DC#  RECBUS X-- NAME --X BASEKV  INVBUS X-- NAME --X BASEKV
              49  800000 ROCK IS      345.00   36255 COLLI;       765.00

               C O N S     S T A T E S     V A R S      I C O N S
             249435-249466  95142-95144   25113-25130   10850-10852

 ALFDY  GAMDY   TVDC   TIDC VBLOCK  VUNBL  TBLOCK VBYPAS  VUNBY  TBYPAS  RSVOLT
  5.00  10.00  0.010  0.010 0.1500 0.9000   0.010    0.0 0.9500   0.010    0.00

  RSCUR  VRAMP  CRAMP     C0      V1      C1      V2      C2      V3      C3
   0.00  3.000  5.000   300.0   210.0  1500.0   270.0  3000.0   390.0  3300.0

 TCMODE  VDEBLK  TDEBLK  TREBLK  VINBLK   TCOMB  VACBYP  TDEBYP  TINBLK  TINBYP
  0.010  0.1500   0.010   0.020  0.0000  0.0000  0.7000   0.000   0.000   0.000

                    TVRDC
                    0.100
```

Potential Issues to Adjacent RTO's

Additional impacts may be defined in the Facilities Study.

Potential Congestion Issues

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 developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

As a result of the aggregate energy resources in the area, no violations were identified.