



**GENERATOR INTERCONNECTION
LIMITED OPERATION
IMPACT STUDY REPORT**

GEN-2015-088

Published March 2017

By SPP Generator Interconnections Dept.

REVISION HISTORY

Date	Author	Change Description
3/16/2017	SPP	Impact Study of Limited Operation for Generator Interconnection GEN-2015-088 Report Issued

EXECUTIVE SUMMARY

<OMITTED TEXT> A request has been made for (Customer; GEN-2015-088) to be evaluated for Limited Operation System Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for 300.00 MW of wind generation to be interconnected with Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS) into the Transmission System of Nebraska Public Power District (NPPD) in Saline County, Nebraska. GEN-2015-088 Under GIA Section 5.9, this Limited Operation Interconnection Study (LOIS) to determine the impacts of interconnecting to the transmission system before all required Network Upgrades identified in the DISIS-2015-002 (or most recent iteration) Impact Study can be placed into service.

This LOIS addresses the effects of interconnecting the generators to the rest of the transmission system for the system topology and conditions as expected for January 2019. GEN-2015-088 consists of one-hundred-fifty (150) 2.0 MW Vestas wind turbines generators and associated facilities at NPPD's new Tobias Substation which would tap and loop in the Moore – Pauline 345kV circuit in Saline County, Nebraska. The LOIS assumes that only the higher queued projects listed within **Table 1A** and **Table 1B** of this study might go into service before the completion of all Network Upgrades identified within **Table 2** of this report. If additional generation projects, listed within **Table 3**, with queue priority equal to or higher than the study project request rights to go into commercial operation before all Network Upgrades identified within **Table 2** of this report are completed, this LOIS may need to be restudied to ensure that interconnection service remains for the customer's request.

Power flow analysis from this LOIS has determined that the GEN-2015-088 request can interconnect **300.00 MW** of generation with Energy Resource or Network Resource on an interim basis prior to the completion of the required Network Upgrades, listed within **Table 2** of this report. Should any other projects, other than those listed within of this report, come into service an additional study may be required to determine if any limited operation service is available. It should be noted that although this LOIS analyzed many of the most probable contingencies, it is not an all-inclusive list that can account for every operational situation. Additionally, the generator may not be able to inject any power onto the Transmission System due to constraints that fall below the threshold of mitigation for a Generator Interconnection request. Because of this, it is likely that the Customers may be required to reduce their generation output to **0 MW** under certain system conditions to allow system operators to maintain the reliability of the transmission network.

Transient stability analysis was not performed for this LOIS study. The results from DISIS 2015-002-1 remain valid.

Nothing in this study should be construed as a guarantee of delivery or transmission service. If the customer wishes to sell power from the facility, a separate request for transmission service must be requested on Southwest Power Pool's OASIS by the Customer.

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PURPOSE

<OMITTED TEXT> (Interconnection Customer) is being evaluated for a Limited Operation System Impact Study (LOIS) under the Southwest Power Pool (SPP) Open Access Transmission Tariff (OATT) for interconnection requests into the Transmission System of NPPD.

The purpose of this study is to reevaluate the impacts of interconnecting GEN-2015-088 request of 300.00 MW comprised of 2.0 MW Vestas wind turbine generators and associated facilities interconnecting at NPPD's new Tobias Substation which would tap and loop in the Moore – Pauline 345kV circuit in Saline County, Nebraska. The LOIS studied the customer's ERIS and NRIS to commence on or around January of 2019.

Only power flow analysis was conducted for this Limited Operation Interconnection Service. Limited Operation Studies are conducted under GIA Section 5.9.

The LOIS considers the Base Case as well as all Generating Facilities (and with respect to any identified Network Upgrades associated with such higher queued interconnection) that, on the date the LOIS is commenced:

- a) are directly interconnected to the Transmission System;
- b) are interconnected to Affected Systems and may have an impact on the Interconnection Request;
- c) have a pending higher queued Interconnection Request or projects to interconnect to the Transmission System listed in **Table 1A** and **Table 1B**; or
- d) have no Queue Position but have executed an LGIA or requested that an unexecuted LGIA be filed with FERC.

Any changes to these assumptions (for example, one or more of the previously queued requests not included within this study execute an interconnection agreement and commencing commercial operation) may require a re-study of this LOIS at the expense of the Customer.

Nothing within this System Impact Study constitutes a request for transmission service or confers upon the Interconnection Customer any right to receive transmission service rights. Should the Customer require transmission service, those rights should be requested through SPP's Open Access Same-Time Information System (OASIS).

This LOIS study included prior queued generation interconnection requests and projects. Those listed within **Table 1A** are the generation interconnection requests that are assumed to have rights to either full or partial interconnection service prior to the requested January 2019 in-service of GEN-2015-088 for this LOIS. Also listed in **Table 1A** are both the amount of MWs of interconnection service expected at the effective time of this study and the total MWs requested of interconnection service, the fuel type, the point of interconnection (POI), and the current status of each particular prior queued request. **Table 1B** lists the prior queued projects included within the study and currently status.

Table 1A: Generation Requests Included within LOIS

Project	MW	Total MW	Fuel Source	POI	Status
GEN-2003-021N	75	75	Wind	Ainsworth Wind Tap 115kV	COMMERCIAL OPERATION
GEN-2004-023N	75	75	Coal	Columbus Co 115kV	COMMERCIAL OPERATION
GEN-2006-020N	42	42	Wind	Bloomfield 115kV	COMMERCIAL OPERATION
GEN-2006-038N005	80	80	Wind	Broken Bow 115kV	COMMERCIAL OPERATION
GEN-2006-038N019	80	80	Wind	Petersburg North 115kV	COMMERCIAL OPERATION
GEN-2007-011N08	81	81	Wind	Bloomfield 115kV	COMMERCIAL OPERATION
GEN-2008-1190	60	60	Wind	S1399 161kV	COMMERCIAL OPERATION
NPPD Distributed (Broken Bow)	7.3	7.3	Heat	Broken Bow 115kV	COMMERCIAL OPERATION
NPPD Distributed (Burwell)	3	3	Heat	Ord 115kV	COMMERCIAL OPERATION
NPPD Distributed (Ord)	10.8	10.8	Heat	Ord 115kV	COMMERCIAL OPERATION
NPPD Distributed (Stuart)	1.8	1.8	Heat	Ainsworth 115kV	COMMERCIAL OPERATION
NPPD Distributed (Columbus Hydro)	45	45	Hydro	Columbus 115kV	COMMERCIAL OPERATION
NPPD Distributed (Burt County Wind)	12	12	Wind	Tekamah & Oakland 115kV	COMMERCIAL OPERATION
NPPD Distributed (Buffalo County Solar)	10	10	Solar	Kearney Northeast 34.5 kV	COMMERCIAL OPERATION
GEN-2006-037N1	74.8	74.8	Wind	Broken Bow 115kV	COMMERCIAL OPERATION
GEN-2006-044N	40.5	40.5	Wind	North Petersburg 115kV	COMMERCIAL OPERATION
GEN-2008-086N02	201.0	201.0	Wind	Meadow Grove 230kV	COMMERCIAL OPERATION
GEN-2008-123N	89.7	89.7	Wind	Tap Pauline - Hildreth (Rosemont) 115kV	IA FULLY EXECUTED/ON SCHEDULE
GEN-2009-040	73.8	73.8	Wind	Tap Smittyville - Knob Hill 115KV	COMMERCIAL OPERATION
GEN-2010-041	10.5	10.5	Wind	S1399 161kV	IA FULLY EXECUTED/ON SCHEDULE
GEN-2011-018	73.6	73.6	Wind	Steele City 115kV	COMMERCIAL OPERATION
NPPD Distributed (North Platte - Lexington)	54	54	Hydro	Multiple: Jeffrey 115kV, John_1 115kV, John_2 115kV	COMMERCIAL OPERATION
GEN-2011-056	3.6	3.6	Hydro	Jeffrey 115kV	COMMERCIAL OPERATION
GEN-2011-056A	3.6	3.6	Hydro	John 1 115kV	COMMERCIAL OPERATION
GEN-2011-056B	4.5	4.5	Hydro	John 2 115kV	COMMERCIAL OPERATION

Table 1A: Generation Requests Included within LOIS

Project	MW	Total MW	Fuel Source	POI	Status
GEN-2012-021	4.8	4.8	Gas	Terry Bundy Generating Station 115kV	COMMERCIAL OPERATION
GEN-2013-002	50.6	50.6	Wind	Sheldon - Folsom & Pleasant Hill 115kV CKT 2	IA FULLY EXECUTED/ON SUSPENSION
GEN-2013-008	1.2	1.2	Wind	Steele City 115kV	COMMERCIAL OPERATION
GEN-2013-019	73.6	73.6	Wind	Tap Sheldon - Folsom & Pleasant Hill (GEN-2013-002 Tap) 115kV CKT 2	IA FULLY EXECUTED/ON SUSPENSION
GEN-2013-032	204	204	Wind	Antelope 115kV	IA FULLY EXECUTED/ON SCHEDULE 6/2017
GEN-2014-004	3.96	3.96	Wind	Steele City 115kV (GEN-2011-018 POI)	COMMERCIAL OPERATION
GEN-2014-013	73.5	73.5	Wind	Meadow Grove (GEN-2008-086N2 Sub) 230kV	COMMERCIAL OPERATION
GEN-2014-031	35.8	35.8	Wind	Meadow Grove 230kV	COMMERCIAL OPERATION
GEN-2014-032	10.2	10.2	Wind	Meadow Grove 230kV	COMMERCIAL OPERATION
GEN-2015-007	160.0	160.0	Wind	Hoskins 345kV	IA FULLY EXECUTED/ON SCHEDULE 12/2019
GEN-2015-023	300.7	300.7	Wind	Holt County 345kV	IA FULLY EXECUTED/ON SCHEDULE 12/2020
GEN-2015-053	50.0	50.0	Wind	Antelope 115kV	FACILITY STUDY STAGE
GEN-2015-076	158.4	158.4	Wind	Belden 115kV	FACILITY STUDY STAGE
GEN-2015-088	66.0	66.0	Wind	Tap Fairbury – Hebron 115kV	FACILITY STUDY STAGE
GEN-2015-088	300.0	300.0	Wind	Tap Moore – Pauline 345kV	FACILITY STUDY STAGE

Table 1B: Upgrade Projects included within LOIS

Upgrade Project	Type	Description	Status	Study Assignment
Twin Church - Dixon County 230kV CKT 1	Conductor clearance increase	Increase conductor clearance to achieve at least 326 MVA Summer Peak emergency	On Schedule for 11/2018 In-Service	Assigned to DISIS-2010-002 & DISIS-2011-001 Customer(s)
Belvidere - Fairbury 115kV CKT 1	Uprate	Uprate Belvidere - Fairbury to at least 107 MVA	Facility Study Stage	Assigned to DISIS-2015-002 Customer(s)
Beatrice - Harbine 115kV CKT 1	Uprate	Uprate Beatrice - Harbine to at least 102 MVA	Facility Study Stage	

This LOIS was required because the Customers are requesting interconnection prior to the completion of all of their required upgrades listed within the latest iteration of their Definitive Interconnection System Impact Study (DISIS). **Table 2** below lists the required upgrade projects for which these requests have cost responsibility. GEN-2015-088 was included within the DISIS-2015-002 that was studied in spring 2016 and posted April 29, 2016. The cluster has been restudied since the original posting. These reports can be located at the following Generation Interconnection Study URL: <http://sppoasis.spp.org/documents/swpp/transmission/GenStudies.cfm?YearType=2015> Impact Studies

Table 2: Upgrade Projects not included but Required for Full Interconnection Service

Upgrade Project	Type	Description	Status	Study Assignment
Gentleman – Thedford – Holt 345 kV (“R-Plan”) Project	New line	Build approximately two-hundred-twenty-seven (227) miles of new 345kV from Gentleman – Thedford – Holt, construct Thedford Substation and 345/161/13kV transformer, and construct new Holt County Substation	On Schedule for 10/2019	Assigned in 2012 Integrated Transmission Plan – 10 year assignment (2012 ITP10)
Bondurant – Montezuma 345kV CKT 1	Uprate	Replace structures, wave trap, update CT and relay settings	Affected System Facility Study Stage	Assigned to DISIS-2015-002 Customer(s)

Any changes to these assumptions, for example, one or more of the previously queued requests not included within this study execute an interconnection agreement and commencing commercial operation, may require a re-study of this LOIS at the expense of the Customer. The higher or equally queued projects that were not included in this study are listed in **Table 3**. While this list is not all inclusive it is a list of the most probable and affecting prior queued requests that were not included within this LOIS, either because no request for an LOIS has been made or the request is on suspension, etc.

Table 3: Higher or Equally Queued GI Requests not included within LOIS

Project	MW	Total MW	Fuel Source	POI	Status
None					

Nothing in this System Impact Study constitutes a request for transmission service or grants the Interconnection Customer any rights to transmission service.

FACILITIES

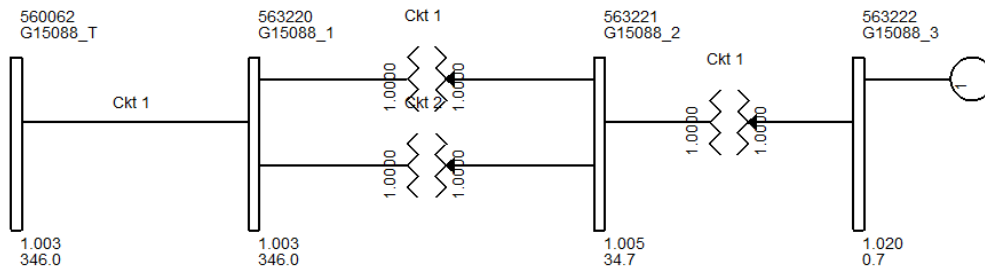
GENERATING FACILITY

Interconnection Customer’s request, GEN-2015-088, totals 300.00 MW; it is comprised of 2.0 MW Vestas wind turbine generators and associated facilities.

INTERCONNECTION FACILITIES

The POI for GEN-2015-088 is at NPPD’s new Tobias Substation which would tap and loop in the Moore – Pauline 345kV circuit in Saline County, Nebraska. **Figure 1** depicts the one-line diagram of the local transmission system including the POI as well as the power flow model representing the requests.

Figure 1: Proposed POI Configuration and Request Power Flow Model



BASE CASE NETWORK UPGRADES

The Network Upgrades included within the cases used for this LOIS study are those facilities that are a part of the SPP Transmission Expansion Plan or the Balanced Portfolio projects that have in-service dates prior to the GEN-2015-088 LOIS requested in-service date of January 2019. These facilities have an approved Notification to Construct (NTC), or are in construction stages and expected to be in-service at the effective time of this study. No other upgrades were included for this LOIS. If for some reason, construction on these projects is delayed or discontinued, a restudy may be needed to determine the interconnection service availability of the Customer.

Power flow analysis is used to determine if the transmission system can accommodate the injection from the request without violating thermal or voltage transmission planning criteria.

POWER FLOW ANALYSIS

Power flow analysis is used to determine if the transmission system can accommodate the injection from the request without violating thermal or voltage transmission planning criteria.

MODEL PREPARATION

Power flow analysis was performed using modified versions of the 2015 series of transmission service request study models including the follow.

- Year 1 2016 winter peak (16WP)
- Year 2 2017 summer peak (17SP)
- Year 5 2020 summer (20SP)
- Year 5 2020 winter peak (20WP)

To incorporate the Interconnection Customers' request, a re-dispatch of existing generation within SPP was performed with respect to the amount of the Customers' injection.

For Variable Energy Resources (VER) (solar/wind) in each power flow case, Energy Resource Interconnection Service (ERIS), is evaluated for the generating plants within a geographical area of the interconnection request(s) for the VERs dispatched at 100% nameplate of maximum generation. The VERs in the remote areas are dispatched at 20% nameplate of maximum generation. These projects are dispatched across the SPP footprint using load factor ratios.

Peaking units are not dispatched in the spring case, or in the "High VER" summer and winter peak cases. To study peaking units' impacts, the Year 1 winter peak and Year 2 summer peak, and Year 5 summer and winter peaks summer peak models are developed with peaking units dispatched at 100% of the nameplate rating and VERs dispatched at 20% of the nameplate rating. Each interconnection request is also modeled separately at 100% nameplate for certain analyses.

All generators (VER and peaking) that requested Network Resource Interconnection Service (NRIS) are dispatched in an additional analysis into the interconnecting Transmission Owner's (T.O.) area at 100% nameplate with Energy Resource Interconnection Service (ERIS) only requests at 80% nameplate. This method allows for identification of network constraints that are common between regional groupings to have affecting requests share the mitigating upgrade costs throughout the cluster.

For this LOIS, only the previous queued requests listed in **Table 1** were assumed to be in-service at 100% dispatch.

STUDY METHODOLOGY AND CRITERIA

THERMAL OVERLOADS

Network constraints are found by using PSS/E AC Contingency Calculation (ACCC) analysis with PSS/E MUST First Contingency Incremental Transfer Capability (FCITC) analysis on the entire cluster grouping dispatched at the various levels previously described.

For Energy Resource Interconnection Service (ERIS), thermal overloads are determined for system intact (n-0) greater than 100% of Rate A - normal and for contingency (n-1) greater than 100% of Rate B – emergency conditions.

The overloads are then screened to determine which interconnection requests have at least

- 3% Distribution Factor (DF) for system intact conditions (n-0),
- 20% DF upon outage-based conditions (n-1),
- or 3% DF on contingent elements that resulted in a non-converged solution.

Appropriate transmission reinforcements are identified to mitigate the constraints.

Interconnection Requests that requested Network Resource Interconnection Service (NRIS) are also studied in a separate NRIS analysis to determine if any constraint measured greater than or equal to a 3% DF. If so, these constraints are also assigned transmission reinforcements to mitigate the impacts.

VOLTAGE

For non-converged power flow solutions that are determined to be caused by lack of voltage support, appropriate transmission support will be identified to mitigate the constraint.

After all thermal overload and voltage support mitigations are determined; a full ACCC analysis is then performed to determine voltage constraints. The following voltage performance guidelines are used in accordance with the Transmission Owner local planning criteria.

SPP voltage criteria is applicable to all SPP facilities 69 kV and greater in the absence of more stringent criteria:

System Intact	Contingency
0.95 – 1.05 per unit	0.90 – 1.05 per unit

Areas and specific buses having more-stringent voltage criteria:

Areas/Facilities	System Intact	Contingency
AEPW – all buses EMDE High Voltage	0.95 – 1.05 per unit	0.92 – 1.05 per unit
WERE Low Voltage	0.95 – 1.05 per unit	0.93 – 1.05 per unit
WERE High Voltage	0.95 – 1.05 per unit	0.95 – 1.05 per unit
TUCO 230 kV Bus #525830	0.925 – 1.05 per unit	0.925 – 1.05 per unit
Wolf Creek 345 kV Bus #532797	0.985 – 1.03 per unit	0.985 – 1.03 per unit
FCS Bus #646251	1.001 – 1.047 per unit	1.001 – 1.047 per unit

First-Tier External Areas facilities 115 kV and greater.

Area	System Intact	Contingency
EES-EAI LAGN EES AMMO CLEC LAFA LEPA XEL MP SMMPA GRE OTP ALTW MEC MDU DPC ALTE	0.95 – 1.05 per unit	0.90 – 1.05 per unit
OTP-H (115kV+)	0.97 – 1.05 per unit	0.92 – 1.10 per unit
SPC	0.95 – 1.05 per unit	0.95 – 1.05 per unit

The constraints identified through the voltage scan are screened for the following for each interconnection request. 1) 3% DF on the contingent element and 2) 2% change in pu voltage. In certain conditions, engineering judgement was used to determine whether or not a generator had impacts to voltage constraints.

RESULTS

The LOIS ACCC analysis indicates that the Customers can interconnect their generation into the NPPD transmission system as requested before all required upgrades listed within the DISIS-2015-002 study can be placed into service. Should any other GI projects, other than those listed within **Table 1** of this report, come into service an additional study may be required to determine if any limited operation service is available.

ACCC results for the LOIS can be found in **Table 4, 5 and 6** below. **Table 6** has the overloads that are less than 20% TDF and are not for mitigation. Generator Interconnection Energy Resource analysis does not mitigate for issues in which the affecting GI request has less than a 20% OTDF. **Table 6** is provided for informational purposes only so that the Customer understands there may be operational conditions when they may be required to reduce their output to maintain system reliability.

CURTAILMENT AND SYSTEM RELIABILITY

In no way does this study guarantee operation for all periods of time. It should be noted that although this study analyzed many of the most probable contingencies, it is not an all-inclusive list and cannot account for every operational situation. Because of this, it is likely that the Customer(s) may be required to reduce their generation output to **0 MW** under certain system conditions to allow system operators to maintain the reliability of the transmission network.

Table 4: Thermal Constraints for Transmission Reinforcement Mitigation

Dispatch Group	Season	Source	Flow	Monitored Element	RATE A (MVA)	RATE B (MVA)	TDF	TC % LOADING	Max MW Available	Contingency
			N/A	None					300.00	

Table 5: Steady State Voltage Constraints for Transmission Reinforcement Mitigation

Dispatch Group	Season	Source	Monitored Element	VMIN (PU)	VMAX (PU)	V Differ (PU)	TC Voltage (PU)	Max MW Available	Contingency
			None					300.00	

Table 6: Additional Constraints of GEN-2015-088 LOIS

Dispatch Group	Season	Source	Flow	Monitored Element	RATE A (MVA)	RATE B (MVA)	TDF	TC % LOADING	Contingency
				None					

STABILITY ANALYSIS

Transient stability analysis was not performed for this LOIS study. The results from DISIS 2015-002-1 remain valid. Results from the Material Modification analysis will be provided in a separate future report.

CONCLUSION

<OMITTED TEXT> A request has been made for (Customer; GEN-2015-088) to be evaluated for GEN-2015-088 Limited Operation System Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for a total of 300.00 MW of wind generation to be interconnected with ERIS and NRIS into the Transmission System of NPPD in Saline County, Nebraska. The POI will be at the at NPPD's new Tobias Substation which would tap and loop in the Moore – Pauline 345kV circuit. Under GIA Section 5.9, this LOIS to determine the impacts of interconnecting to the transmission system before all required Network Upgrades identified in the DISIS-2015-002 (or most recent iteration) Impact Study can be placed into service.

GEN-2015-088

Power flow analysis from this LOIS has determined that GEN-2015-088 request can interconnect their generation as a Network Resource prior to the completion of the required Network Upgrades, listed within **Table 2** of this report. Should any other projects (other than those listed within **Table 1** of this report) come into service, an additional study may be required to determine if any limited operation service is available. Refer to **Table 4 and 5** for the Limited Operation Interconnection Service available due to interconnection constraints.

Transient stability analysis was not performed for this LOIS study. The results from DISIS 2015-002-1 remain valid.

Any changes to these assumptions may require a re-study of this LOIS at the expense of the Customer. (For example, one or more of the previously queued requests not included within this study executes an interconnection agreement and commences commercial operation.)

Nothing in this System Impact Study constitutes a request for transmission service or confers upon the Interconnection Customer any right to receive transmission service.