AMERICAN TRANSMISSION COMPANY
THE ENERGY ACCESS COMPANY

Interconnection Feasibility Study Report
98 MW Wind Generation
Fond du Lac County, Wisconsin

G507
MISO Queue #38422-03

September 30, 2005
American Transmission Company, LLC

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System Planning

1. Summary

This report contains the Feasibility Study Report for the Generation Interconnection Request Midwest Independent System Operator ("MISO") project #G507, MISO Queue #38422-03. The purpose of this study is to identify all steady state thermal and voltage violations caused by the proposed interconnection. The requested in-service date for this project is December 1, 2006.

The G507 wind farm will connect on line X-2 near the point where the 345 kV line #971L51 crosses over the 138 kV line #X-2 between the Ohmstead and Kettle Moraine substations. Figure 1 shows the existing transmission system including the proposed G507 point of interconnection ("POI") as a loop-through connection to line X-2.

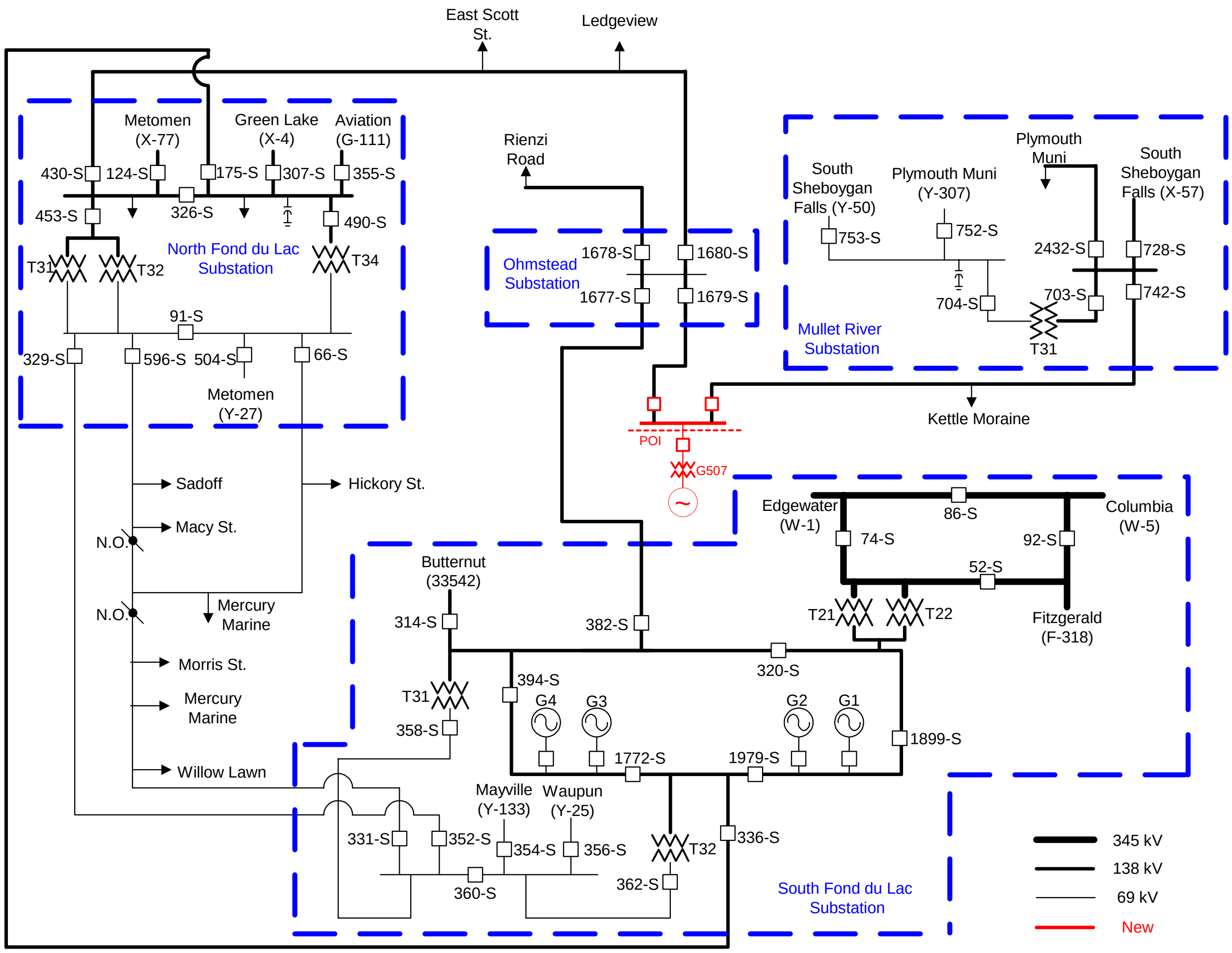

Figure 1: One-line of local system with G507 interconnected on line X-2

To maintain a post-contingent voltage of 0.90 p.u., the G507 wind farm will be required to maintain a minimum power factor no lower than 0.95 leading (absorbing VARs) from 2007 to 2014.

Thermal and voltage constraints were identified in this study. However, the study did not identify any injection limits that are required to be fixed in order to attain Energy Resource status for the full 98 MW of requested capacity.

Further Study

The next step in the Generator Interconnection Request process is for the Generator customer to decide whether to proceed with an Interconnection System Impact Study ("ISIS"). The ISIS will determine the system upgrades required to resolve all limits identified in this report and will include short circuit, transient and dynamic stability, and deliverability studies as applicable. Limits identified in the ISIS will also need to be resolved to obtain interconnection service. The ISIS will also review the substation site and determine if the enough space exists to allow the alternate interconnection.

Required Interconnection Facilities

To be determined in the ISIS.

Network Upgrades

To be determined in the ISIS.

Special Facility Requirements

The ISIS will determine Low Voltage Ride Through requirements and other generator site needs.

Operation Restrictions

The double contingency analysis identified thirteen operating restrictions on G507 due to thermal and voltage constraints. A summary of the operation restrictions on G507 under prior outage conditions is provided in Tables B.1 and B.2 in Appendix B.

2. Criteria, Methodology and Assumptions

2.1 Study Criteria

All relevant MISO-adopted NERC Reliability Criteria and the American Transmission Company ("ATC") contingency criteria are to be met for both the thermal and voltage analysis. Details of the analysis criteria applied in this study can be found in the Appendix C.

2.2 Study Methodology

The results of this study are subject to change. The results of the Study are based on data provided by the Generator and other ATC system information that was available at the time the study was performed, and the injection study does not guarantee deliverability to the MISO energy market. If there are any significant changes in the generator and controls data, in earlier queue Generator Interconnection Requests, in related Transmission Service Requests, or ATC transmission system development plans, then the results of this study may also change significantly. Therefore, this request is subject to restudy. The Generator is responsible for communicating any significant generation facility data changes in a timely fashion to MISO and ATC prior to commercial operation.

2.2.1 Competing Generation Requests

ATC determined in its sole judgment that no Generator Interconnection Requests with an earlier queue position will impact the G507 study results.

Public information related to Generator Interconnection Request queue can be found via the MISO web site at **http://oasis.midwestiso.org/documents/ATC/queue.html**

2.2.2 Linear Transfer Analysis and A.C. Power Flow Analysis Methods

Thermal overloads were identified using linear transfer analysis and then verified with AC solutions. The linear transfer analysis was used to evaluate the intact system, N-1, N-2 and certain ATC multiple contingency conditions. The linear transfer analysis utilized adjusted MW ratings to account for reactive power flows and a 5% transmission reserve margin ("TRM"). All AC solutions utilized actual equipment ratings (i.e. 0% TRM) with real and reactive line flows.

The linear transfer analysis was performed using the Linear Transfer Analysis modules of the Managing and Utilizing System Transmission-6.01 (MUST, Version 6.01) program from Power Technologies, Inc (PTI). All AC solutions were performed using the Power Flow module of the Power System Simulation/Engineering-29 (PSS/E, Version 29) program from Power Technologies, Inc (PTI). These programs are accepted industry-wide for power flow analysis.

2.2.3 Base Cases

2.2.3.1 Power flow analysis

Base cases used in the thermal and voltage analysis for this study were developed based upon an ATC developed 2014 summer peak model and the July 2005 build of MISO seasonal cases of winter peak 2006/07 and 2007/08, and the summer peaks of 2007, 2008, 2011, and 2014. The MISO seasonal cases are accessible through the MISO Extranet. The output of G507 was delivered to all MISO generation.

Power flow analysis includes evaluation of thermal and steady state voltage violations in the intact system and under N-1 and N-2 contingencies. Calculation of the operating restrictions can be found in Appendix C, C.4.3 Operating Restriction Calculation.

2.2.3.2 Deliverability analysis

Deliverability analysis, required for G507 to attain Network Resource status, was not performed for this study.

2.3 Assumptions

2.3.1 Generation Facility Modeling

The G507 generation was modeled at 0.95 lead power factor (absorbing MVAR) at the Point Of Interconnection (POI) for the power flow analysis, unless specified otherwise.

3. Analysis Results

3.1 Power Flow Analysis Results

3.1.1 Determination of the Minimum Power Factor Requirement (Voltage Analysis)

The minimum power factor requirement for the G507 wind farm was identified based on the voltage performance at the POI and buses one substation away from the POI bus for an intact system and under N-1 contingencies. The voltage magnitude of the buses must not be lower than 0.95 p.u. under an intact system condition, and must not be lower than 0.90 p.u. under N-1 contingency. The 2007, 2008, 2011 and 2014 summer cases were used for the analysis of the minimum power factor requirement. The winter case of 2006/7 was found to have better voltage performance in the vicinity of G507 and therefore was not used in determining power factor requirements.

The worst N-1 contingency was identified through AC analysis at local buses. The power factor at the G507 POI was set to 0.95 p.u. leading (+98 MW, -32.2 MVAR) in the system model.

The minimum power factors identified for the intact system and under the worst N-1 contingency were compared to the Good Utility Practice of 0.95 leading to determine the minimum power factor requirement. The analysis identified a minimum power factor for G507 to be 0.95 leading at the Point of Interconnection (“POI”).

3.1.2 Results of Single Contingencies (N-1)

With the minimum identified power factor, the study identified zero steady-state voltage violations due to G507 for NERC Category A (system intact) and NERC Category B (single contingencies) events for all study models.

With the minimum identified power factor, the study identified zero steady-state thermal violations due to G507 for NERC Category A events and five violations due to G507 for NERC Category B events for all study models. Results of the N-1 thermal analysis can be found in Table A.1 in Appendix A.

The maximum allowable real power output without system upgrades was determined by reducing G507 generation until all steady-state thermal and voltage violations due to G507 were resolved. Results of the maximum allowable generation analysis revealed that maximum allowable real power output without system upgrades is 0 MW, due to all limits identified existing prior to G507 interconnecting. However, the study did not identify any injection limits that are required to be fixed in order to attain Energy Resource status for the full 98 MW of requested capacity.

3.1.3 Results of Double Contingencies (N-2)

Thermal and voltage constraints were evaluated for NERC Category C events (N-2 contingencies) in the electrical proximity of G507. The purpose of the N-2 analysis is to reveal potential violations and identify operating restrictions to eliminate the violations under prior outage conditions.

The double contingency constraints are not required to be resolved for the generator to attain either Energy Resource or Network Resource status. All limitations found in the single contingency analysis have been excluded from the double contingency analysis because physical upgrades will be required for all injection limits for G507. All identified operating restrictions will be reviewed in the ISIS.

3.1.3.1 Thermal analysis

Thermal violations under a selected number of N-2 contingencies were evaluated using linear transfer analysis. The study identified eight thermal violations as a result of local contingencies. The violations are listed in Table A.2 in Appendix A. The required operating restrictions for these contingencies are listed in Table B.1 in Appendix B. This restriction may be reviewed in the ISIS.

3.1.3.2 Voltage analysis

Voltage violations under a selected number of N-2 contingencies were evaluated using AC power flow algorithms. The study identified five voltage violations as a result of a local N-2 contingency. The violations are listed in Table A.3 in Appendix A. Table A.4 indicates the needed Power Factor at the POI in order to achieve the “Pre-G507” bus voltage levels for the same N-2 contingency. Table A.5 indicates the needed Power Factor at the POI in order to achieve 0.9 p.u. bus voltage levels for the same N-2 contingency. The required operating restriction for either contingency is listed in Table B.2 in Appendix B. This restriction may be reviewed in the ISIS.

Appendix A

Power Flow Analysis Results

Table A.1 – Identified Thermal Violations due to G507 under N-1 Contingencies

Limiting Element	**Existing MVA Rating[1]**	**Worst MVA Loading**	**Worst Contingency**	**TDF (%)**	**Case Description**	**Solution Planned for Limiting Element**
Ellington – Hintz 138 kV line #80332	293	322	North Appleton – Werner West 345 kV[2]	6.4	Summer 2007	No
Portage – Trienda 138 kV Line #X-19	240	254	Portage – Trienda 138 kV Line #X-67	3.3	Summer 2007	No
Portage – Trienda 138 kV Line #X-19	240	263	Portage – Trienda 138 kV Line #X-67	3.2	Summer 2008	No
Portage – Trienda 138 kV Line #X-19	240	270	Portage – Trienda 138 kV Line #X-67	3.0	Summer 2011	No
Portage – Trienda 138 kV Line #X-19	240	314	Portage – Trienda 138 kV Line #X-67	3.0	Summer 2014	No

Notes:

1. Seasonal emergency rating for contingency violations.
2. Ellington – Hintz 138 kV experiences the worst loading of all overloaded lines due to an outage of North Appleton – Werner West 345. Werner West – Hintz 138 kV also experiences an overload.

Table A.2 – Identified Thermal Violations due to G507 under N-2 Contingencies

Limiting Element	Existing MVA Rating	Worst MVA Loading	Worst Double Contingency	TDF (%)	Case Description	Planned Solution for Limiting Element
Ohmstead – G507 138 kV Line #X-2	287	629 530 601 528 514 497	South Fond du Lac – Edgewater 345 kV & Edgewater – Cedarsauk 345 kV[1]	99.2 99.4 99.2 99.4 99.4 99.5	Winter 06/07 Summer 2007 Winter 07/08 Summer 2008 Summer 2011 Summer 2014	No[2]
North Fond du Lac – South Fond du Lac 69 kV Line #Y-68	56	57 80 70 82 93 99	North Fond du Lac – South Fond du Lac 138 kV & Ohmstead – Ledgeview Tap 138 kV[3]	5.3 5.2 5.3 5.2 4.9 4.9	Winter 06/07 Summer 2007 Winter 07/08 Summer 2008 Summer 2011 Summer 2014	No
Mullet River 138/69 kV Transformer	80 69 80 69 n/A[7] 69	122 119 121 118 n/A[7] 122	Ohmstead – G507 138 kV & Mullet River – South Sheboygan Falls 138 kV[4]	100.0 100.0 100.0 100.0 n/A[7] 100.0	Winter 06/07 Summer 2007 Winter 07/08 Summer 2008 Summer 2011 Summer 2014	No
Ellington – Hintz 138 kV Line #80332	293	325	North Appleton – Werner West 345 kV & North Appleton – Fitzgerald 345 kV[5]	4.9	Summer 2007	No
North Appleton – Ellington 138 kV Line #6843	241	249	North Appleton – Werner West 345 kV & Fitzgerald – Sunset Point 138 kV	3.2	Summer 2007	No
South Fond du Lac 138/69 kV Transformer #2	76	106 110 106 112	South Fond du Lac 138/69 kV Transformer #1 & Ohmstead – Ledgeveiw Tap 138 kV	3.1 3.1 4.5 4.5	Summer 2007 Summer 2008 Summer 2011 Summer 2014	No
North Fond du Lac – South Fond du Lac 138 kV Line #X-35	293	294 309 331 349	Ohmstead – Ledgeview Tap 138 kV & Fitzgerald 345/138 kV Transformer	14.7 14.7 14.7 14.6	Summer 2007 Summer 2008 Summer 2011 Summer 2014	No
North Fond du Lac – Rosendale 69 kV Line #Y-27	53	54 60	North Fond du Lac – Metomen 138 kV & North Fond du Lac – Green Lake 138 kV[6]	3.3 3.3	Summer 2011 Summer 2014	No

Notes:

1. Ohmstead – G507 138 kV experiences the worst loading of all overloaded lines due to an outage of South Fond du Lac – Edgewater 345 kV and Edgewater – Cedarsauk 345 kV N-2 condition. North Fond du Lac – East Scott St. 138 kV, Ohmstead – Ledgeview Tap 138 kV and East Scott St. – Ledgeview Tap 138 kV also experience an overload.
2. The overloads associated with the double contingency of South Fond du Lac – Edgewater 345 kV and Edgerwater – Cedarsauk 345 kV are alleviated with the execution of the Edgewater Generation Reduction Operation Guide.
3. North Fond du Lac – South Fond du Lac 69 kV experiences the worst loading of all overloaded lines due to an outage of North Fond du Lac – South Fond du Lac 138 kV and Ohmstead – Ledgeview Tap 138kV N-2 condition. South Fond du Lac 138/69 kV Transformer also experiences an overload.
4. Mullet River 138/69 kV Transformer experiences the worst loading of all overloaded lines due to an outage of Ohmstead – G507 138 kV and Mullet River – South Sheboygan Falls 138 kV N-2 condition. North Mullet River – Plymouth Muni #3 69 kV also experiences an overload.
5. Ellington – Hintz 138 kV experiences the worst loading of all overloaded lines due to an outage of North Appleton – Werner West 345 kV and North Appleton – Fitzgerald 345 kV N-2 condition. Werner West – Hintz 138 kV also experiences an overload.

6. North Fond du Lac – Rosendale 69 kV experiences the worst loading of all overloaded lines due to an outage North Fond du Lac 138 kV and North Fond du Lac – Green Lake 138 kV N-2 condition. Metomen – Rosendale 69 kV also experiences an overload.
7. The Summer 2011 Model with G507 at 95% leading (Absorbing) Power Factor would not solve for this N-2 condition.

Table A.3 – Identified Voltage Violations due to G507 under N-2 Contingencies

Limiting Element	Voltage w/o G507	Voltage w/ G507	Worst Double Contingency	Case Description	Planned Solution for Limiting Element
G507 138kV Bus	0.8488 0.8183 0.8398 0.8141 0.8087 0.8290	0.7449 0.7083 0.7387 0.7047 n/A[1] 0.7119	Ohmstead – G507 138 kV & Mullet River – South Sheboygan Falls 138 kV	Winter 06/07 Summer 2007 Winter 07/08 Summer 2008 Summer 2011 Summer 2014	No
Plymouth Muni #1 138 kV Bus	0.8488 0.8184 0.8398 0.8142 0.8092 0.8295	0.7430 0.7067 0.7368 0.7031 n/A[1] 0.7105	Ohmstead – G507 138 kV & Mullet River – South Sheboygan Falls 138 kV	Winter 06/07 Summer 2007 Winter 07/08 Summer 2008 Summer 2011 Summer 2014	No
Kettle Moraine 138 kV Bus	0.8488 0.8183 0.8397 0.8140 0.8087 0.8290	0.7438 0.7073 0.7376 0.7037 n/A[1] 0.7108	Ohmstead – G507 138 kV & Mullet River – South Sheboygan Falls 138 kV	Winter 06/07 Summer 2007 Winter 07/08 Summer 2008 Summer 2011 Summer 2014	No
Mullet River 138 kV Bus	0.8492 0.8191 0.8402 0.8148 0.8097 0.8299	0.7434 0.7075 0.7373 0.7039 n/A[1] 0.7111	Ohmstead – G507 138 kV & Mullet River – South Sheboygan Falls 138 kV	Winter 06/07 Summer 2007 Winter 07/08 Summer 2008 Summer 2011 Summer 2014	No

Notes:
1. The Summer 2011 Model with G507 at 95% leading (Absorbing) Power Factor would not solve for this N-2 condition.

Table A.4 – Identified G507 POI Power Factor to Maintain "Pre-G507" Voltage Levels under N-2 Contingencies[1]

Case Description	G507 POI Power Factor	G507 MVar's[2]
Winter 06/07	99.2% Leading	-12.2
Summer 2007	98.8% Leading	-15.1
Winter 07/08	99.0% Leading	-13.7
Summer 2008	98.8% Leading	-15.3
Summer 2011	99.9% Lagging	2.0
Summer 2014	99.0% Leading	-13.8

Notes:
1. Table A.4 is for information purposes. The generator may be required to provide the reactive power requirements outlined in Table A.4. The N-2 voltage limits will be reviewed in the System Impact Study.
2. Negative MVar values indicate a Leading Power Factor or absorbing MVar's. Positive MVar values indicate a Lagging Power Factor or generating MVar's.

Table A.5 – Identified G507 POI Power Factor to Maintain 0.9 p.u bus voltages under N-2 Contingencies[1]

Case Description	G507 POI Power Factor	G507 MVar's[2]
Winter 06/07	99.9% Leading	-1.7
Summer 2007	99.9% Lagging	4.6
Winter 07/08	100.0% Unity	-0.3
Summer 2008	99.6% Lagging	5.2
Summer 2011	99.3% Lagging	12.0
Summer 2014	99.9% Leading	-3.0

Notes:
1. Table A.5 is for information purposes.
2. Negative MVar values indicate a Leading Power Factor or absorbing MVar's. Positive MVar values indicate a Lagging Power Factor or generating MVar

Appendix B

Summary of Operation Restrictions

Table B.1 – Summary of the Identified Operation Restrictions on the G507 Wind Farm due to Thermal Constraints

Prior outage	Allowable MW Output[1]	Worst Next Contingency	Limiting Elements	MVA Rating	Worst Season
North Appleton – Werner West 345 kV	0	North Appleton – Fitzgerald 345 kV	Ellington – Hintz 138 kV	293	Summer 2007
	0	Fitzgerald – Sunset Point 138 kV	North Appleton – Ellington 138 kV	241	Summer 2007
North Appleton – Fitzgerald 345 kV	0	North Appleton – Werner West 345 kV	Ellington – Hintz 138 kV	293	Summer 2007
Fitzgerald 345/138 kV Transformer	91	Ohmstead – Ledgeview Tap 138 kV	North Fond du Lac – South Fond du Lac 138 kV	293	Summer 2007
	0				All summer seasons after 2007
North Fond du Lac – South Fond du Lac 138 kV	79	Ohmstead – Ledgeview Tap 138 kV	North Fond du Lac – South Fond du Lac 69 kV	56	Winter 06/07
	0				All Seasons from Summer 2007
Ohmstead – Ledgeview Tap 138 kV	79	North Fond du Lac – South Fond du Lac 138 kV	North Fond du Lac – South Fond du Lac 69 kV	56	Winter 06/07
	0				All Seasons from Summer 2007
	0	South Fond du Lac 138/69 kV Transformer #1	South Fond du Lac 138/69 kV Transformer #2	76	All Summer Seasons
	91	Fitzgerald 345/138 kV Transformer	North Fond du Lac – South Fond du Lac 138 kV	293	Summer 2007
	0				All summer seasons after 2007
Ohmstead – G507 138 kV	56	Mullet River – South Sheboygan Falls 138 kV	Mullet River 138/69 kV Transformer	80	Winter 06/07
	48			69	Summer 2007
	57			80	Winter 07/08
	49			69	Summer 2008
	n/A[2]			69	Summer 2011
	45			69	Summer 2014
Mullet River – South Sheboygan Falls 138 kV	56	Ohmstead – G507 138 kV	Mullet River 138/69 kV Transformer	80	Winter 06/07
	48			69	Summer 2007
	57			80	Winter 07/08
	49			69	Summer 2008
	n/A[2]			69	Summer 2011
	45			69	Summer 2014
Fitzgerald – Sunset Point 138 kV	0	North Appleton – Werner West 345 kV	North Appleton – Ellington 138 kV	241	Summer 2007
North Fond du Lac – Metomen 138 kV	68	North Fond du Lac – Green Lake 138 kV	North Fond du Lac – Rosendale 69 kV	53	Summer 2011
	0				Summer 2014
North Fond du Lac – Green Lake 138 kV	68	North Fond du Lac – Metomen 138 kV	North Fond du Lac – Rosendale 69 kV	53	Summer 2011
	0				Summer 2014
South Fond du Lac 138/69 kV Transformer #1	0	Ohmstead – Ledgeview Tap 138 kV	South Fond du Lac 138/69 kV Transformer #2	76	All Summer Seasons

Notes:

1. Maximum real power output was found at 95% Leading (Absorbing) Power Factor for all study models.
2. The Summer 2011 Model with G507 at 95% leading (Absorbing) Power Factor would not solve for this N-2 condition

Table B.2 – Summary of the Identified Operation Restrictions on the G507 Wind Farm due to Voltage Constraints

Prior outage	Allowable MW Output[1]	Worst Next Contingency	Worst Season
Ohmstead – G507 138 kV	0	Mullet River – South Sheboygan Falls 138 kV	All Seasons
Mullet River – South Sheboygan Falls 138 kV	0	Ohmstead – G507 138 kV	All Seasons

Notes:

1. Maximum real power output was found at 95% Leading (Absorbing) power factor for all study models. If power factor is improved to those listed in Table A.5, there would be no operating restrictions due to voltage under the prior outage scenario. Thermal operating restrictions would still apply.

Appendix C

Study Criteria

Study Criteria

C.1 Contingencies

For stability analysis, a set of branches in the vicinity of the generator/power plant of concern is selected as contingencies, based on engineering judgment. Fault analysis is performed for the following six categories of contingency conditions:

1. Three-phase fault cleared in primary time with an otherwise intact system.
2. Three-phase fault cleared in delayed clearing time (i.e. breaker failure conditions) with an otherwise intact system.
3. Three-phase fault cleared in primary clearing time with a pre-existing outage of any other transmission element.
4. Single Line Ground (SLG) bus section fault cleared in primary clearing time with an otherwise intact system.
5. SLG internal breaker fault cleared in primary clearing time with an otherwise intact system.
6. SLG fault of double circuits on common tower cleared in primary time with an otherwise intact system.

For power flow analysis, contingencies include:

1. N-1 contingencies – all lines and transformers operated at 69kV and above in the following control areas/zones: ATC Planning Zones 1-5 and ties to those zones and all branches of voltage level 69kV and above in the Dairyland Power Cooperative, Northern States Power Control Area, Commonwealth Edison, and Alliant West control areas.
2. Selected N-2 and multiple contingencies that ATC has determined to be significant.

C.2 Monitored Elements

C.2.1 Intact System, N-1, N-2, and Special Multiple Contingency Evaluation Using Linear Transfer Analysis Method

All load carrying elements operated at 69kV and above in the following control areas/zones were studied: ATC Planning Zones 1-5, ties to those zones and all branches of voltage level 69kV and above in the Dairyland Power Cooperative, Northern States Power Control Area, Commonwealth Edison, and Alliant West control areas.

C.3 Thermal Loading Criteria

C.3.1 Injection Violations

Generation injection violations include 1) thermal violations of the transmission elements that connect the Generator to the rest of the transmission network (outlet congestion); 2) thermal violations of the transmission elements that have TDF ≥ 20% anywhere in the studied system.

C.3.2 Operating Restriction Calculation

$$\text{Allowable Output} = \frac{\text{Equipment Rating} - [\text{Line Flow} - (\text{Generation Output} * \text{TDF})]}{\text{TDF}}$$

C.4 Steady State Voltage Criteria

C.4.1 Intact System, N-1 and Special Multiple Contingency Evaluation Using ACCC

Under intact system conditions, the voltage magnitude of all transmission system buses with a decrease of 0.01 per unit due to the Generator must not be lower than 0.95 per unit. Under contingency conditions, the voltage magnitude of all transmission system buses with a decrease of 0.01 per unit due to the Generator must not be lower than 0.90 per unit.

C.4.2 N-2 Contingency Evaluation

Power flow solutions must converge for a selected number of N-2 contingencies in the electrical proximity of the studied Generator. Divergence of a power flow solution indicates potential voltage collapse.

C.5 Stability Criteria

Critical Clearing Time (CCT) is a period relative to the start of a fault, within which all generators in the system remain stable (synchronized). CCT is obtained from simulation. Maximum Expected Clearing Time (MECT) determines a period of time that is needed to clear a fault using the existing system facilities. MECT is dictated by the existing system facilities. In any contingency, if the computed CCT is less than the MECT plus a margin determined by ATC (1.0 cycle in this study), it is considered an unstable situation and is unacceptable. Otherwise, it is considered acceptable stability performance.

In the context of stability analysis, voltages of all transmission system buses must recover to be at least 70% of the nominal system voltages immediately after fault removal and 80% of the nominal system voltages in 0.5 second after fault removal.