Interconnection Feasibility Study Report
280 MW Coal Generation
Grant County, Wisconsin

G527
MISO Queue #38512-01

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American Transmission Company, LLC

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System Planning

1. Summary

This report contains the results of the Feasibility Study for the Midwest Independent System Operator ("MISO") Generation Interconnection Request project #G527, MISO Queue #38512-01. The purpose of this study is to identify steady state thermal and voltage violations caused by the proposed interconnection. The requested back feed date for this project is November 1, 2010 and the requested in-service date is October 1, 2011.

The G527 generation is proposed to connect to the Nelson Dewey substation at either the 138kV or 161kV bus. Figure 1 shows the existing transmission system including proposed G527 points of interconnection ("POI"). It does not necessarily show the ultimate POI or expected substation layout. The final interconnection will depend on the thermal, voltage, and stability analysis performed in the Feasibility Study and the Interconnection System Impact Study ("ISIS") in addition to operational issues and physical space requirements to support the interconnection.

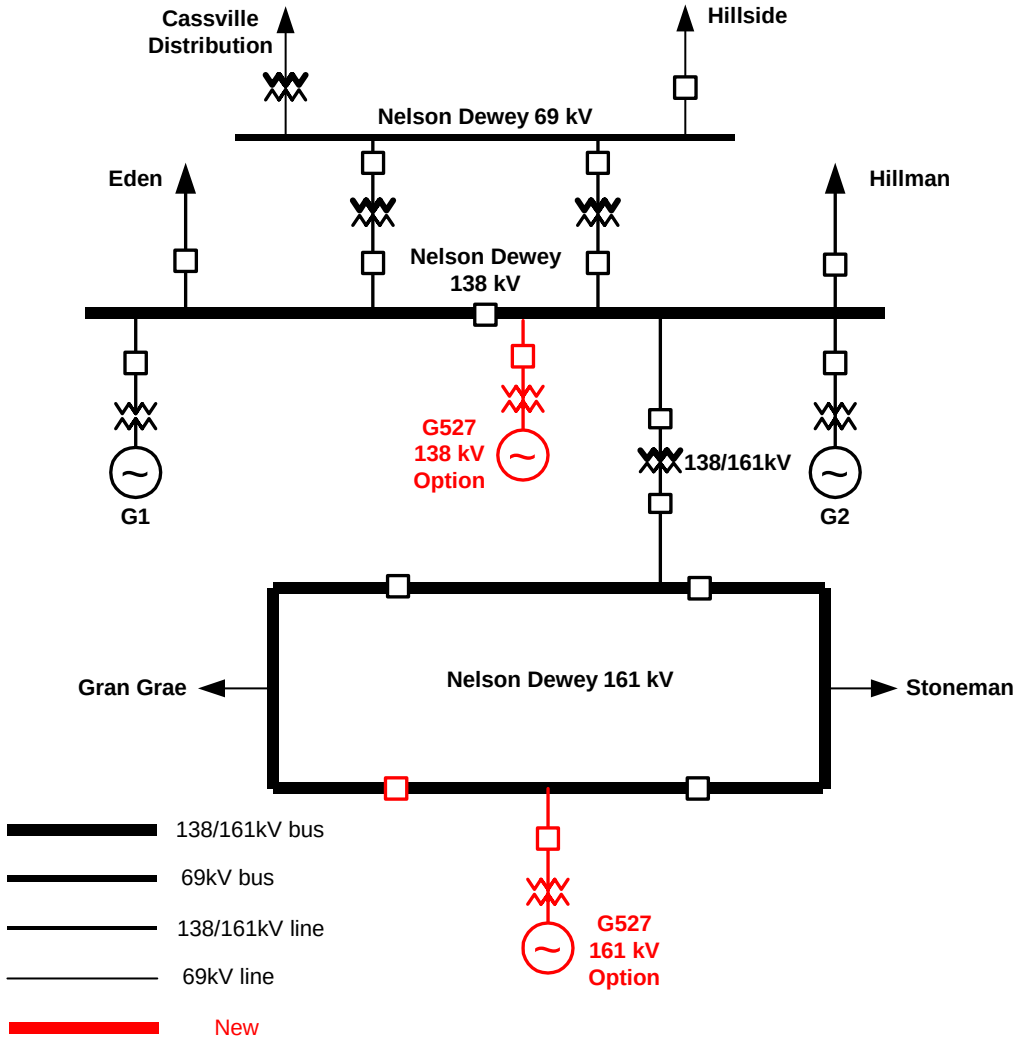

Figure 1: Equivalent G527 Interconnections at the Nelson Dewey substation

138kV Connection

With the proposed generator connection to the Nelson Dewey 138 kV bus, this study identified one steady-state NERC Category A event and fifteen steady-state NERC Category B event thermal violations (Table A.1, Appendix A). The Category A event and six of the Category B events will require mitigation to acquire energy resource status for the full 280 MW of requested capacity. Simulations were run with and without G282 (Darlington wind generator) in service, with G523 in service, with G523 and additional planned or proposed projects in service, and with only the additional planned or proposed projects in service (no G523). The additional planned or proposed projects modeled are listed in Table 3.1. The category A violation occurred only when G282 was in service. Six of the Category B violations occurred only when G282 was in service and one Category B violation occurred only when G282 was out of service. Although double contingencies were analyzed only for the summer case with G282, G523 and the additional projects in service, a total of twenty double contingency violations requiring potential operating restrictions were found (Table A.2, Appendix A).

The single Category A injection limit identified when the proposed generation is connected to the 138 kV bus is the Nelson Dewey 161/138kV transformer. This limit was found only when G282 is modeled. The six identified Category B injection limits when generation is connected to the 138 kV bus are the Nelson Dewey 161/138kV transformer, the 161 kV Nelson Dewey-Cassville line (Q-2E), the 138 kV Potosi-Hillman line (X-15, only with G282 out), the Nelson Dewey-Lancaster 138 kV line (X-16, only with G282 in), the Spring Green-Wyoming Valley 138 kV line (X-17, only with G282 in) and the Wyoming Valley-Eden 138 kV line (X-17, only with G282 in). Solutions to all seven injection limits will be required to attain Energy Resource status for the full 280 MW of requested capacity.

A transfer sensitivity study was performed by sourcing 280 MW from G527 and delivering it to the Alliant Energy-WP&L ("ALTE") control area (Table A.3, Appendix A). The transfer sensitivity identified twenty violations including ten violations that were not identified during the injection study. Six violations identified during the injection study did not occur in the sensitivity study. Eight of the violations occurred only if G523 was in service. Six of these eight violations did not occur if planned and proposed projects (Table 3.1) were in service. All of the new violations had distribution factors less than 20%. Three of the violations that were eliminated in the sensitivity study were injection limits. These were the Category A Nelson Dewey 161/138kV transformer violation and the Category B Spring Green-Wyoming Valley 138 kV line and Nelson Dewey-Lancaster 138 kV line violations. Solutions to sensitivity study limits are not required to attain Energy Resource status for the full 280 MW of requested capacity, but these limits indicate potential sources of congestion costs in the MISO Day 2 market.

The maximum allowable generation without system upgrades was found to be 211 MW (Table A.4, Appendix A) based on injections limits (DF>20%) to the system. Including the three projects that have been identified to resolve the injection limits increases the maximum allowable generation to 280 MW. Total plant output is limited to zero MW when considering all identified constraints (DF>3%) (Table B.1, Appendix B).

Voltage analysis determined that the existing system can not support the G527 injection of 280 MW at the Nelson Dewey 138kV bus and maintain the POI bus voltage above 0.90 per unit under the first contingency condition of the loss of the Nelson Dewey 161/138 kV transformer without var support from G527 (Table A.5, Appendix A). Further reactive power analysis determined that the system is able to sustain the 138kV POI bus voltage of 1.02 per unit under contingency while using less than 56% of the modeled reactive power capability of G527 (Table A.6, Appendix A).

161kV Connection

For Generator connection to the Nelson Dewey 161 kV bus this study identified eleven steady-state NERC Category B event thermal violations (Table A.7, Appendix A). One of these events will require mitigation to acquire energy resource status for the full 280 MW of requested capacity. Simulations were run with and without G282 (Darlington wind generator) in service, with G523 in service, with G523 and additional lines in service, and with only additional lines modeled (no G523). Although double contingencies were analyzed only for the summer case with G282, G523 and the additional lines in service, a total of twenty-three double contingency violations requiring potential operating restrictions were found (Table A.8, Appendix A).

The one identified Category B injection limit when generation is connected to the 161 kV bus is the 161 kV Nelson Dewey-Cassville (Q-2E) line. A solution to this injection limit is required to attain Energy Resource status for the full 280 MW of requested capacity.

A transfer sensitivity study was performed by sourcing 280 MW from G527 and delivering it to the Alliant Energy-WP&L ("ALTE") control area (Table A.9, Appendix A). The transfer sensitivity identified nine violations that were not identified during the injection study, but two violations identified during the injection study did not occur in the sensitivity study. All of the new violations had distribution factors less than 20%. None of the violations that were eliminated in the sensitivity study were injection limits, leaving the 161 kV Nelson Dewey-Cassville (Q-2E) line as the only violation with a distribution factor greater than 20%. Solutions to sensitivity study limits are not required to attain Energy Resource status for the full 280 MW of requested capacity, but these limits indicate potential sources of congestion costs in the MISO Day 2 market.

The maximum allowable generation without system upgrades was found to be 200.8 MW (Table A.10 in Appendix A) based on the injection limit (DF>20%) to the system. Total plant output is limited to zero MW when considering all identified constraints (DF>3%) (Table B.2, Appendix B). Including the project that has been identified to resolve the injection limit increases the maximum allowable generation to 280 MW.

Voltage analysis determined that the existing system can support the G527 injection of 280 MW and maintain the 161kV POI bus voltage above 0.949 per unit under first contingency conditions (Table A.11, Appendix A). Further reactive power analysis determined that the system is able to sustain the 161kV POI bus voltage of 1.02 per unit under contingency while using less than 30% of the modeled reactive power capability of G527 (Table A.12, Appendix A).

Further Study
The next step in the Generator Interconnection Request process is for the Generator customer to decide whether to proceed with an ISIS. The ISIS will determine the system upgrades required to resolve all injection 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 determine the final interconnection configuration at the Nelson Dewey substation.

Required Interconnection Facilities
To be determined in the ISIS.

Network Upgrades
To be determined in the ISIS.

Special Facility Requirements
To be determined in the ISIS.

Operation Restrictions
The double contingency analysis identified thirteen operating restrictions on G527 due to thermal constraints with the generator connected at 138kV and sixteen operating restrictions with the generator connected at 161kV. A summary of the operation restrictions on G527 under prior outage conditions is provided in Tables B.1 (138 kV) and B.2 (161 kV) 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 four Generator Interconnection Requests with an earlier queue position will impact the G527 study results. G144, G282, G477 and G523 are considered competing requests for the interconnection of this generator and therefore included in each base case. G144 is a 550 MW coal fired generating facility located in Marathon County, WI. G282 is a 99 MW wind generating facility located in Lafayette County, WI. G477 is a 531 MW integrated gasification combined cycle generating facility located in Minnesota. G523 is a 550 MW coal fired generating facility located in Marathon County, WI. Additional simulations were done with G282 and/or G523 out of service to determine their affect on simulation 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-7.0 (MUST, Version 7.0) 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 the ATC summer peak 2005 model and the July 2005 build of MISO seasonal cases of winter peak 2010/11 and the summer peak of 2011. Three cases were developed to model the winter peak of 2010/11, a shoulder peak of 2011, and the summer peak of 2011. The ATC system was modified by updating all loads to the expected coincident peak value and including all proposed projects through 2007 and all planned projects through 2008 as listed in the ATC Ten Year Assessment. These criteria excluded the Monroe County-Council Creek 161 kV line, a provisional project with an in-service date of 2010. It is expected that modeling this line would increase line loading in the DPC system. The effect of this line will be analyzed in the ISIS. The MISO seasonal cases are accessible through the MISO Extranet. The output of G527 was delivered to all on-line MISO generation, unless specified otherwise.

Power flow analysis includes evaluation of thermal violations with an intact system and under N-1 and N-2 contingencies.

2.2.3.2 Deliverability analysis

Deliverability analysis, required for G527 to attain Network Resource status, was not performed for this study. This will be performed in the ISIS.

2.3 Assumptions

2.3.1 Generation Facility Modeling

The G527 generation was modeled at 280 MW of real power output while controlling the Nelson Dewey 138kV or 161kV POI bus voltage to 1.02 pu for the power flow analysis, voltage analysis, and reactive power analysis unless specified otherwise. No GSU transformer was modeled because no data has been provided. There is only one 138kV and one 161 kV bus modeled at Nelson Dewey in the MISO seasonal cases. Physical ratings of the Nelson Dewey bus sections will be reviewed in the ISIS when the final interconnection configuration at the Nelson Dewey substation is determined.

3. Analysis Results

3.1 Power Flow Analysis Results

3.1.1 Voltage Analysis & Reactive Capability

Voltage analysis was performed by modeling G527 as a 280 MW, 0 MVAR generator at the 161kV and 138kV Nelson Dewey POI busses. The 280 MW injection was transferred outside of the ATC footprint, 75% to the south and 25% to the west. The analysis determined that the existing system can support the 161kV G527 injection of 280 MW while maintaining the 161kV POI bus voltage above 0.949 per unit under contingency (Table A.11, Appendix A). 138kV interconnection simulations determined that the existing system (no Mvar contribution from G527) can not support the 138kV G527 injection of 280 MW while maintaining the 138kV POI bus voltage above 0.90 per unit under the contingency loss of the Nelson Dewey 161/138 kV transformer. Simulations of this contingency were unable to be solved (Table A.5, Appendix A).

Further reactive power analysis was performed by modeling G527 as a 280 MW PMax, 175 MVAR (0.85 power factor) QMax generator at the 161 and 138 kV POI buses. The 280 MW injection was one again transferred outside of the ATC footprint, 75% to the south and 25% to the west. This analysis determined that the system is able to sustain the 161kV POI bus voltage of 1.02 per unit under contingency while using less than 30% of the modeled reactive power capability of G527 (Table A.12, Appendix A). Further analysis determined that the system is able to sustain the 138kV POI bus voltage of 1.02 per unit under contingency while using less than 56% of the modeled reactive power capability of G527 (Table A.6, Appendix A).

3.1.2 Results of Single Contingencies (N-1)

138kV Interconnection

Study of the 280 MW injection from G527 to the Nelson Dewey 138kV bus identified one steady-state thermal violation for NERC Category A events and fifteen violations for NERC Category B events. In addition to the Category A violation, six of the fifteen Category B violations have been identified as injection limits. These injection limits can be resolved by three projects, (1) add a second Nelson Dewey 161/138 kV transformer, (2) re-conductor and upgrade the 1.24 miles of the Nelson Dewey-Cassville 161 kV line owned by Dairyland Power Cooperative (DPC) to a rating of 240 MVA or greater (the next most limiting line component is rated 280 MVA), and (3) replace the 896 A (214 MVA) emergency rated 138 kV line trap on B-phase of the Hillman end of the Hillman-Potosi line with a line trap rated 230 MVA or greater (the next most limiting line component is rated 246 MVA). The need for these projects is driven by the connection of G527 to the Nelson Dewey 138 kV bus.

This analysis was performed on each base case and then with the projects listed in Table 3.1 added. With the inclusion of projects from Table 3.1, two generation dispatch scenarios were examined. In one scenario, referred to as “Summer 2011-2”, G523 was in service. In the second scenario, referred to as “Summer 2011-3”, G523 was out of service. Results of this N-1 thermal analysis can be found in Table A.1 in Appendix A.

Table 3.1: Additional Transmission Projects Potentially Affecting G527

Project Description	Expected In-Service Year	Project Status
Construct Gardner Park – Central Wisconsin 345kV line	2009	Planned
Construct Morgan – Werner West 345kV line	2009	Planned
String a new 138kV line from Clintonville to Werner West primarily on the Morgan – Werner West 345kV line structures	2009	Planned
Construct Cranberry – Conover 115kV line Rebuild/convert Conover – Plains 69kV line to 138kV Construct 138kV bus at Conover and install 138/115kV and 138/69kV transformers Construct 138kV bus at Iron Grove and install a 138/69kV transformer Construct 138kV bus at Aspen and install a 138/69kV transformer	2010	Proposed

Note: All four projects are included in the Summer 2011-2, Shoulder 2011-2, and Winter 2010/11-2 models, which include G523, and the Summer 2011-3, Shoulder 2011-3, and Winter 2010/11-3 models, which do not include G523.

A transfer sensitivity study was performed delivering 100% of the G527 output to ALTE. The study found no limits with DF >20% that were not found in the injection analysis. In fact, three of the injection limits, Nelson Dewey 161/138kV (base case), Nelson Dewey-Lancaster 138kV and Wyoming Valley-Spring Green 138 kV, did not appear as limits (DF>20%) with G527 generation delivered to ALTE. There were differences in limits with lower DFs, with six limits found with delivery to MISO not found with delivery to ALTE and ten limits found with delivery to ALTE not found with delivery to MISO.

The maximum allowable real power output without system upgrades was determined by reducing G527 generation until all steady-state thermal violations due to G527 were resolved. The maximum allowable output was identified as 211 MW based on injections limits (DF>20%) with the 138 kV connection without system upgrades. This increases to 280 MW with the three projects listed in Table 3.2 in service. Total plant output is limited to zero MW when considering all identified constraints (DF>3%) (Table B.1, Appendix B).

For the limits identified in the N-1 analysis, a solution of limited scope is proposed in the footnotes of Table A.1 in Appendix A. Solutions not identified in the ATC 10-Year Assessment are shown in Table 3.2, and were developed in the following order.

1. If installing one element will economically resolve several violations, do that first.
2. If the line is not limited by the conductor rating, then replace the terminal equipment.
3. If the line is limited by the conductor rating, then increase phase conductor clearance to the maximum operating temperature of the conductor.
4. If the maximum operating temperature of the conductor does not resolve the limit, then a line reconductor or rebuild is proposed.

Table 3.2: Proposed Transmission Projects Resolving G527 138 kV N-1 Limits

Limiting Element	Proposed Solution
Nelson Dewey 161/138 kV Transformer	Install second identical Nelson-Dewey 161/138 kV Transformer.
Eden-Wyoming Valley 138 kV (X-17)	
Spring Green-Wyoming Valley 138 kV (X-17)	
Nelson Dewey-Lancaster 138 kV (X-16)	
Nelson Dewey-Cassville 161 kV (Q-2E)	Replace conductor and increase the clearance on 1.24 mile DPC portion of line to increase the SE rating from 201 MVA to at least 240 MVA.
Potosi-Hillman 138 kV (X-15)	Upgrade B-phase Line Trap at Hillman end of line from 896 A (214 MVA) to at least 230 MVA Emergency rating.

161kV Interconnection

Study of the 280 MW injection from G527 to the Nelson Dewey 161kV bus identified eleven violations for NERC Category B events. One of these eleven Category B violations has been identified as an injection limit. This injection limits can be resolved by re-conductoring and upgrading the 1.24 miles of the Nelson Dewey-Cassville 161 kV line owned by Dairyland Power Cooperative (DPC). The need for this project is driven by the connection of G527 to the Nelson Dewey 161kV bus.

As for the 138kV analysis, this analysis was performed on each base case and then with the projects listed in Table 3.1 added. With the inclusion of projects from Table 3.1, two generation dispatch scenarios were examined. In one scenario, referred to as "Summer 2011-2", G523 was in service. In the second scenario, referred to as "Summer 2011-3", G523 was out of service. Results of this N-1 thermal analysis can be found in Table A.7 in Appendix A.

A transfer sensitivity study was performed delivering 100% of the G527 output to ALTE. The study found the same single injection limit (DF>20%) that was found in the injection analysis. There were differences in limits with lower DFs (>3%), with two limits found with delivery to MISO not found with delivery to ALTE and nine limits found with delivery to ALTE not found with delivery to MISO (Table A.9, Appendix A).

The maximum allowable real power output without system upgrades was determined by reducing G527 generation until all steady-state thermal violations due to G527 were resolved. The maximum allowable output was identified as 200.8 MW based on injections limits (DF>20%) with the 138 kV connection without system upgrades (Table A.10, Appendix A). This increases to 280 MW with the project listed in Table 3.3 in service. Total plant output is limited to zero MW when considering all identified constraints (DF>3%) (Table B.2, Appendix B).

For the limit identified in the N-1 analysis, a solution of limited scoped is proposed in the footnotes of Table A.7 in Appendix A. This solution, which is not identified in the ATC 10-Year Assessment, is shown in Table 3.3.

Table 3.3: Proposed Transmission Projects Resolving G527 161 kV N-1 Limits

Limiting Element	Proposed Solution
Nelson Dewey-Cassville 161 kV (Q-2E)	Replace conductor and increase the clearance on 1.24 mile DPC portion of line to increase the SE rating from 201 MVA to at least 250 MVA.

The viability of the proposed solution cannot be assessed in the Feasibility Study. It may be possible that increasing the conductor clearance resolves the loading issue but is not physically or financially reasonable (i.e. the age and condition of the line structures may be an issue). Also, the solution is directly related to the individual constraint, it is possible that a separate plan may address this limit and offer secondary benefits such as relieving N-2 constraints. Solutions of this nature will be developed and examined in the ISIS.

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 G527. The purpose of the N-2 analysis is to reveal potential violations and identify potential operating restrictions to eliminate the violations under prior outage conditions. The N-2 analysis was performed only on the summer peak model that included the projects listed in Table 3.1 and modeled G282 and G523 in service for both generation dispatch scenarios and both generator connections.

The double contingency constraints are not required to be resolved for the generator to attain either Energy Resource or Network Resource status. All identified operating restrictions will be reviewed in the ISIS as solutions are developed for NERC Category A and B violations.

3.1.3.1 Thermal analysis

Thermal violations under a selected number of N-2 contingencies were evaluated using linear transfer analysis. The N-2 analysis was performed using the "Summer 2011-2" model. The study identified thirty-nine thermal violations for the 138 kV connection (Table A.2, Appendix A) and twnty-three thermal violations for the 161 kV connection (Table A.8, Appendix A) as a result of local contingencies. All limiting elements are included only for the most limiting double contingency. The required operating restrictions for the double contingencies are listed in Tables B.1 and B2 in Appendix B. The restrictions are based on the most limiting element. These restrictions will be reviewed in the ISIS and a complete description of all N-2 limits and operating restrictions will be developed once the required solutions for N-1 limits are identified. Because of their number and the variety of system configurations analyzed, no attempt was made to identify projects that would resolve N-2 contingencies.

Appendix A

Power Flow Analysis Results

Table A.1 – Identified Thermal Violations due to G527 (138kV Connection) with Delivery to MISO for N-1 Contingencies (TDF>3%)

Limiting Element	Existing Rating (MVA)	Required Rating (MW)	Worst Contingency	TDF (%)	Case[4]	Injection Limit	Solution Planned
Nelson Dewey 161/138 kV[2]	210	212.2	System Intact	63.5%	SH-2	Yes	No[5]
Nelson Dewey 161/138 kV[1]	286	322.6	Nelson Dewey-Lancaster 138 kV	73.8%	SH-2	Yes	No[5]
Nelson Dewey-Cassville 161 kV(Q-2E)[1]	201	223.7	Nelson Dewey-Lancaster 138 kV	49.8%	SH-1	Yes	No[6]
Nelson Dewey-Lancaster 138 kV (X-16)[2]	282	269.6	Nelson Dewey 161/138 kV	41.8%	SUM-3	Yes	No[5]
Eden-Wyoming Valley 138 kV (X-17)[2]	192	202.9	Nelson Dewey 161/138 kV	35.0%	SH-3	Yes	No[5]
Wyoming Valley-Spring Green 138 kV (X-17)[2]	203	196.2	Nelson Dewey 161/138 kV	35.0%	SH-3	Yes	No[5]
Potosi-Hillman 138 kV (X-15)[3]	214	216.1	Nelson Dewey-Lancaster 138 kV	21.6%	SUM-1	Yes	No[7]
Platteville-Platteville Tap 69 kV[1]	41	66.5	Nelson Dewey 161/138 kV	9.6%	SUM-3	No	No
Hillman-Platteville Tap 69 kV[1]	29	76.6	Nelson Dewey 161/138 kV	9.6%	SUM-2	No	No
Darlington 138/69 kV[2]	105	110.8	Nelson Dewey-Lancaster 138 kV	4.7%	SUM-3	No	No
Hillman 138/69 kV[1]	49	83.0	Nelson Dewey-Lancaster 138 kV	4.0%	SUM-2	No	No
Colley Road-Marine 138 kV[1]	287	280.0	Sunrise-Lakehead Tap 138 kV	3.9%	SUM-1	No	No
Hillsboro 161/69 kV[1]	112	114.3	Genoa (NSP)-Genoa (DPC) 69 kV	3.5%	SUM-3	No	No
Pleasant Valley-Maren Tap 138 kV[1]	295	282.8	Cherry Valley-Silver Lake 345 kV	3.5%	SUM-1	No	No
Whitewater Bus 3-Bus 4 138 kV[1]	287	274.4	Colley Road-Dickinson 138 kV	3.2%	SUM-1	No	No
Gran Grae-Wauzeka 69 kV[2]	72	68.5	Eden-Wyoming Valley 138 kV	3.0%	SUM-1	No	No

Existing MW rating assumed to be 95% of the existing MVA rating

Notes:

1. Violation occurs with G282 in or out of service.
2. Violation occurs only with G282 in service.
3. Violation occurs only with G282 out of service. This is the only element whose worst violation occurs with G282 out of service.
4. SUM-1, SH-1 and WIN-1 represent the expected summer peak 2011, shoulder peak 2011 and winter peak 2010-2011, respectively, with planned projects through 2008 and proposed projects through 2007. G523 is in service. SUM-2, SH-2, and WIN-2 represent the same cases with planned and proposed projects through 2008 plus the Clintonville – Werner West 138kV line (Planned), Morgan – Central Wisconsin – Werner West 345kV line (Planned), Gardner Park – Central Wisconsin 345kV line (Planned), and the Cranberry – Conover 138kV project (Proposed) included. All four projects have an expected in-service date prior to Summer 2010. SUM-3, SH-3 and WIN-3, represent the same system topology as the SUM-2, SH-2, and WIN-2 cases with G523 out of service.
5. These overloads can be resolved by adding a second Nelson Dewey 161/138 kV Transformer.
6. This overload can be resolved by upgrading the 1.24 mile DPC portion of this line to at least 240 MVA. The next most limiting element of the line is rated 280 MVA. New conductors and possibly structures are needed.
7. This overload can be resolved by replacing the 896 A (214 MVA) emergency rated 138 kV line trap on B-phase of the Hillman end of the Hillman-Potosi line with a line trap rated at least 230 MVA. The next most limiting element of the line is rated 246 MVA.

Table A.2 – Identified Thermal Violations due to G527 (138 kV) under N-2 Contingencies[1]

Blanchardville-Forward 69 kV	49	66.7	Nelson Dewey 161/138 kV	Eden-Wyoming Valley 138 kV	11.50%
Bloomington - Hillside 69 kV	71	112.2	Nelson Dewey 161/138 kV	Nelson Dewey-Lancaster 138 kV	23.40%
Bloomington-Glen Haven Tap 69 kV	82	117.4	Nelson Dewey 161/138 kV	Nelson Dewey-Lancaster 138 kV	23.40%
Cassville-Nelson Dewey 161 kV	201	295.2	Nelson Dewey-Potosi 138 kV	Nelson Dewey-Lancaster 138 kV	64.40%
Cassville-Turkey River 161 kV	235	230.9	Nelson Dewey-Potosi 138 kV	Nelson Dewey-Lancaster 138 kV	57.00%
Darlington 138/69 kV	105	127.5	Hillman138/69 kV	Nelson Dewey-Lancaster 138 kV	5.50%
Darlington-G282 138 kV	246	334.7	Nelson Dewey 161/138 kV	Nelson Dewey-Lancaster 138 kV	53.40%
Darlington-North Monroe 138 kV	105	167.6	Nelson Dewey 161/138 kV	Nelson Dewey-Lancaster 138 kV	37.40%
Darlington-Rock Branch 69 kV	49	87.4	Hillman 138/69 kV	Nelson Dewey-Lancaster 138 kV	3.20%
Dodgeville-Land's End 69 kV	48	50.1	Darlington-G282 138 kV	Eden-Wyoming Valley 138 kV	5.10%
Eden 138/ 69 kV	83	147.8	Nelson Dewey 161/138 kV	Eden-Wyoming Valley 138 kV	23.90%
Eden-Lancaster 138 kV	282	395.7	Nelson Dewey 161/138 kV	Nelson Dewey-Potosi 138 kV	76.10%
Eden-Land's End 69 kV	48	60	Darlington-G282 138 kV	Eden-Wyoming Valley 138 kV	5.10%
Eden-Wyoming Valley 138 kV	192	258	Nelson Dewey 161/138 kV	Nelson Dewey-Potosi 138 kV	49.60%
Gran Grae-Nelson Dewey 161 kV	221	226.7	Cassville-Nelson Dewey 161 kV	Nelson Dewey-Lancaster 138 kV	52.20%
Hillman138/69 kV	49	90.6	Lancaster-Beetown 69 kV	Darlington 138/69 kV	3.60%
Hillman-Belmont 69 kV	72	75.1	Nelson Dewey-Lancaster 138 kV	Darlington-G282 138 kV	6.40%
Hillman-G282 138 kV	246	235.9	Nelson Dewey 161/138 kV	Nelson Dewey-Lancaster 138 kV	53.40%
Hillman-Platteville Tap 69 kV	29	86.8	Turkey River-Cassville 161 kV	Stoneman-Beetown 69 kV	3.50%
Hillman-Potosi 138 kV	214	398.7	Nelson Dewey 161/138 kV	Nelson Dewey-Lancaster 138 kV	76.50%
Hillsboro 161/69 kV	112	118	Coulee-Genoa 161 kV	Genoa- Lacrosse Tap 161 kV	4.50%
Lancaster-Platteville Tap 69 kV	61	104.9	Nelson Dewey-Potosi 138 kV	Nelson Dewey-Lancaster 138 kV	5.60%
Monticello Tap -New Gaus 69 kV	69	67.4	Nelson Dewey 161/138 kV	Nelson Dewey-Lancaster 138 kV	5.00%
Nelson Dewey 138/69 kV 1	46	61.4	Nelson Dewey 161/138 kV	Nelson Dewey-Lancaster 138 kV	11.70%
Nelson Dewey 138/69 kV 2	46	61	Nelson Dewey 161/138 kV	Nelson Dewey-Lancaster 138 kV	11.60%
Nelson Dewey 161/138 kV	286	472.3	Nelson Dewey-Potosi 138 kV	Nelson Dewey-Lancaster 138 kV	94.70%
Nelson Dewey-Glen Haven Tap 69 kV	82	119.7	Nelson Dewey 161/138 kV	Nelson Dewey-Lancaster 138 kV	23.40%
Nelson Dewey-Lancaster 138 kV	282	421.6	Nelson Dewey 161/138 kV	Nelson Dewey-Potosi 138 kV	76.10%
Nelson Dewey-Potosi 138 kV	287	402	Nelson Dewey 161/138 kV	Nelson Dewey-Lancaster 138 kV	76.50%
New Hollandale-Blanchardville 69 kV	72	69.9	Nelson Dewey 161/138 kV	Eden-Wyoming Valley 138 kV	11.50%
North Monroe 138/69 kV	93	115.3	Nelson Dewey 161/138 kV	Nelson Dewey-Lancaster 138 kV	5.20%
North Monroe-Monticello Tap 69 kV	69	74.2	Nelson Dewey 161/138 kV	Nelson Dewey-Lancaster 138 kV	5.00%
Platteville - Platteville Tap 69 kV	41	77.7	Turkey River-Cassville 161 kV	Stoneman-Beetown 69 kV	3.50%
Platteville-Platteville Tap 69 kV	41	101.4	Nelson Dewey-Potosi 138 kV	Nelson Dewey-Lancaster 138 kV	5.60%
Rock Branch-New Hollandale 69 kV	72	72.9	Nelson Dewey 161/138 kV	Eden-Wyoming Valley 138 kV	11.50%
Stoneman 69 kV-Cassville 161 kV	60	64.3	Nelson Dewey-Potosi 138 kV	Nelson Dewey-Lancaster 138 kV	7.40%
Wauzeka - Boscobel 69 kV	72	75.6	Nelson Dewey-Potosi 138 kV	Nelson Dewey-Lancaster 138 kV	4.00%
Wauzeka-Gran Grae 69 kV	72	78.8	Nelson Dewey-Potosi 138 kV	Nelson Dewey-Lancaster 138 kV	4.00%
Wyoming Valley-Spring Green 138 kV	203	249.3	Nelson Dewey 161/138 kV	Nelson Dewey-Potosi 138 kV	49.60%
Blanchardville-Forward 69 kV	49	66.7	Nelson Dewey 161/138 kV	Eden-Wyoming Valley 138 kV	11.50%

Notes: N-2 analysis was performed using the Summer 2011-2 system model.
Existing MW rating assumed to be 95% of the existing MVA rating

Table A.3 – Identified Thermal Violations due to G527 (138kV Connection) with Delivery to ALTE for N-1 Contingencies (TDF>3%)

Limiting Element	Existing Rating (MVA)	Required Rating (MW)	Worst Contingency	TDF (%)	Case[8]	Injection Limit	Solution Planned
Rocky Run-Gardner Park 345 kV[1,5,7]	717	833.1	System Intact	3.5%	SUM-1	No	No
Nelson Dewey 161/138 kV[2,6]	286	293.3	Nelson Dewey-Lancaster 138 kV	63.4%	SH-2	Yes	No
Nelson Dewey-Cassville 161 kV[2,4,6]	201	202.3	Nelson Dewey-Lancaster 138 kV	42.1%	SH-1	Yes	No
Eden-Wyoming Valley 138 kV[2,6]	192	192.4	Nelson Dewey 161/138 kV	31.2%	SH-3	Yes	No
Potosi-Hillman 138 kV[3,7]	214	219.2	Nelson Dewey-Lancaster 138 kV	22.7%	SUM-1	Yes	No
Hillman-Platteville Tap 69 kV[1,6]	29	70.4	Nelson Dewey 161/138 kV	7.5%	SUM-2	No	No
Platteville-Platteville Tap 69 kV[1,6]	41	61.3	Nelson Dewey 161/138 kV	7.5%	SUM-2	No	No
Werner West-Werner 138 kV[1,5,7]	287	315.1	N. Appleton-Werner West 345 kV	7.4%	SUM-1	No	No
Hintz-Werner 138 kV[1,5,7]	287	282.9	N. Appleton-Werner West 345 kV	7.4%	SUM-1	No	No
Hillman 138/69 kV[1,6]	49	96.7	Darlington-G282 138 kV	4.9%	SUM-1	No	No
Darlington 138/69 kV[2,6]	105	109.7	Nelson Dewey-Lancaster 138 kV	4.3%	SUM-3	No	No
Hillsboro 161/69 kV[1,6]	112	114.7	Genoa (NSP)-Genoa (DPC) 69 kV	3.7%	SUM-3	No	No
Hoover-Whiting Avenue 115 kV[1,5,7]	205	245.3	Werner West-Rocky Run 345 kV	3.5%	SUM-1	No	No
Lancaster-Platteville Tap 69 kV[1,7]	61	87.8	Nelson Dewey-Potosi 138 kV	3.4%	SUM-1	No	No
Platteville-Platteville Tap 69 kV[1,7]	41	83.3	Nelson Dewey-Potosi 138 kV	3.4%	SUM-1	No	No
Boscobel-Wauzeka 69 kV[1,6]	72	68.9	Nelson Dewey-Lancaster 138 kV	3.4%	SUM-1	No	No
Gran Grae-Wauzeka 69 kV[1,6]	72	72.1	Nelson Dewey-Lancaster 138 kV	3.4%	SUM-1	No	No
Rocky Run-Gardner Park 345 kV[1,4,7]	717	965.3	Forbes-Chisago 500 kV	3.3%	SUM-1	No	No
Ellington-Casaloma 138 kV[1,5,7]	216	209.6	North Applton-Werner West 345 kV	3.3%	SUM-1	No	No
Port Edwards-Sand Lake 138 kV[1,5,7]	155	156.8	Werner West-Rocky Run 345 kV	3.1%	SUM-1	No	No

Existing MW rating assumed to be 95% of the existing MVA rating

Notes:

1. Violation occurs with G282 in or out of service.
2. Violations occur only with G282 in service.
3. Violation occurs only with G282 out of service.
4. Violation occurs only with G523 in service.
5. Violation occurs only with G523 in service, prior to planned and proposed projects going into service.
6. Worst violation occurs with G282 in service.
7. Worst violation occurs with G282 in service.
8. SUM-1, SH-1 and WIN-1 represent the expected summer peak 2011, shoulder peak 2011 and winter peak 2010-2011, respectively, with planned projects through 2008 and proposed projects through 2007. G523 is in service. SUM-2, SH-2, and WIN-2 represent the same cases with planned and proposed projects through 2008 plus the Clintonville – Werner West 138kV line (Planned), Morgan – Central Wisconsin – Werner West 345kV line (Planned), Gardner Park – Central Wisconsin 345kV line (Planned), and the Cranberry – Conover 138kV project (Proposed) included. All four projects have an expected in-service date prior to Summer 2010. SUM-3, SH-3 and WIN-3, represent the same system topology as the SUM-2, SH-2, and WIN-2 cases with G523 out of service.

Table A.4 – Maximum Allowable Generation without System Upgrades (138 kV Connection)[1]

Limiting Element	Worst Contingency	Model Description	G527 Maximum MW	Max MW with Planned and Proposed Projects
Nelson Dewey 161/138 kV Transformer	Nelson Dewey-Lancaster 138 kV	SH-2	211.0	211.0
Nelson Dewey-Cassville 161 kV (Q-2E)	Nelson Dewey-Lancaster 138 kV	SH-1	214.2	218.7
Potosi-Hillman 138 kV (X-15)	Nelson Dewey-Lancaster 138 kV	SUM-1	220.7[3]	238.3[3]
Eden-Wyoming Valley 138 kV (X-17)	Nelson Dewey 161/138 kV	SH-3	221.4	232.3
Nelson Dewey-Lancaster 138 kV (X-16)	Nelson Dewey 161/138 kV	SUM-3	275.9	280.0
Spring Green-Wyoming Valley 138 kV (X-17)	Nelson Dewey 161/138 kV	SH-3	270.4	280.0
Nelson Dewey 161/138 kV Transformer	System Intact	SH-2	260.0	260.0

Notes:
1. Only steady state analysis was considered, stability limitations will be considered in the ISIS.
2. Limits (if any) for up to 280 MW of output with Clintonville – Werner West 138kV line (Planned), Morgan – Central Wisconsin – Werner West 345kV line (Proposed), Gardner Park – Central Wisconsin 345kV line (Proposed), and the Cranberry – Conover 138kV project (Proposed) included are shown in the final column. All four projects have an expected in-service date prior to Summer 2010.
3. G282 off, all other cases, G282 on.

Table A.5: Voltage Analysis of G527 (280 MW, 138 kV) without Generator Upgrades[1]

Single Contingency	G527 Scenario	Nelson Dewey 161 kV Voltage (pu)	Nelson Dewey 138 kV Voltage (pu)	Nelson Dewey 69 kV Voltage (pu)
System Intact	280 MW/56 Mvars	1.0176	1.0200	1.0131
Nelson Dewey 161/138 kV	280 MW/91 Mvars	0.9987	1.0200	1.0111
System Intact	280 MW/0 Mvars	0.9992	0.9952	1.0063
Nelson Dewey 161/138 kV	280 MW/0 Mvars	Did Not Solve	Did Not Solve	Did Not Solve
Nelson Dewey-Potosi 138 kV	280 MW/0 Mvars	1.0090	1.0084	1.0125
Nelson Dewey-Lancaster 138 kV	280 MW/0 Mvars	1.0034	1.0023	1.0099
Nelson Dewey-Cassville 161 kV	280 MW/0 Mvars	0.9433	0.9389	1.0056
Nelson Dewey-Gran Grae 161 kV	280 MW/0 Mvars	0.9985	0.9929	1.0073

Notes:
1. Voltages of system buses while injecting 280 MW at G527. No GSU modeled. G527 MW output dispatched outside of ATC footprint (75% Illinois, 25% Minnesota). Analysis performed on SUM-2 Case.

Table A.6: Reactive Power Analysis of G527 (280 MW, 138 kV) without Generator Upgrades[1]

Contingency	G527 Mvar Output	Percent of Unit Qmax	Nelson Dewey 161 kV Bus Voltage (pu)	Nelson Dewey 138 kV Bus Voltage (pu)	Nelson Dewey 69 kV Bus Voltage (pu)
System Intact	54.0	30.9%	1.0191	1.0200	1.0096
Nelson Dewey 161/138 kV	97.9	55.9%	1.0029	1.0200	1.0082
Nelson Dewey-Potosi 138 kV	38.3	21.9%	1.0188	1.0200	1.0095
Nelson Dewey-Lancaster 138 kV	41.1	23.5%	1.0185	1.0200	1.0076
Nelson Dewey-Cassville 161 kV	62.3	35.6%	1.0183	1.0200	1.0097
Nelson Dewey-Gran Grae 161 kV	48.9	27.9%	1.0220	1.0200	1.0068

Notes:
1. Reactive power required from G527 to keep voltage at POI at 1.02 pu. G527 modeled as 280 MW, 175 Mvar (0.85 pf). G527 power delivered 75% to Illinois and 25% to Minnesota. SUM-2 case used.

Table A.7 – Identified Thermal Violations due to G527 (161 kV Connection) with Delivery to MISO for N-1 Contingencies (TDF>3%)

Limiting Element	Existing MVA Rating	Required MW Rating	Worst Contingency	TDF (%)	Case[7]	Injection Limit	Solution Planned
Nelson Dewey-Cassville 161 kV[1,5]	201	232.9	Nelson Dewey-Lancaster 138 kV	53.0%	SUM-3	Yes	No
Potosi-Hillman 138 kV[3,4]	214	203.4	Nelson Dewey-Lancaster 138 kV	17.1%	SUM-1	No	No[8]
Hillman-Platteville Tap 69 kV[1,5]	29	61.7	Nelson Dewey-Cassville 161 kV	4.8%	SUM-2	No	No
Hillman 138/69 kV[1,5]	49	95.0	Darlington-G282 138 kV	4.3%	SUM-1	No	No
Hillsboro 161/69 kV[1,5]	112	115.2	Genoa (NSP)-Genoa (DPC) 69 kV	3.9%	SUM-3	No	No
Darlington 138/69 kV[2]	105	108.3	Nelson Dewey-Lancaster 138 kV	3.8%	SUM-3	No	No
Pleasant Valley-Maren Tap 138 kV[1,5]	295	282.5	Cherry Valley-Silver Lake 345 kV	3.4%	SUM-1	No	No
Colley Road-Marine 138 kV[1,5]	287	278.4	Sunrise-Lakehead Tap 138 kV	3.3%	SUM-1	No	No
Lancaster-Platteville Tap 69 kV[1,6]	61	87.4	Nelson Dewey-Potosi 138 kV	3.3%	SUM-1	No	No
Platteville-Platteville Tap 69 kV[1,6]	41	83.0	Nelson Dewey-Potosi 138 kV	3.3%	SUM-1	No	No
Gran Grae-Wauzeka 69 kV[1,5]	72	71.2	Nelson Dewey-Lancaster 138 kV	3.1%	SUM-1	No	No

Existing MW rating assumed to be 95% of the existing MVA rating

Notes:

1. Violation occurs with G282 in or out of service.
2. Violations occur only with G282 in service.
3. Violation occurs only with G282 out of service.
4. Violation occurs only with G523 in service, prior to planned and proposed projects going into service.
5. Worst violation occurs with G282 in service.
6. Worst violation occurs with G282 out of service.
7. SUM-1, SH-1 and WIN-1 represent the expected summer peak 2011, shoulder peak 2011 and winter peak 2010-2011, respectively, with planned projects through 2008 and proposed projects through 2007. G523 is in service. SUM-2, SH-2, and WIN-2 represent the same cases with planned and proposed projects through 2008 plus the Clintonville – Werner West 138kV line (Planned), Morgan – Central Wisconsin – Werner West 345kV line (Planned), Gardner Park – Central Wisconsin 345kV line (Planned), and the Cranberry – Conover 138kV project (Proposed) included. All four projects have an expected in-service date prior to Summer 2010. SUM-3, SH-3 and WIN-3, represent the same system topology as the SUM-2, SH-2, and WIN-2 cases with G523 out of service.
8. This violation can be resolved by implementing the projects listed in Table 3.1.

Table A.8 – Identified Thermal Violations due to G527 (161 kV) under N-2 Contingencies[1]

Limiting Element	Existing MVA Rating	Worst MW Loading	Contingency #1	Contingency #2	TDF (%)
Blanchardville-Forward 69 kV	49	47.1	Cassville-Nelson Dewey 161 kV	Eden-Wyoming Valley 138 kV	6.10%
Cassville-Nelson Dewey 161 kV	201	297.1	Nelson Dewey-Potosi 138 kV	Nelson Dewey-Lancaster 138 kV	65.00%
Cassville-Turkey River 161 kV	235	232.4	Nelson Dewey-Potosi 138 kV	Nelson Dewey-Lancaster 138 kV	57.50%
Darlington 138/69 kV	105	123.7	Hillman 138/69 kV	Nelson Dewey-Lancaster 138 kV	4.30%
Darlington-Rock Branch 69 kV	49	78.8	Cassville-Nelson Dewey 161 kV	Nelson Dewey-Lancaster 138 kV	4.30%
Dodgeville-Land's End 69 kV	48	47.7	Darlington-G282 138 kV	Eden-Wyoming Valley 138 kV	4.30%
Eden-Land's End 69 kV	48	57.6	Darlington-G282 138 kV	Eden-Wyoming Valley 138 kV	4.30%
Eden-Wyoming Valley 138 kV	192	186.5	Cassville-Nelson Dewey 161 kV	Nelson Dewey-Gran Grae 161 kV	32.70%
Gran Grae 161/69 kV	134	129	Seneca-Bell Center 161 kV	Nelson Dewey–Glen Haven 69 kV	3.70%
Hillman 138/69 kV	49	99.3	Stoneman-Beetown 69 kV	Nelson Dewey-Lancaster 138 kV	3.70%
Hillman-Belmont 69 kV	72	73.1	Nelson Dewey-Lancaster 138 kV	Darlington-G282 138 kV	5.70%
Hillman-Platteville Tap 69 kV	29	67.1	Cassville-Nelson Dewey 161 kV	Hillman-McGregor 69 kV	4.80%
Hillman-Potosi 138 kV	214	232.8	Cassville-Nelson Dewey 161 kV	Nelson Dewey-Lancaster 138 kV	37.80%
Hillsboro 161/69 kV	112	119.1	Genoa-Coulee 161 kV	Genoa-Lacrosse Tap 161 kV	4.90%
Lancaster - Platteville Tap 69 kV	61	86.8	Nelson Dewey-Potosi 138 kV	G282 138/34.5 kV	3.30%
Nelson Dewey 161/138 kV	286	300	Cassville-Nelson Dewey 161 kV	Nelson Dewey-Gran Grae 161 kV	100.00%
Nelson Dewey-Gran Grae 161 kV	221	300	Cassville-Nelson Dewey 161 kV	Nelson Dewey 161/138 kV	100.00%
Nelson Dewey-Lancaster 138 kV	282	285.7	Cassville-Nelson Dewey 161 kV	Nelson Dewey-Potosi 138 kV	36.70%
Platteville - Platteville Tap 69 kV	41	83.3	Nelson Dewey-Potosi 138 kV	G282 138/34.5 kV	3.30%
Platteville Tap-Platteville 69 kV	41	70.6	Cassville-Nelson Dewey 161 kV	Darlington-G282 138 kV	7.00%
Stoneman 69 kV-Cassville 161 kV	60	69.8	Turkey River-Cassville 161 kV	Nelson Dewey 161/138 kV	20.70%
Wauzeka - Boscobel 69 kV	72	75.3	Nelson Dewey-Potosi 138 kV	Nelson Dewey-Lancaster 138 kV	3.90%
Wauzeka-Gran Grae 69 kV	72	78.5	Nelson Dewey-Potosi 138 kV	Nelson Dewey-Lancaster 138 kV	3.90%

Notes: N-2 analysis was performed using the Summer 2011-2 system model.
Existing MW rating assumed to be 95% of the existing MVA rating

Table A.9 – Identified Thermal Violations due to G527 (161 kV Connection) with Delivery to ALTE for N-1 Contingencies (TDF>3%)

Limiting Element	Existing MVA Rating	Required MW Rating	Worst Contingency	TDF (%)	Case[8]	Injection Limit	Solution Planned
Rocky Run-Gardner Park 345 kV[1,5,7]	717	833.8	Intact System	3.7%	SUM-1	NO	No[9]
Nelson Dewey-Cassville 161 kV[2,4,6]	201	211.5	Nelson Dewey-Lancaster 138 kV Line	45.4%	SH-1	YES	No
Potosi-Hillman 138 kV[3,7]	214	206.5	Nelson Dewey-Lancaster 138 kV Line	18.2%	SUM-1	NO	No
Werner West-Werner 138 kV[1,5,7]	287	316.3	North Appleton-Werner West 345 kV	7.8%	SUM-1	NO	No[9]
Hintz-Werner 138 kV[1,5,7]	287	284.2	North Appleton-Werner West 345 kV	7.8%	SUM-1	NO	No[9]
Lancaster-Platteville Tap 69 kV[1,7]	61	89.5	Nelson Dewey-Potosi 138 kV	4.0%	SUM-1	NO	No
Platteville-Platteville Tap 69 kV[1,7]	41	85.0	Nelson Dewey-Potosi 138 kV	4.0%	SUM-1	NO	No
Hillsboro 161/69 kV[1,6]	112	115.6	Genoa (NSP)-Genoa (DPC) 69 kV	4.0%	SUM-3	NO	No
Hoover-Whiting Avenue 115 kV[1,5,7]	205	245.9	Werner West-Rocky Run 345 kV	3.8%	SUM-1	NO	No[9]
Rocky Run-Gardner Park 345 kV[1,4,7]	717	966.0	Forbes-Chisago 500 kV	3.6%	SUM-1	NO	No[9]
Ellington-Casaloma 138 kV[1,5,7]	216	210.2	North Appleton-Werner West 345 kV	3.5%	SUM-1	NO	No[9]
Boscobel-Wauzeka 69 kV[1,6]	72	69.3	Nelson Dewey-Lancaster 138 kV Line	3.5%	SUM-1	NO	No
Gran Grae-Wauzeka 69 kV[1,6]	72	72.5	Nelson Dewey-Lancaster 138 kV Line	3.5%	SUM-1	NO	No
Port Edwards-Sand Lake 138 kV[1,5,7]	155	157.7	Werner West-Rocky Run 345 kV	3.4%	SUM-1	NO	No[9]
Darlington 138/69 kV[2,6]	105	107.1	Nelson Dewey-Lancaster 138 kV Line	3.4%	SUM-3	NO	No
Hillman-Platteville (WPL) 69 kV[1,6]	29	57.2	Nelson Dewey-Cassville 161 kV Line	3.2%	SUM-2	NO	No
Platteville DPC – Platteville WPL 69 kV[1,6]	47	48.1	Nelson Dewey-Cassville 161 kV Line	3.2%	SUM-2	NO	No
Hillman 138/69 kV[1,6]	49	91.5	Darlington-G282 138 kV	3.0%	SUM-1	NO	No

Existing MW rating assumed to be 95% of the existing MVA rating

Notes:
1 - Violation occurs with G282 in or out of service.
2 - Violations occur only with G282 in service.
3 - Violation occurs only with G282 out of service.
4 - Violation occurs only with G523 in service.
5 - Violation occurs only with G523 in service and only prior to planned and proposed projects going into service.
6 - Worst violation occurs with G282 in service.
7 - Worst violation occurs with G282 out of service.
8 - Case Descriptions: SUM-1, SH-1 and WIN-1 represent the expected summer peak 2011, shoulder peak 2011 and winter peak 2010-2011, respectively, with planned projects through 2008 and proposed projects through 2007. G523 is in service. SUM-2, SH-2, and WIN-2 represent the same cases with planned and proposed projects through 2008 plus the Clintonville – Werner West 138kV line (Planned), Morgan – Central Wisconsin – Werner West 345kV line (Planned), Gardner Park – Central Wisconsin 345kV line (Planned), and the Cranberry – Conover 138kV project (Proposed) included. All four projects have an expected in-service date prior to Summer 2010. SUM-3, SH-3 and WIN-3, represent the same system topology as the SUM-2, SH-2, and WIN-2 cases with G523 out of service.
9 - These limits do not appear if planned and proposed projects listed in Table 3.1 are implemented.

Table A.10 – Maximum Allowable Generation without System Upgrades (161 kV Connection)[1]

Limiting Element	Worst Contingency	Model Description	G527 Maximum MW	Max MW with Planned and Proposed Projects
Nelson Dewey-Cassville 161 kV (Q-2E)	Nelson Dewey-Lancaster 138 kV	SH-1	200.8	205.0

Notes:
1. Only steady state analysis was considered, stability limitations will be considered in the ISIS.
2. Limits (if any) for up to 280 MW of output with Clintonville – Werner West 138kV line (Planned), Morgan – Central Wisconsin – Werner West 345kV line (Proposed), Gardner Park – Central Wisconsin 345kV line (Proposed), and the Cranberry – Conover 138kV project (Proposed) included are shown in the final column. All four projects have an expected in-service date prior to Summer 2010.
3. G282 on-line.

Table A.11: Voltage Analysis of G527 (280 MW, 161 kV) without Generator Upgrades[1]

Single Contingency	G527 Scenario	Nelson Dewey 161 kV Voltage (pu)	Nelson Dewey 138 kV Voltage (pu)	Nelson Dewey 69 kV Voltage (pu)
System Intact	280 MW/39 Mvars	1.0200	1.0148	1.0134
Nelson Dewey 161/138 kV	280 MW/3 Mvars	1.0200	0.9689	1.0053
System Intact	280 MW/0 Mvars	1.0034	0.9989	1.0109
Nelson Dewey 161/138 kV	280 MW/0 Mvars	1.0185	0.9708	1.0076
Nelson Dewey-Potosi 138 kV	280 MW/0 Mvars	1.0163	1.0160	1.0133
Nelson Dewey-Lancaster 138 kV	280 MW/0 Mvars	1.0133	1.0127	1.0086
Nelson Dewey-Cassville 161 kV	280 MW/0 Mvars	0.9491	0.9442	1.0081
Nelson Dewey-Gran Grae 161 kV	280 MW/0 Mvars	1.0025	0.9966	1.0138

Notes:
1. Voltages of system buses while injecting 280 MW at G527. No GSU modeled. G527 MW output dispatched outside of ATC footprint (75% Illinois, 25% Minnesota). Analysis performed on 2011-2 Summer Peak Case.

Table A.12: Reactive Power Analysis of G527 (280 MW, 161 kV) without Generator Upgrades[1]

Contingency	G527 Mvar Output	Percent of Unit Qmax	Nelson Dewey 161 kV Bus Voltage (pu)	Nelson Dewey 138 kV Bus Voltage (pu)	Nelson Dewey 69 kV Bus Voltage (pu)
System Intact	39.1	22.3%	1.0200	1.0149	1.0134
Nelson Dewey 161/138 kV	2.6	1.5%	1.0200	0.9689	1.0053
Nelson Dewey-Potosi 138 kV	9.2	5.3%	1.0200	1.0195	1.0140
Nelson Dewey-Lancaster 138 kV	14.2	8.1%	1.0200	1.0192	1.0118
Nelson Dewey-Cassville 161 kV	51.3	29.3%	1.0200	1.0125	1.0091
Nelson Dewey-Gran Grae 161 kV	31.9	18.2%	1.0200	1.0131	1.0061

Notes: Reactive power required from G527 to keep voltage at POI at 1.02 pu. G527 modeled as 280 MW, 175 Mvar (0.85 pf). G527 power delivered 75% to Illinois and 25% to Minnesota. Summer 2011-2 case used.

Appendix B

Summary of Operation Restrictions

Table B.1 – Summary of the Identified Operation Restrictions on the G527 (138 kV Connection) due to Thermal Constraints[1]

Prior Outage	Allowable MW Output	Worst Next Contingency	Most Limiting Element	MVA Rating
Stoneman-Beetown 69 kV	0	Turkey River-Cassville 161 kV	Hillman-Platteville Tap 69 kV	29
Turkey River-Cassville 161 kV	0	Stoneman-Beetown 69 kV	Hillman-Platteville Tap 69 kV	29
Hillman 138/69 kV	0	Nelson Dewey-Lancaster 138 kV	Darlington-Rock Branch 69 kV	49
Nelson Dewey-Lancaster 138 kV	0	Hillman 138/69 kV	Darlington-Rock Branch 69 kV	49
Darlington 138/69 kV	0	Lancaster-Beetown 69 kV	Hillman138/69 kV	49
Lancaster-Beetown 69 kV	0	Darlington 138/69 kV	Hillman138/69 kV	49
Nelson Dewey-Potosi 138 kV	0	Nelson Dewey-Lancaster 138 kV	Platteville-Platteville Tap 69 kV	41
Nelson Dewey 161/138 kV	0	Nelson Dewey-Lancaster 138 kV	North Monroe 138/69 kV	93
Eden-Wyoming Valley 138 kV	0	Nelson Dewey 161/138 kV	Eden 138/ 69 kV	83
Darlington-G282 138 kV	0	Eden-Wyoming Valley 138 kV	Eden-Land's End 69 kV	48
Coulee-Genoa 161 kV	22	Genoa- Lacrosse Tap 161 kV	Hillsboro 161/69 kV	112
Genoa- Lacrosse Tap 161 kV	22	Coulee-Genoa 161 kV	Hillsboro 161/69 kV	112
Cassville-Nelson Dewey 161 kV	248	Nelson Dewey-Lancaster 138 kV	Gran Grae-Nelson Dewey 161 kV	221

Notes:
1. Additional operating restrictions may be identified in the ISIS due to stability analysis
2. N-2 contingencies were analyzed only with the Summer 2011-2 model

Table B.2 – Summary of the Identified Operation Restrictions on the G527 (161 kV Connection) due to Thermal Constraints[1]

Prior Outage	Allowable MW Output	Worst Next Contingency	Most Limiting Element	MVA Rating
Nelson Dewey-Lancaster 138 kV	0	Stoneman-Beetown 69 kV	Hillman 138/69 kV	49
Stoneman-Beetown 69 kV	0	Nelson Dewey-Lancaster 138 kV	Hillman 138/69 kV	49
G282 138/34.5 kV	0	Nelson Dewey-Potosi 138 kV	Platteville - Platteville Tap 69 kV	41
Nelson Dewey-Potosi 138 kV	0	G282 138/34.5 kV	Platteville - Platteville Tap 69 kV	41
Cassville-Nelson Dewey 161 kV	0	Hillman-McGregor 69 kV	Hillman-Platteville Tap 69 kV	29
Hillman-McGregor 69 kV	0	Cassville-Nelson Dewey 161 kV	Hillman-Platteville Tap 69 kV	29
Hillman 138/69 kV	0	Nelson Dewey-Lancaster 138 kV	Darlington 138/69 kV	105
Darlington-G282 138 kV	0	Cassville-Nelson Dewey 161 kV	Platteville Tap-Platteville 69 kV	41
Eden-Wyoming Valley 138 kV	1	Darlington-G282 138 kV	Eden-Land's End 69 kV	48
Genoa-Coulee 161 kV	21	Genoa-Lacrosse Tap 161 kV	Hillsboro 161/69 kV	112
Genoa-Lacrosse Tap 161 kV	21	Genoa-Coulee 161 kV	Hillsboro 161/69 kV	112
Nelson Dewey 161/138 kV	190	Cassville-Nelson Dewey 161 kV	Nelson Dewey-Gran Grae 161 kV	221
Turkey River-Cassville 161 kV	218	Nelson Dewey 161/138 kV	Stoneman 69 kV-Cassville 161 kV	60
Nelson Dewey–Glen Haven 69 kV	234	Seneca-Bell Center 161 kV	Gran Grae 161/69 kV	134
Seneca-Bell Center 161 kV	234	Nelson Dewey–Glen Haven 69 kV	Gran Grae 161/69 kV	134
Nelson Dewey-Gran Grae 161 kV	252	Cassville-Nelson Dewey 161 kV	Nelson Dewey 161/138 kV	286

Notes:
1. Additional operating restrictions may be identified in the ISIS due to stability analysis
2. N-2 contingencies were analyzed only with the Summer 2011-2 model

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.

A Transmission Reliability Margin (TRM) of 5% was applied to all MVA ratings of monitored elements. Violations in this report are based upon the TRM adjustment of MVA ratings.

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.