Langdon, ND
159 MW
Wind-Powered Generation Facility

System Impact Study

Supplemental Report #1

Addressing followup items from the
September 27, 2007 DRS Approval of the
Langdon Wind Project

- Items listed in the DRS motion
- Items included in minutes of the DRS meeting
- Additional items discussed at various meetings

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0.0 Background Information

The MAPP DRS, on a September 27, 2007 conference call, reviewed the *Langdon, ND 159 MW Wind-Powered Generation Facility System Impact Study* dated September 12, 2007 and approved the following motion:

> *The system impact study for Interconnection only of Langdon, ND 159 MW Wind Powered Generation Facility contingent upon:*
>
> 1. *Implementation of system improvements as follows:*
>
> - *New Langdon-Hensel 115 kV line addition*
> - *Existing Devils Lake-Sweetwater-Langdon 115 kV line uprate and application of wind adjusted rating and associated operating guide*
> - *Existing Hensel-Drayton 115 kV line uprate and application of wind adjusted rating and associated operating guide*
> - *a. Further upgrades may be required if the MISO G651 project proceeds*
> - *Ramsey 230/115 kV transformer SPS (temporary)*
> - *Langdon generation reduction SPS to manage voltage stability and thermal limits on the Langdon 115 kV outlet lines.*
>
> 2. *Develop operating guide for mitigation of Langdon's impacts with MISO congestion management procedures for loading of D602F, to be approved by the TOS*
> 3. *Future presentation of out-year analysis to the DRS which will address prior queued generation projects (with in-service dates after approximately December 2009)*
> 4. *Permanent solution for Ramsey 230/115 kV transformer overload issue to be placed in-service by October 2009.*

Additional discussions during the September 27, 2007 conference call resulted in the following requests:

- Provide documentation of the votes of "no objection"
- Provide results of contingency analysis using Rate A
- Provide additional study work related to the Groton Synchronous Condenser

The following additional items that were discussed but not included in the DRS meeting minutes are also provided in the report:

- Identification of the project schedule
- Steady state sensitivity analysis to show impact of the Ellendale Wind project (G132). This prior queued project was not included in the steady state analysis in the original System Impact Study dated September 12, 2007
- Steady state sensitivity analysis to show impact of additional higher-queued projects that were not included in the original System Impact Study
- Dynamic sensitivity analysis with D602F flow limited to 1785 MVA. The original System Impact Study used a limit of 1765 MVA.
- Update stability results for the FD3 fault with a gen-load dispatch

1.0 Analysis

1.1 Models employed

The base cases for the System Impact Study are documented in Section 4.1 of the report approved by the DRS on September 27, 2007. For this supplemental report, a number of additional prior queued projects with in-service dates between 2007 and 2009 were identified for inclusion in the models. They are as follows:

- 180 MW at Ellendale 230 kV; G132
- 50 MW at Oliver County (1); G502
- 50 MW at Oliver County (2); GS659
- 10 MW at Antelope Valley 1; GI-0101
- 10 MW at Antelope Valley 2; GI-0101

These projects are in addition to the projects that were initially modeled, which were:

- 150 MW at OTP Rugby 230 kV; MISO Project G380
- 16 MW at NSP Minot [McHenry-Souris 115 kV]; MISO Project G408
- 39 MW at OTP Hanks Corner [connected back to Hensel 69 kV]; MISO Project G651

The MHEX and NDEX loadings within the various study cases were at the following MW values for the post-project cases:

Condition	MHEX	NDEX
Summer off-peak	2175	2080
Summer peak	2175	1560
Winter peak	-700	620

1.2 Conditions studied

The following models were included within this analysis. These models were named in the following manner with the defined system paramters included below:

- "E00" refers to the existing system
- "E0H" refers to the existing system with the Langdon-Hensel 115 kV line addition, but without the Langdon generation
- "E16" refers to the addition of the Langdon 159 MW generation project dispatched to existing generation with the Langdon-Hensel 115 kV line addition
- "16L" refers to the addition of the Langdon 159 MW generation project dispatched to ND load with the Langdon-Hensel 115 kV line addition
- "16D" refers to the addition of the Langdon 159 MW generation project dispatched to existing generation with the Langdon-Hensel 115 kV line addition and F601C at 1785 MW
- "F0G" refers to the existing system with Groton Synchronous Condenser status off
- "FLG" refers to the addition of the Langdon 159 MW generation project dispatched to existing generation with the Langdon-Hensel 115 kV line addition and Groton Synchronous Condenser off

The Langdon generation was dispatched by displacing MPC (Young 2) and OTP (Hoot Lake Units 2 & 3) generation for steady state analysis and the majority of the dynamic stability analysis.

A "generation to load" dispatch was also evaluated for a comparative dynamic stability analysis. The load that was scaled was the MPC and OTP load selected by load ID in the cases. MPC's load in northern Minnesota that is served from the Moranville and Running substations was excluded.

2.0 Documentation and Results of Detailed Analyses

This report is a supplement to the Langdon, ND 159 MW Wind-Power Generation Facility System Impact Study dated September 12, 2007. This report includes additional study work to evaluate the impacts the Langdon wind project may have with other near-term prior queued projects.

2.1 Addition of Langdon-Hensel 115 kV line; uprate and application of wind-adjusted ratings for local 115 kV lines

The new Langdon-Hensel 115 kV line was placed in service on December 31, 2007.

The Hensel-Drayton 115 kV line was uprated to accommodate a summer continuous rating of 130 MVA. The rating increase was achieved by raising conductors to increase clearance. The work was completed on December 14, 2007.

The Langdon-Sweetwater-Devils Lake 115 kV line was uprated to accommodate a summer continuous rating of 130 MVA. The rating increase was achieved by raising conductors to increase clearance. This was completed on March 4, 2008. The previous winter rating of 127 MVA was adequate for the short period of Langdon Wind operation preceding completion of the uprate.

The Langdon Wind Generation Operating guide addresses operation of the wind farm to maintain flows within the wind-adjusted ratings. The guide was approved by the TOS on December 5, 2007. The TOS minutes are included in Appendix A.

2.2 Required upgrades to accommodate prior queued Hanks Corner project (G651)

As of March 25, 2008 the G651 project (Hanks Corner 39 MW wind) has withdrawn from the MISO Generation Interconnection Queue, so no additional upgrades will be required on the Hensel-Drayton 115 kV line.

2.3 Implementation of Ramsey and Langdon SPS's

The Ramsey SPS was approved by the MRO SPS Review Team on January 11, 2008. The Ramsey Transformer Operating Guide covers operation of the Ramsey transformer with the SPS in place. The operating guide was approved for temporary use until the end of October 2009 by the TOS on December 5, 2007. The TOS meeting minutes and the MRO letter of approval are included in Appendix A.

The Langdon SPS was approved by the MRO SPS Review Team on January 11, 2008. The Langdon Wind Generation Operating Guide covers operation of the wind farm with the SPS in place. The operating guide was approved by the TOS on December 5, 2007. The TOS meeting minutes and the MRO letter of approval are included in Appendix A.

2.4 Implementation of operating guide to address mitigation of impacts on D602F

The Dorsey-Forbes 500 kV Line Operating guide addresses mitigation of impacts due to Langdon Wind. The guide was approved by the TOS on December 5, 2007. The TOS minutes are included in Appendix A.

2.5 "No Objection" vote documentation

"No Objection" votes were received from:

- Manitoba Hydro
- Midwest Independant System Operator
- Western Area Power Administration
- Great River Energy
- Minnesota Power
- Missouri River Energy Services

The full text of the emails from these companies is included in Appendix B.

The project participants are not aware of any outstanding objections.

2.6 Steady state contingency analysis using Rate A

A detailed AC contingency analysis using the MUST program from Siemens PTI™ was performed for the summer peak, summer off-peak and winter peak cases with the near-term prior queued projects modeled. The purpose of this analysis was to determine if any new loading or voltage violations are caused by the Langdon wind project. This analysis monitored facilities based on Rate A to develop a list of "Significantly Affected Facilities". The results of this analysis did not indicate any new facility or voltage issues. A full listing of the results is shown in Appendix C.

2.7 Dynamic sensitivity analysis with the Groton synchronous condenser off-line

The dynamic stability analysis for the September 12, 2007 version of the System Impact Study was performed with the Groton synchronous condenser in service and the Rapid City DC = 0. It was noted during discussions that the preferred modeling to represent a worst-case scenario for the summer off-peak high transfer case (NDEX = 2080) is with the Groton synchronous condenser off-line and Rapid City DC = 0. Therefore, the original case was modified by turning off the Groton synchronous condenser and the most limiting faults were re-studied..

The analysis included the list of faults in Table 2.6.1. This list includes the faults that were determined to be the most limiting from the generation interconnection studies already completed for G132 and GS659, two of the most significant prior queued projects being addressed by this supplemental report.

Table 2.6.1 – Fault List

Fault Name	Faulted Bus	Fault Type	Clearing Time (cycles)	Initial Clearing	Backup Clearing (cycles)	Backup Clearing
AG1	Leland Olds 345kV	SLGBF	4	Leland Old-Ft Thompson line	11	FLTD Line
EI2	Coal Creek 230kV	fault	10	CU HVDC bipole	7	Coal Creek 1&2
NMZ	Chisago Co 500kV	3-phase	4	Chisago Co – Forbes 500kV line		100% DC reduction
FD3	Square Butte 230kV	3-phase	5	Square Butte-Stanton 230kV line		
EF3	Stanton 230kV	3-phase	5	Stanton-Coal Ck-McHenry 230kV		

This additional stability analysis indicates that performance for the known limiting faults is within system performance criteria. The Langdon generation addition does not aggravate any of the previously known issues, including those for G132 and GS659.

Stability table and reports are in Appendix D.

2.8 Identification of project schedule

November 29, 2007	Langdon wind farm in service at maximum of 120 MW
December 15, 2007	Langdon wind farm in service at 160 MW. The Langdon SPS must be in service before Langdon generation exceeds 120 MW
December 15, 2007	Langdon-Hensel 115 kV line completed. The Ramsey SPS must be in service before the Langdon-Hensel line is commissioned.

2.9 Steady state analysis to show impact of the Ellendale Wind project (G132)

A sensitivity thermal analysis was performed on the summer off-peak case to determine how the Langdon generation project may interact with other near-term prior queued projects from a thermal standpoint. The intent of this analysis was to determine if the Langdon generation project had an impact on the loading issues identified in the Ellendale area, as identified in the G132 interconnection study. Two new contingencies were performed as part of this analysis and are listed in Table 2.9.1.

Table 2.9.1 – Ellendale Area Thermal Analysis

		Loading, MVA		
Outage	Monitored	Existing System with prior q'd gen	Langdon-Hensel line w/o gen	Langdon 160 MW with Langdon-Hensel
Ellendale-Oakes & Oakes-Forman	Ellendale Transformer	143.3 (139%)	143.6 (139%)	141.8 (137%)
	Ellendale-Aberdeen	133.5 (162%)	133.9 (162%)	132.1 (160%)
Center-Jamestown	Ellendale-G132	323.2 (138%)	322.8 (137%)	319.4 (136%)
	Ellendale-Oakes	256.7 (109%)	256.4 (109%)	253.5 (107%)

This table shows that the Langdon generation project has a negligible impact on system performance. This result is not surprising given the significant electrical distance between the Langdon and Ellendale generation projects. Previously identified overloaded facilities in the Ellendale area that were identified in the G132 interconnection studies are actually slightly unloaded due to the Langdon wind project.

2.10 Steady state analysis to show impact of other prior queued projects on Ramsey transformer loading

A sensitivity of the system intact loadings on the Ramsey transformer was done to determine if the addition of the near-term prior queued projects aggravate the Ramsey transformer loading issue introduced by the facilities included as part of the Langdon wind project. Table 2.10.1 shows the Ramsey transformer flows for the relevant combinations of system conditions once all the prior queued projects were included in the study models.

Table 2.10.1 – Ramsey Transformer Flows – System Intact Conditions

	Winter Peak Flows, MVA (%)	
	Analysis From Main Report*	**Sensitivity Analysis**
Existing System	82.9 (99%)	81.1 (97%)
Add Langdon-Hensel 115 kV	112.8 (134%)	110.5 (132%)
Add Langdon-Generation 160 MW **Add Langdon-Hensel 115 kV**	75.1 (89%)	74.6 (89%)

* Included only prior queued projects G380, G408, G651

Table 2.10.1 shows that the addition of the near-term prior queued generation projects listed in Section 1.1 decrease the loading by 2% during the previously identified critical condition in which the new Langdon-Hensel 115 kV line is in-service when output from the Langdon wind generation is low.

2.11 Dynamic sensitivity analysis with D602F flow limited to 1785 MVA

The System Impact Study report approved by the DRS on September 27, 2007 included stability analysis of the NMZ fault with F601C reduced to 1765 MVA to honor operating limitations on this line (which is also a flowgate). It was later observed that the F601C standing operating guide prescribes a limit of 1785 MVA, which is 20 MVA higher than the previous submitted study material. This is important because it was observed that the transient voltage performance at the Wahpeton 115 kV bus following the NMZ disturbance has a direct relation to the flow on the Forbes-Chisago Co 500 kV line. When the flow on the Forbes-Chisago Co 500 kV line is 1785 MVA, the minimum dynamic voltage at Wahpeton 115 kV is 0.84 pu following the NMZ disturbance, which is above the 0.80 pu criteria.

The stability table and reports from this analysis are in Appendix E.

2.12 Updated dynamic stability results for the FD3 fault with a gen-load dispatch

The System Impact Study report approved by the DRS on September 27, 2007 included stability analysis of the FD3 fault with a gen-gen dispatch. The fault was re-studied with Langdon Wind dispatched to ND load.

The stability table and report from this analysis is in Appendix F.

3.0 Conclusions

Based on the results of this additional analysis, no further issues have been identified with the Langdon wind project in-service and the near-term prior queued projects in-service.

The documentation and study results presented in this report address the follow-up requests from the DRS approval on September 27, 2007, with the following exceptions:

- Future presentation of out-year analysis to the DRS which will address prior queued generation projects (with in-service dates after approximately December 2009)
- Permanent solution for Ramsey 230/115 kV transformer overload issue to be placed in-service by October 2009.

Additional information and analysis will be provided to the DRS as needed at future meetings.