September 2010 10-Year Assessment
www.atc10yearplan.com

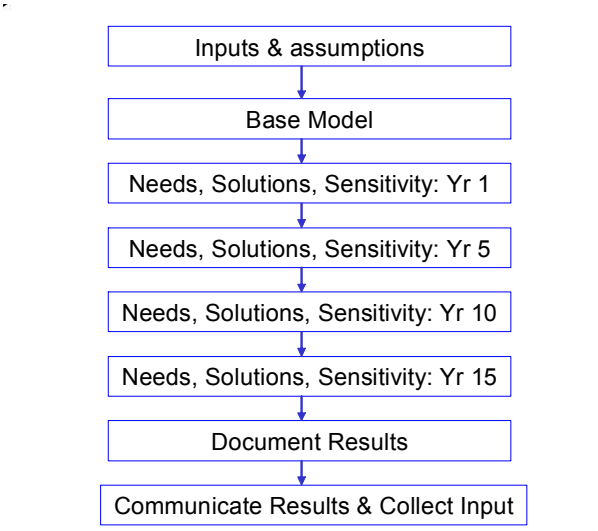
Methodology & assumptions

1.1 Overview

This section describes the methods and techniques that we use to analyze our network transmission system for this assessment. Economic, regional, environmental and asset management planning processes are covered on other sections of this Web site.

As part of the network assessment, ATC conducted power flow analyses to identify problems or constraints on the transmission system and evaluated the merits of potential reinforcements to address the system limitations that were identified. Once these analyses are complete, ATC meets with our stakeholders to discuss the preliminary results.

ATC's network planning process is summarized in the below figure:



Included in this section is a discussion of which years ATC identified to model to satisfy both the near-term (1 – 5 year horizon) and long-term (5 year and beyond horizon) NERC standards for assessing the transmission system. Also included in this section is discussion on how ATC built each of the models used in this assessment. Discussion items include topics such as load forecasting, which reinforcements and new generation to include in models, which system load levels, import levels and system bias scenarios to evaluate.

During the network assessment of our transmission system, we performed simulations on a variety of models as discussed below in this section. ATC not only uses these models to identify where constraints or system limitations may exist, but we also use these models in testing the robustness of potential system reinforcements. Per our Planning criteria,

constraints or system limitations are identified for NERC Category A type system conditions when bus voltages drop below 95 percent or exceed 105 percent of their nominal voltage or when any system element exceeds it normal rating for the appropriate seasonal model. For NERC Category A or system intact conditions, ATC's Planning criteria also requires for generators to be limited to 90 percent of their net Q_{max} capability within ATC footprint.

For NERC Category B, C or D contingencies, system limitations or constraints are identified using slightly different criterion. For these types of system contingency conditions, ATC's Planning Criteria identify system limitations when bus voltages drop below 90 percent or exceed 110 percent of their nominal voltage or when any system element exceeds its emergency rating for the appropriate seasonal model. For these three NERC categories, ATC's Planning criteria requires generators to be limited to 95 percent of their net Q_{max} capability within ATC footprint.

In all of the models, normal operating procedures were modeled for the applicable normal system conditions. All existing and planned protection systems, including any backup or redundant systems that would be applicable to a given contingency were simulated in the studies and analyses. All existing and planned control devices that would be applicable to a given contingency were simulated in the studies and analyses. These control devices include transformer automatic tap changers, capacitor bank automatic controls, and Distribution Superconducting Magnetic Energy Storage (DSMES) units. No specific facility outages are modeled in the planning horizon at the demand levels that were studied due to lack of future outage schedules. As the future unfolds and facility outages are scheduled, they will be timed for conditions that provide acceptable reliability.

The analyses conducted in this transmission system assessment included steady state power flow analyses, stability simulations, multiple outage impacts as well as economic evaluations, generator interconnection impacts, transmission-distribution interconnection impacts and environmental assessment impacts.

1.2 Network assessment methodology

American Transmission Co.'s 2010 10-Year Transmission System Assessment provides current results of planning activities and analyses of the company's transmission facilities. These activities and analyses identify needs for network transmission system enhancement and potential projects responsive to those needs.

Since 2001, we have engaged in open and collaborative efforts to share information and solicit input on our plans. We believe that in making our planning efforts transparent and available to the public, the proposals for needed facilities can be more readily understood and accepted by communities that stand to benefit from them. In recent years the federal government has taken additional steps to ensure that transmission-owning utilities have produced and shared planning information with the public and local stakeholders.

The information in this report provides further foundation for continued public discussions on the transmission planning process, identified transmission needs and limitations, possible resolutions to those needs and coordination with other public infrastructure planning processes.

Computer simulation model years for the 2010 network Assessment analyses were selected in order to meet NERC requirements for a 1-5 year horizon and beyond the 5 year horizon. The years 2011 and 2015 were selected to meet the 1-5 year horizon. The years 2020 and 2025 meet the beyond 5 year horizon. A range of system conditions and study years were developed and analyzed for the 2010 Assessment. Steady state peak load models for all four years were created. In order to determine how close ATC generators were to their maximum var output, two additional models were created for each year. The one model reduced ATC generator net Q_{max} by 10 percent for each year studied. These models were utilized to determine generator var output under intact system conditions (TPL-001-0). A second model for each year was created with net Q_{max} reduced by 5 percent. These models were used for our N-1 (TPL-002-0) analysis.

The needs identified in this Assessment were determined by identifying facilities whose normal or emergency ratings or tolerances are exceeded. The criterion we use to determine what these ratings and tolerances should be is provided in Planning criteria).

This 2010 network Assessment was developed in a chronological fashion. Planned transmission additions expected to be in service by June 2011 were included in the 2011 model, as listed in Table PF-1. Projects for which we have completed our analysis and are either under construction, have filed an application to construct, or are in the process of preparing an application were included in the 2015, 2020 and 2025 models as appropriate based on projected in service dates (See Tables PF-2, PF-3 and PF-4).

1.2.1 Load forecast

Steady state summer peak models are built using our customers' load forecasts (50/50 projections) as a starting point, meaning that there is a 50 percent chance that the load level will either fall below or exceed the customer projection. Customer load forecasts were gathered for all ATC customers through the year 2019 (and in some cases 2020/2025). The forecasts were compared to previous historical and forecasted data to ensure validity and consistency. As a final step, the finalized forecast information was forwarded back to our individual customers to ensure their concurrence. Once consensus was achieved, the data was incorporated into our models.

Certain ATC customers did not provide an 11^{th}-year load forecast for the year 2020. To obtain a forecast for 2020, certain customer-provided forecasts were extended by growing their load by a fixed growth percentage based upon the previous 3-years' growth

(approximately 1.3% compounded annually). Non-scalable loads were held at their 2019 levels using this methodology.

The 2025 summer peak load model was developed utilizing similar methodology. To obtain a projection for 2025, customer-provided forecasts were extended by growing their load by a fixed growth percentage based upon the previous 3-years' growth (approximately 1.3% compounded annually). Non-scalable loads were once again held at their 2019 (or 2020) load levels. It should be noted that the loads utilized in the 2025 summer peak model do not reflect an actual load forecast, but merely a projection (or "load model") based upon the best available information. The purpose for the 2025 projection is not to develop projects to address all issues, but to develop a sense for the need(s) for long lead-time projects.

ATC Peak Load Projections (MW) including line losses

Year	MW load	Compounded growth rate
2010	13,681	N/A
2011	14,099	N/A
2015	14,832	1.3% (2011-2015)
2020	15,879	1.4% (2015-2020)
2025	16,973*	1.3% (2020-2025)
Overall		1.4% (2010-2025)

**load model, not a load forecast*

It should be noted that we worked with the distribution companies as much as possible to confirm forecast variations from past trends. In a few cases we revised power factors to reasonable levels to prevent creating expensive transmission projects for voltage support. In most cases these issues would ultimately be solved through distribution system power factor correction. ATC will be in ongoing discussions with our customers to determine the best plan for these situations.

1.2.2 Model building
1.2.2.a Assumptions common to all models

1.2.2.a.1 New generation

There have been numerous generation projects proposed within ATC's service territory. Many of these proposed projects have interconnection studies completed and a few have had transmission service facility studies completed. Several have proceeded to or through the licensing phase and several more are under construction. However, there are numerous proposed generation projects that have dropped out of the generation queue (refer to Generation interconnections), adding considerable uncertainty to the transmission planning process. To address this planning uncertainty, we have adopted a criterion for

purposes of this and prior Assessments, to establish which proposed generation projects would be included in the 2010 Assessment models.

Previously (before the advent of the MISO Day 2 market) the criterion was that those generation projects for which, at the time the models were developed,

1. *ATC had **completed** a generation interconnection impact study, a generation interconnection facility study, a transmission service impact study and a transmission service facility study, **and***
2. *the generation developer or a customer of the developer had **accepted** the transmission service approved by ATC.*

In the 2010 10-Year Assessment, the criterion was broken into two time frames, years 1 through 5 and 6+ years.

1. For years 1 through 5, only those generators with FERC approved interconnection agreements will be included in the planning models.
2. Beginning with year 6 and continuing into the future, generators are only required to have a Facility Study completed in order to be included in the 10-Year Assessment models.

A number of wind generators in the ATC footprint have suspended FERC approved interconnection agreements. For the first three years following their requested in-service dates, ATC criterion calls for modeling these facilities but dispatching them at the bottom of the dispatch order. After the three years, the generators will be dispatched in their normal dispatch order. The wind generators with suspended agreements were included in the models built for the 10-Year Assessment analysis. The 2010 and 2011 models showed these generators as out of service. The 2015 and 2020 models should have had these generators in-service and dispatched.

1.2.2.a.2 Generation retirements

On occasion, generators connected to the ATC transmission system are retired or mothballed. As a result, we developed criteria to determine when generators should no longer be included in our 10-Year Assessment models. If the generator has a completed MISO Attachment Y study, the generator will be disconnected in the appropriate load flow study models. In addition, ATC sent an annual letter to each generation owner. Generating companies were asked to identify generator retirements or mothballing that should be included in ATC's planning horizon. Generators identified as such by the customer will be modeled off line in the relevant models.

There are generators that have been publicly announced as likely candidates for retirement. However, using the disconnection criteria above, in the 2010 10-Year Assessment models we assumed the following generators to be out of service:

Plant Name	*Zone*	*Installed capacity*	*Assumed out of service*
Presque Isle 3	2	58 MW	Jan 2010
Presque Isle 4	2	58 MW	Jan 2010
Point Beach 1	4	103 MW	Jan 2011
Point Beach 2	4	105 MW	Jan 2011
Blount 3	3	39 MW	Jan 2013
Blount 4	3	22 MW	Jan 2013
Blount 5	3	28 MW	Jan 2013
Net decrease in 2010		116 MW	
Net decrease after 2010		297 MW	

Please note that recently some of our customer generators reduced their P_{max} outputs, but those reductions occurred after the cutoff points defined below.

1.2.2.a.3 Cutoff dates
For model building purposes, we assumed cutoff dates for generation changes to be included in models. In order to include the latest data in the models, cutoff dates correspond to the dates the models were built as follows:

- 2011 models - October 29, 2009
- 2015 models - October 29, 2009
- 2020 models -October 29, 2009, and
- 2025 models - October, 2009.

It was assumed that if the generator was available as of the cutoff date, it was available for dispatch in that grouping of models.

1.2.2.a.4 Generation projects schedule
To maintain the schedule needed to complete this Assessment, the models were developed during late 2009 and early 2010. Only those generation projects that qualified to be included in our planning models as of the various cutoff dates, were included in the Assessment models.

For generation projects not in service by June 2010, the criterion above resulted in the following proposed generation projects being included in the applicable power flow models:

Plant Name	*Zone*	*Installed capacity increase*	*Dispatched increase*	*Assumed in-service*
Marshfield CT	1	55.2 MW	55.2 MW	May 2010
Oak Creek #2	5	615 MW	615 MW	Aug 2010
Green Lake wind farm	1	32 MW	32 MW	Sep 2010
Quilt Block wind farm	3	19.6 MW	19.6 MW	Dec 2010
Glacier Hills wind farm	3	19.8 MW	19.8 MW	Dec 2010
Stoney Brook wind farm	4	19.7 MW	19.7 MW	Dec 2011
Bowers Road wind farm	3	21 MW	21 MW	Dec 2011
EcoMet wind farm	4	20.1 MW	20.1 MW	Dec 2011
Ledge wind farm	4	30.0 MW	30.0 MW	Dec 2012
Lake Breeze wind farm	4	19.6 MW	19.6 MW	Oct 2013
Net increase by Dec 2011:		802.4 MW		
Net increase 2011-2020:		49.6 MW		

**wind farm Installed capacity lists is 20% of total installed capacity*

A more comprehensive discussion of proposed generation is provided in Generation Interconnections, including a map showing all of the currently active generation interconnection requests that ATC has received (See Figure PR-9.)

1.2.2.a.5 Generation outside system
The model for the system external to ATC was taken from the most appropriate model included in the MMWG 2009 Series models. The external system interchange was adjusted from the 2009 MMWG Series models to match the latest ATC members' firm interchange with the exception of the Shoulder 70% model which was built to represent a 3000 MW import into ATC.

1.2.2.a.6 Generation dispatch
Balancing Authority (Control) area generation was dispatched based on economic dispatch for that Balancing Authority with the exception of the Shoulder 70% model.

1.2.2.a.7 Line and equipment ratings
We revised line and equipment ratings based on updates to our Substation Equipment and Line Database (SELD). As of June 2010, nearly 81 percent of all ATC lines and 89 percent of ATC transformers have SELD ratings that have been validated. Additionally, nearly 96 percent of ATC lines 100 kV or higher have ratings in SELD that have been validated.

Ratings not yet validated in SELD generally are based on the ratings received from the utilities that contributed the facilities to ATC.

1.2.2.a.8 Project criteria included in all assessment models
All of the models built for the Assessment include revised system topology based on projects that were placed in service in the model year, or were anticipated to be placed in service by June 15 of that year. Refer to Tables PF-1 through PF-4 for projects that were included in the analyses. Please also refer to the Project deficient seasonal models, Section *1.2.2.b.1*, for more discussion about how projects are chosen for inclusion our models.

1.2.2.b Steady state power flow models

1.2.2.b.1 Project deficient seasonal models
The load flow models built for the 10-Year Assessment are special models built exclusively for system analyses in the Assessment. Some projects were purposely left out of these models in order to verify system problems and determine which problems worsen over time. We have taken the approach of evaluating subsequent summer peak seasons in each of our annual Assessments to determine the immediacy of needs identified, hence providing a means of prioritization.

The 2011, 2015, 2020 and 2025 steady state project deficient summer peak models were developed to evaluate needs, verify findings of the 2009 Assessment, and confirm that previously identified needs will increase over time. The 2020 and 2025 project deficient models reflect years sufficiently forward in time to determine the need for and assess the performance of larger-scale projects (345-kV lines, for example) that could be expected to be in service in that timeframe.

1.2.2.b.2 All project seasonal models
After the initial analyses portion of the 10-Year Assessment was completed, “All Project” models were built. The “All Project” models were built with all planned and proposed projects in the 2011, 2015 and 2020 models. The later models also include the majority of the provisional projects. These models are more indicative of the expected system configurations for the three study years. The “All Project” models are more appropriate for internal studies performed by ATC planners throughout the year and for regional models. As part of the 10-Year Assessment, the zone planners perform contingency analyses on each of the “All Project” models. These analyses will verify whether all of the planned, proposed, and provisional projects will resolve issues revealed in the 10-Year Assessment process.

1.2.2.b.3 Load, dispatch and interchange profiles

1.2.2.b.3.a Load Sensitivities (2015)
ATC planning explored two sensitivity analyses in our 2010 10-Year Assessment analyses, the minimum (light load) scenario and the high wind generation scenario. The modeling details of these sensitivities are outlined below.

Minimum load scenario (2011)

- ATC Peak Load: 5,515 MW
  - 2009 forecast collection, scalable loads reduced to 32% of peak + non-scalable loads = 40% of Peak load
- Total ATC Generation: 5,297 MW
- Includes all planned and proposed projects to be in-service by 6/15/2011
- *Interchange:* Firm interchange only as of 10/29/2009
- *Dispatch:* ATC-wide Merit order as of 10/29/2009

High wind generation scenario (2015)

- ATC Peak Load: 9,678 MW
  - 2009 forecast collection, scalable loads reduced to 62.5% + non-scalable loads = 67% of Peak load as provided in Operations data
- Total ATC Generation: 8,725 MW
- Includes all planned and proposed projects to be in-service by 6/15/2011
- *Interchange:* ATC net as provided in Operations data -1218
- *Dispatch:* ATC-wide Merit order as of 10/29/2009
- *Special additions:*
  - Wind generation in the ATC footprint dispatched to 61% of P_{max} as provided in Operations data,
  - Wind generation west of ATC dispatched to 50% as provided in Operations data,
  - Wind Generation south of ATC dispatched to 95% as provided in Operations data,
  - Reduce surrounding control area load and dispatch to 80% load level

1.2.2.b.3.b Summer peak (2011, 2015, 2020, 2025)

- ❑ We utilized interconnection point load forecasts provided by various distribution companies in 2009 for both real and reactive power components of load. Please refer to the Load Forecast section for further details.
- ❑ Only firm interchange was included in our analyses.
- ❑ Special additions: none

1.2.2.b.3.b.1 Summer peak 95% Q_{Max} (2011, 2015, 2020, 2025)

- ❑ We utilized interconnection point load forecasts provided by various distribution companies in 2009 for both real and reactive power components of load. Please refer to the Load Forecast section for further details.
- ❑ Only firm interchange was included in our analyses.
- ❑ Special additions: Generator Q_{Max} reduced to 95%.

1.2.2.b.3.b.2 Summer peak 90% Q_{Max} (2011, 2015, 2020, 2025)

- ❑ We utilized interconnection point load forecasts provided by various distribution companies in 2009 for both real and reactive power components of load. Please refer to the Load Forecast section for further details.
- ❑ Only firm interchange was included in our analyses.
- ❑ Special additions: Generator Q_{Max} reduced to 90%.

1.2.2.b.3.c High load model (2015)

- ❑ We utilized interconnection point load forecasts provided by various distribution companies in 2009. The 2015 high load (or "hot summer") model was created by increasing load 5 percent above expected summer peak conditions as a proxy for a 90/10 model in order to determine in-service date sensitivity to load growth that is higher or weather that is warmer than forecasted. Please refer to the Load Forecast section for further details.
- ❑ The system external to ATC was taken from the MMWG 2009 Series, 2015 summer model.
- ❑ The external system interchange was adjusted from the 2009 MMWG Series 2015 summer interchange to match latest ATC members' firm interchange.
- ❑ ATC load forecast increased by 5% above the summer peak load forecast using a constant power factor, Planning/Operations coordinated 69-kV ratings included.

1.2.2.b.3.d Shoulder 70% models (2011, 2015)

- ❑ We utilized interconnection point load forecasts provided by various distribution companies in 2009.
- ❑ The 2015 shoulder model was created by selectively scaling down loads that generally vary by time-of-day to approximately 70 percent of the summer peak condition. A 70 percent load level was chosen to represent the shoulder model because under this scenario, flows are changing as a result of the Ludington pumping cycle. However, we recognize that loads at individual points will vary under real-time shoulder conditions.
- ❑ The shoulder 70% model included a 3000 MW import into ATC. Firm interchange plus economic transactions up to a 3000 MW import were included.
- ❑ Planning and operations coordinated 69-kV ratings included.

1.2.2.b.3.e Shoulder 90% models (2011, 2015)

- ❑ We utilized interconnection point load forecasts provided by various distribution companies in 2009. The 2015 shoulder 90% model was created by decreasing load 10 percent below expected summer peak conditions. Please refer to the Load Forecast section for further details.
- ❑ To simulate a steady state reverse east-west bias power flow, models were developed with 90% load levels, 1700 MW import into ATC, and a 2000 MW transaction from east to west.
- ❑ ATC system biased in an East to West direction, Planning/Operations coordinated 69-kV ratings included.

1.2.2.b.3.f Model years

We started model development for this Assessment by building a system model that represented 2010 summer peak conditions. This 2010 model is referred to as an "as-built" model because essentially everything in the model is certain to be in service by 2010 summer. This model then was modified to create each of the subsequent Assessment study models including the changes previously described for each model.

Computer simulation model years for the 2010 network Assessment analyses were selected in order to meet NERC requirements for a 1-5 year horizon and beyond the 5 year horizon. The years 2011 and 2015 were selected to meet the 1-5 year horizon. The years 2020 and 2025 meet the beyond 5 year horizon. The years 2011, 2015 and 2020 were chosen to coordinate with the most recently released MMWG models that were available.

The 2011, 2015, 2020 and 2025 models were developed to evaluate needs, verify findings of the 2009 Assessment, and confirm that previously identified needs will increase over time. The 2020 and 2025 models reflect years sufficiently forward in time to determine the need for and assess the performance of larger-scale projects (345-kV lines, for example) that could be expected to be in service in that timeframe.

1.2.2.c Dynamic stability/short-circuit assessment models

We conduct transient analyses to evaluate dynamic stability of generators as part of our study of new generation interconnections and voltage stability analysis on portions of the system where severe low voltages are identified. In instances where our stability criteria were not met, remedial projects were devised and included in this Assessment (see System stability).

We also conduct short circuit analyses as part of our study of new generation interconnections to evaluate the adequacy of circuit breakers on the transmission system. In instances where short-circuit duties exceeded existing circuit breaker ratings, plans for circuit breaker replacements have been included in this Assessment.

1.2.3 Needs and solution development

1.2.3.a Steady state project-deficient needs assessment

1.2.3.a.1 System intact and single contingency simulations
ATC performed system intact and single contingency simulations on the 2011, 2015, 2020 and 2025 models. Single contingency simulations include the following: single element (line, transformer, generator, bus and switched shunt) and event-based breaker-to-breaker outages. We run these simulations for summer peak and under the sensitivity situations described in Section 1.2.2.b.3.

1.2.3.a.2 Comparison of results vs. Planning criteria
The models described in Section 1.2.3.a.1 are analyzed and compared to our Planning Criteria. Limits that approach or exceed our criteria are then listed in Tables ZS-1 through ZS-4.

1.2.3.a.3 Reconciliation of significant changes to power flow results
To reconcile changes in power flow results between Assessments, zone planners run data comparisons to determine if constraints identified in prior Assessments have become more severe, less severe, or have been mitigated. Steps are taken to verify topology and other model changes to ensure that the results are consistent with all of the available information.

1.2.3.a.4 Future considerations
In future Assessments, we will continue to communicate needs and solicit solution development options from our stakeholders early in the process.

1.2.3.b Solution development

1.2.3.b.1 New constraint
If a new constraint is found in the initial screening, the zone planner will take steps to ensure that the constraint is valid, including verification of the power flow model. If the new constraint is within the current five-year timeframe, the zone planner will then check for potential delayability, including investigation of operating guides or other mitigation measures.

After all potential mitigation measures for a given constraint or need have been evaluated, system solution options are developed. Potential projects that may resolve identified needs are vetted internally and with our external customers. Each solution option is subject to sufficient evaluation to determine its effect upon the identified constraint. After all discussion and collaboration has concluded, the results of the solution option evaluation are recorded in a project development document.

Cost estimates are requested from the Project Control Office for solution options that effectively address the identified constraint. After cost information has been obtained, the zone planner selects the most efficient solution option from a cost-benefit standpoint and develops a provisional project request form. Finally, the provisional project request form is processed through ATC's Project Approval Process.

1.2.3.b.2 Repeat constraint
If a previously identified constraint is found in our initial screening, the zone planner will re-verify that existing solution options address that constraint. If an in-service date or scope change is warranted, updated cost estimates are requested from the Project Control Office. The project request form is then updated with the revised in-service date, cost, scope, and/or justification. The updated project request form is then resubmitted through ATC's Project Approval Process.

1.2.3.b.3 Unspecified Network Project (Placeholder) Process
Unspecified Network Projects are defined as those projects which may shift into the 10-year timeframe as a result of:

- ❑ Changing load forecast,
- ❑ Changes in generation and distribution interconnection projects,
- ❑ Changes in mandatory reliability or renewable portfolio standards, and/or
- ❑ Additional projects that are driven by economic benefits or multiple outage impacts.

Several million dollars were set aside in ATC's budget in order to address Unspecified Network Projects. ATC's placeholder process begins with internal discussions to determine how to best serve our customers' local and regional needs. In these discussions, we collaboratively determine which projects are likely to be built or incur costs within the 10-year Assessment period. Projects with a 50 percent probability of occurrence or greater are estimated by the Project Control Office. The cost/benefit results are discussed, vetted and approved by our AIM Executive committee. Finally, after consensus is reached, our budget is updated with to include these placeholder dollars.

1.2.3.c All Projects assessment
After the 10-Year Assessment analysis is completed, models are built that include all planned, proposed, and some provisional projects. These models are called "All Projects" models and are more indicative of the expected system configurations for 2011, 2015 and 2020 study years. These models are more appropriate for internal planning studies performed throughout the year.

As part of the 10-Year Assessment, zone planners perform a contingency analysis on each of the "All Projects" models. The contingency analysis includes systematically removing each line, generator, transformer, switched shunt and modeled bus ties individually to determine the affect on the transmission system. The analysis will verify whether all of the

planned, proposed, and provisional projects will resolve issues revealed in the Assessment process.

The zone analysis discussions presented in this Assessment provides a list of reinforcements that are beginning to optimize our reinforcement plans, at least at the one- or maybe two-zone level. Three important questions regarding this plan include the following:

- ❑ How do the reinforcements for all the zones perform together?
- ❑ Does applying a solution in one zone create a problem that was not seen before in another zone?
- ❑ Are some zone solutions redundant when all the solutions are applied to the system?

As we did in the 2009 Assessment, this year we attempted to address the first two questions. We built year 2011, 2015 and year 2020 models that included reinforcements reflecting our best thoughts on all of the most likely planned, proposed, and provisional projects to address the identified issues. These projects are those identified in the project tables for this Assessment with specific in-service dates. First contingency analysis was performed on these new models, including selected outages on neighboring systems. This analysis showed that the reinforcements in total did indeed deal with the issues identified and did not create any new issues to be resolved. Please refer to the All Projects section for details of our analyses.

1.2.3.d Stability review & analysis

1.2.3.d.1 System angular stability assessment

For each 10-Year Assessment, generator stability is screened or assessed at all major generating stations connected to the ATC system. Numerous generator interconnection studies add to our knowledge of the ATC system stability response to selected Category B2, C3 and D2 outages that constitute the worst case scenarios for stability perspective. A MRO/RFC joint on-site review completed in December 2008 determined that ATC was fully complaint with NERC Standards that cover multiple outages (Category C), including the system's stability response to multiple outages.

In the 2010 10-Year Assessment, we revisited a select list of generator stations as described below, conducting simulations by applying NERC Standards for categories B2, C3 and D2 using the 2015 Light Load All Project model. As generator stability concerns arise they are evaluated and appropriate corrective actions are developed and implemented. Generator stations with total net output above 100 MW and associated transmission lines operating above 100 kV are generally selected to assess system angular stabilities.

The methodology used in screening or assessing the major generator stations includes a review to determine that no significant system topological changes have occurred near the generator stations other than local load growth. In addition, the methodology includes a review of the parameter values and the model types used to represent the dynamic response of the units at the generator stations in system angular stability simulations to determine that no significant changes have occurred. This methodology also includes a review of the date the last time a stability study was conducted for a major generator station to determine that the elapsed time does not exceed five years. Considering the number of existing major generator stations shown in Table ZS-7 - ATC System Angular Stability Assessment this requires that at least six major generator stations be included in the system angular stability analysis for each 10-Year Assessment in order to complete a study of all major generator stations in a 5-year sequence.

If these criteria are confirmed, the generator stability results of the previous existing studies remain applicable and are acceptable for the following years with proposed system upgrades. If any of these criteria are not met then the generator stability is screened or restudied, and the preliminary needs and results of the analyses are communicated to our stakeholders. Please refer to System stability analysis for more details.

1.2.3.d.2 System voltage stability assessment
ATC is still developing a rigorous process for assessing voltage stability across the system. Currently we monitored single and multiple contingency voltages for the Rhinelander area which was started in the 2009 10-Year Assessment using the 2008, 2009, and 2013 summer peak all project system models to screen for indications of where voltage stability may be an issue. Additional studies will need to be conducted since the load breakdown data by customer class supplied changed significantly from what had historically been provided and because of the results obtained for some of the NERC C3 contingencies will require additional analysis. We then compare the stability performance against our Planning criteria, document the preliminary needs and results, and communicate those results to our stakeholders.

The MRO/RFC joint on-site review completed in December 2008 determined that ATC was fully compliant with the voltage stability assessment requirements in the applicable NERC standards. Please refer to System stability analysis for more details.

1.2.3.e Multiple outage review & analysis

1.2.3.e.1 Overview
ATC's steady-state multiple outage assessment started with Commonwealth Associates (CAI) performing more extensive analysis of our transmission system in 2004 to identify NERC Category C type contingencies that potentially could lead to cascading. Since then, we have taken this initial screening and enhanced our review in succeeding years.

1.2.3 e.2 Model development
For the 2010 work, ATC used the 2015 and 2020 summer peak models with 95% Q_{max} including all projects identified in the 10-Year Assessment for additional steady state multiple outage analysis. Physical Operational Margin (POM)-Optimal Mitigation Measure (OPM) software was used to determine available mitigation measures that could be used to alleviate identified system constraints that could potentially cause problems. The mitigation measures used were generation re-dispatch, generator reactive power re-dispatch, transformer under load tap changing, capacitor bank adjustment, phase shifter angle adjustment and load-shedding.

1.2.3.e.3 Contingencies studied
NERC Category C contingencies are specific sets of multiple outages including lines, transformers and generators. For this Assessment, we revisited Category C event analysis by evaluating the existing severe multiple outages list, which included:

- 43 multiple outages selected and tested in 2005 studies,
- 16 breaker failure (NERC Category C2) multiple outages selected from 2009 studies,
- 4 bus section (NERC Category C1) multiple outages selected from 2009 studies,
- 30 selected contingencies from Zone 3,
- 5 selected contingencies from Zone 5, and
- 30 selected contingencies from Zone 1 identified in the 2009 studies.

In addition to the above selected multiple outages, 15 selected outages that resulted from new projects in the 2020 model were tested.

In addition to the re-evaluation of previously defined multiple outages, in 2010 we performed additional Category C analyses by screening all 345-kV branches and generators connected to the bulk electric system and all ties into our service territory (100 kV and above). Furthermore, we performed detailed Category C analyses for ATC planning Zones 2 and 4 for 100 kV and above and generators connected to the bulk electric system.

1.2.3.e.4 Contingency types
As part of these analyses, several contingency types are identified. They are as follows:

- C3: N-1-1, combination of transmission lines, transformers and/or generators,
- C5: N-2, two circuits on a common tower,
- C2: Breaker (failure or internal fault), and
- C1: Bus section.

1.2.3.e.5 Contingency thresholds
The screening thresholds are identified as follows:

- Generators connected to Bulk Electric System,
- Voltage level of 100 kV and above for transmission lines,
- Transformer size ≥100 kV, both high and low voltage sides,
- Monitored buses: 69 kV and above, and
- Severe outages: outages that cause system constraints that require loss of load to mitigate in addition to other non load shed remedial actions.

1.2.3.e.6 Contingency analysis
Our contingency analysis was performed by carrying out a full analysis for both the 2015 and the 2020 summer peak models. In addition to the selected multiple outages applied to the 2015 model, multiple outages resulting from new projects were tested using the 2020 model. For both 2015 and 2020 models, a full analysis of ATC Zone 2 and Zone 4 was performed.

1.2.3 e.7 Contingency results
Our results consist of lists of contingencies resulting in thermal constraints, voltage constraints, and voltage stability constraints. Also available are simulation results of available mitigation measures, as estimated by POM-OPM software that can be employed to alleviate identified system constraints. Please refer to Multiple Outages for the results of our analyses.

1.2.4 Documentation

1.2.4.a Writing/approval processes
The 10-Year Assessment is written and developed by several contributors. The following steps are performed in order to ensure cohesive, consistent information:

- ❑ Requests are made for the latest financial, environmental, demographics, asset renewal and economics information from other ATC departments.
- ❑ Drafts of each section's text, figures and tables are compiled for peer review.

- ❑ A comprehensive meeting is held with all Planning and Asset Renewal managers and team leaders in order to review and approve the information.
- ❑ A summary presentation of all Assessment information is reviewed and approved by ATC management.

Once the information has been approved by all parties, the hard copy Summary Report and Zone Summaries are printed and distributed, and the Full Report text is posted at www.atc10yearplan.com.

Table PF-1
Projects included in the 2011 10-Year Assessment Model

System additions	Planning zone
Construct Crane Creek G551 wind farm	1
Construct Brandon-Fairwater 69-kV line	1
Rebuild Arpin-Rocky Run 345-kV line	1
Construct MEWD CT G588 generator	1
Uprate P-120 Hume-Arpin 115-kV line	1
Construct Green Lake wind farm G376	1
Construct ACEC Badger West T-D 138-kV Substation	1
Construct Warrens T-D 69-kV Substation	1
Uprate Chandler-Delta # 2 69-kV line to 167 degrees	2
Construct ring bus at the Pine River 69-kV Substation and replace 1-5.4 MVAR capacitor bank with 2-4.08 MVAR banks	2
Install one 8.16 MVAR 138-kV capacitor bank at Hiawatha Substation	2
Install one 4.08 MVAR 138-kV capacitor bank at Osceola Substation	2
Uprate Chandler-Delta # 1 69-kV line to 167 degrees	2
Uprate Chandler-Lakehead Tap-Masonville 69 kV line to 167 degrees	2
Uprate Autrain 69-kV line to 293 Amps all season	2
Uprate Winona-M38 138-kV line to 125 degrees	2
Install a 4.08 MVAR 69-kV capacitor bank at the L'Anse Substation	2
Construct Centennial T-D 69-kV Substation	2
Uprate Forsyth-Munising 138 kV line to 200 degrees	2
Install Iron Grove 138/69-13.8 kV transformer	2
Install 2-8.16 MVAR 69-kV capacitor banks at Indian Lake Substation	2
Tap new Sun Valley 69-kV T-D Substation into the Y-119 Verona-Oregon line	3
Rebuild Hillsboro-Dayton 69-kV line	3
Construct 138-kV line from Oak Ridge to Verona with a 138/69 kV transformer at Verona	3
Tap Mazomanie West T-D 69-kV Substation into line Y-62	3
Uprate Walworth-North Lake Geneva 69-kV line	3
Construct Paddock-Rockdale 345-kV line	3
Upgrade existing Sheepskin 10.8 MVAR capacitor bank to 16.2 MVAR	3
Install 2-9.6 MVAR capacitor banks at Dickinson 138-kV Substation	3
Rebuild Verona-Oregon 69 kV line Y-119	3
Uprate Royster-Femrite 69-kV line	3
Install Walnut 69/13.8-kV transformer # 3	3
Uprate Colley Road-Marine 138-kV line	3
Rebuild the Blanchardville-Forward 69-kV line	3
Construct LaMar T-D 69-kV Substation	3
Construct Lafayette wind farm G282	3
Install new Milton DIC T-D 69 kV Substation on the LaMar-Harmony Tap 69 kV line	3
Construct Randolph-EC wind farm G706	3
Construct Bowers Road wind farm G546	3
Install 2-16.33 MVAR 69-kV capacitor bank at Spring Green Substation	3
Construct Beloit Gateway T-D 138-kV Substation	3
Replace Femrite transformer # 4 with a 20 MVA transformer	3

Table PF-1 (continued)
Projects included in the 2011 10-Year Assessment Model

System additions	Planning zone
Construct Schofield T-D 69-kV Substation	3
Tap new Greenleaf T-D Substation into Forest Junction-Rockland 138-kV line	4
Uprate Point Beach-Sheboygan 345-kV line to 167 degrees	4
Tap new SBU Michigan T-D 69 kV Substation into Dunn Road-First Avenue 69-kV line	4
Uprate Cypress-Arcadian 345-kV line to 125 degrees	4
Uprate Point Beach generator #1	4
Construct Stony Brook wind farm G590	4
Install a second 345/138-kV transformer at Kewaunee Substation	4
Uprate Point Beach generator #2	4
Install a second 138/26.2-kV transformer at Maple Substation	5
Rebuild Oak Creek-Root River 138-kV line	5
Install third 345/138-kV transformer at Granville Substation	5
Construct Oak Creek generation (Phase I)	5
Install 2x32.4 MVAR capacitor banks at Summit 138-kV Substation	5
Uprate Bain-Albers 138-kV line	5
Uprate Oak Creek-Nicholson 138-kV line	5
Construct Oak Creek generation (Phase II)	5
Install a second 138-kV parallel underground line from Humboldt terminal to Shorewood Substation	5
Install three new Harbor T-D transformers	5
Install second Pleasant Valley 138/24.9-kV transformer	5
Construct Barland T-D 138-kV Substation on the Ramsey-Norwich 138 kV line	5
Uprate Bain-Kenosha 138-kV line	5
Rebuild/convert Twin Falls-Plains 69-kV double-circuit line to 138/69-kV double-circuit	1 & 2

Table PF-2
*Projects included in the 2015 10-Year Assessment Model**

System additions	Planning zone
Construct Woodmin T-D 115-kV Substation	1
Rebuild Brodhead-South Monroe 69-kV line	3
Construct Southwest Verona T-D 69-kV Substation	3
Construct Hawk T-D 138-kV Substation	3
Construct Rockdale-West Middleton 345-kV line	3
Construct Hanson Road T-D Substation	3
Upgrade West Middleton transformer # 7	3
Construct EcoMet wind farm G611-G927 and related uprates	4
Construct Ledge Wind G773	4
Construct Lake Breeze wind farm G427	4
Install a second T-D transformer at the Tosa 138-kV Substation	5

**Projects included in addition to those listed in Tables PF-1*

Table PF-3
*Projects included in the 2020 10-Year Assessment Model**

System additions	Planning zone
Install second Blackhawk T-D transformer	3

**Projects included in addition to those listed in Tables PF-1 and PF-2*

Table PF-4
*Projects included in the 2025 10-Year Assessment Model**

System additions	Planning zone
None	

**Projects included in addition to those listed in Tables PF-1, PF-2 and PF-3*

Table ZS-1
2011 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2011 Summer Peak Case		2011 90% Load Case		2011 70% Load Case		2011 Minimum Load Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage		
1	Base case loading criteria exceeded	FALSE	--	FALSE	--	FALSE	--	FALSE	--	System Intact	
1	Base case voltage criteria exceeded	--	FALSE	--	FALSE	--	FALSE	--	TRUE	System Intact	
1	Dartford 69-kV bus	--	91.7%	--	--	--	--	--	--	Metomen – Ripon 69-kV line	Marginal voltage, no mitigation needed within this timeframe
1	Petenwell and Council Creek 138-kV buses	--	89.2% 89.2 – 89.8%	--	90.3 – 96.7% 90.1 – 91.2%	--	--	--	--	ACEC Badger West – Saratoga 138-kV line ACEC Badger West – Petenwell 138-kV line	Adjust Council Creek 138/69-kV transformer LTC
1	ACEC Badger West 138-kV bus	--	89.2%	--	90.3%	--	--	--	--	ACEC Badger West – Saratoga 138-kV line	Adjust Council Creek 138/69-kV transformer LTC
1	Necedah, ACEC Dellwood, Friendship, ACEC Friendship and Houghton Rock 69-kV buses	--	87.9 – 91.9% 87.9 – 91.9% 88.9 – 91.9% 90.9 – 91.4%	--	87.9 – 91.9% 88.7 – 91.5% 88.7 – 91.5% 90.0 – 91.4%	--	--	--	--	Petenwell 138/69-kV transformer Petenwell – Big Pond 69-kV line Necedah Tap – Big Pond 69-kV line Necedah Tap – Whistling Wings Tap 69-kV line	Mitigated by generation adjustments
1	Brooks Corner 69-kV bus	--	87.5%	--	88.2%	--	90.2%	--	91.5%	Whitcomb – Deer Trail 69-kV line[4]	Adjust Brooks Corners 69/34.5-kV transformer LTC
1	Arpin 345-kV bus	--	--	--	--	--	--	--	105.4% 110.0%	System Intact Arpin – Rocky Run 345-kV line[1]	Switch Port Edwards 69-kV and McMillan 115-kV capacitors offline
1	Harrison 69-kV bus	--	--	--	--	--	--	--	106.4%	System Intact	Switch Harrison 69-kV capacitor offline
1	Caroline 115-kV bus	--	--	--	--	--	--	--	106.3%	System Intact	Switch area capacitor banks offline and adjust area transformer LTCs
1	Whitcomb 115-kV bus	--	--	--	--	--	--	--	106.0%	System Intact	Switch Birnamwood 69-kV capacitor bank offline and/or corrected Whitcomb transformer modeling
1	Petenwell 138/69-kV transformer	99.0% 95.6%	--	--	--	--	--	--	--	McKenna – Houghton Rock 69-kV line Castle Rock – Quincy ACEC 69-kV line	Mitigated by generation adjustments
1	Vulcan – Port Edwards 138-kV line #1 Vulcan – Port Edwards 138-kV line #2	123.0% 122.8%	--	123.0% 122.8%	--	123.0% 122.8%	--	123.0% 122.8%	--	Port Edwards – Vulcan Chemical 138-kV #2 line Port Edwards – Vulcan Chemical 138-kV #1 line	Change tap on free standing CT's at Port Edwards
2	Base case loading criteria exceeded	FALSE	--	FALSE	--	FALSE	--	FALSE	--	System Intact	
2	Base case voltage criteria exceeded	--	TRUE	--	TRUE	--	TRUE	--	TRUE	System Intact	
2	M38 – Atlantic 69-kV line	116.8 – 121.6%	--	105.0% 105.0% 110.9%	--	--	--	-- --	-- --	M38 – Atlantic 138-kV line Atlantic 138/69-kV transformer M38 – Atlantic 138-kV line[5]	Mitigated by generation adjustments or uprate line
2	Nordic – Mountain 69-kV line	--	--	--	--	96.8% 98.8%	--	--	--	Plains – Arnold 138-kV line Chandler 138/69-kV transformer	Targeted for mitigation by Escanaba area reinforcements

Table ZS-1
2011 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2011 Summer Peak Case		2011 90% Load Case		2011 70% Load Case		2011 Minimum Load Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage		
2	Plains – Arnold 138-kV line	--	--	--	--	95.2%	--	--	--	Dead River 345/138-kV transformers[2]	Targeted for mitigation by Escanaba area reinforcements
2	Straits – McGulpin 138-kV line 9903	97.6%	--	97.6%	--	--	--	--	--	Straits – McGulpin 138-kV line 9901	Targeted for mitigation by Eastern U.P. area reinforcements
2	Pine River – Straits 69-kV line Pine River – Evergreen 69-kV line Evergreen – Straits 69-kV line	--	--	102.4 – 108.8% 102.1 – 108.4% 107.1 – 113.8% 106.7 – 111.9% 105.7 – 111.0%	--	--	--	--	--	Straits – Hiawatha 138-kV line 9902 Straits 138/69-kV transformer Straits – Brevort 138-kV line Brevort – Lakehead 138-kV line Hiawatha – Lakehead 138-kV line	Targeted for mitigation by Eastern U.P. area reinforcements
2	Engadine, Newberry, Newberry Hospital, Roberts, LouPac, Newberry Village, Hulbert and Eckerman 69-kV buses	--	82.9 – 90.7%	--	--	--	--	--	--	Hiawatha – Engadine 69-kV line Engadine – Newberry 69-kV line	Mitigated by generation adjustments
2	Engadine, Newberry, LouPac, Newberry Hospital, Newberry Village, Roberts 69-kV buses	--	--	--	89.4 – 89.9%	--	--	--	--	Hiawatha – Engadine 69-kV line	Mitigated by generation adjustments
2	Engadine, Newberry, Newberry Hospital, Roberts, LouPac, Newberry Village 69-kV buses	--	--	--	89.1 – 89.6%	--	--	--	--	Hiawatha – Engadine 69-kV line[6]	Mitigated by generation adjustments
2	Brevort, Hiawatha and Lakehead 138-kV buses	--	--	--	91.2 – 91.4%	--	--	--	--	Brevort – Straits 138-kV line	Targeted for mitigation by Eastern U.P. area reinforcements
2	Brevort and Lakehead 138-kV buses	--	--	--	91.6 – 91.7%	--	--	--	--	Brevort – Lakehead 138-kV line	Targeted for mitigation by Eastern U.P. area reinforcements
2	Hiawatha 138-kV bus	--	--	--	91.4%	--	--	--	--	Hiawatha – Lakehead 138-kV line	Targeted for mitigation by Eastern U.P. area reinforcements
2	North Bluff, Bay View, Mead, Gladstone, Masonville and Lakehead 69-kV buses	--	90.8 – 91.6%	--	--	--	--	--	--	Chandler 138/69-kV transformer	Mitigated by generation adjustments
2	Chandler, Delta, Escanaba, Masonville, Mead, Gladstone, West, Lakehead, North Bluff, Bay View, Cornell, Harris 69-kV buses	--	--	--	--	--	88.4 – 91.1%	--	--	Chandler 138/69-kV transformer	Mitigated by generation adjustments
2	Ontonagon, Stone Container and Winona 138-kV buses	--	91.3 – 91.7%	--	--	--	91.5 – 91.9%	--	--	M38 – Winona 138-kV line	Mitigated by generation adjustments
2	Straits, St. Ignace, Indian Lake, Evergreen, Valley, Glen Jenks, Manistique, Engadine, Hiawatha, Gould City, Curtis, Rexton, and Blaney Park 69-kV buses and Straits 138-kV bus	--	104.1 – 105.7%	--	--	--	104.2 – 108.0%	--	104.6 – 106.2%	System Intact	Adjust transformer tap settings at Hiawatha, Indian Lake, Straits
2	Hiawatha and Lakehead 138-kV buses	--	--	--	94.2 – 95.2%	--	--	--	105.9 – 106.0%	System Intact	Mitigated by generation adjustments
2	Alger Delta Hiawatha, Sault, Eckerman, Goetzville, Pickford, Rudyard, Newberry Hospital, Newberry Village, Three Mile, Magazine, Kinchloe, Trout Lake, Munising, Alger, Hulbert, Brimley, Dafter, Detour, Engadine, Newberry, Raco, LouPac, Roberts, ESE Hydro, Nine Mile, Pine River, Rockview, Pine Grove, Tone, Talentino 69-kV buses and Brevort 138-kV bus	--	--	--	--	--	--	--	105.0 – 106.5%	System Intact	Mitigated by generation adjustments
2	Lakota Road 69-kV bus	--	--	--	--	--	--	--	119.1%	Lakota Road – Conover 69-kV line	Resolved by transformer model adjustments
2	Lakota Road 115-kV bus	--	--	--	--	--	--	--	110.4%	Eagle River – Cranberry 115-kV line	Mitigated by generation adjustments
2	Atlantic 138-kV bus	--	--	--	--	--	--	--	113.0%	Atlantic – M38 138-kV line	Mitigated by generation adjustments
3	Base Case Loading Criteria Exceeded	FALSE	--	FALSE	--	FALSE	--	FALSE	--	System Intact	
3	Base Case Voltage Criteria Exceeded	--	FALSE	--	FALSE	--	FALSE	--	FALSE	System Intact	

Table ZS-1
2011 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2011 Summer Peak Case		2011 90% Load Case		2011 70% Load Case		2011 Minimum Load Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage		
3	Concord 138-kV bus	--	95.5%	--	--	--	--	--	--	System Intact	Mitigated by generation adjustments
3	Concord, Butler Ridge, and Rubicon 138-kV buses	--	--	--	95.2 – 95.9%	--	--	--	--	System Intact	Mitigated by generation adjustments
3	Butler Ridge and Rubicon 138-kV buses	--	90.9 – 91.4%	--	--	--	--	--	--	Hartford – St. Lawrence 138-kV line	Mitigated by generation adjustments
3	Crawfish River 138-kV bus	--	--	--	91.1%	--	--	--	--	Jefferson – Crawfish River 138-kV line	Mitigated by generation adjustments
3	Crawfish River and Concord 138-kV buses	--	90.5 – 91.7%	--	--	--	--	--	--	Jefferson – Crawfish River 138-kV line	Mitigated by generation adjustments
3	Paddock – Townline 138kV line	--	--	--	--	99.0% 97.1%	--	--	--	NW Beloit – Paddock 138-kV line Blackhawk – NW Beloit 138kV	Mitigated by generation adjustments
3	Hubbard and Hustisford 138-kV buses	--	96% 86.5% 87.1% 87.1% 90.7 – 90.9%	--	95.9% 87.2% 87.7% 87.% --	--	-- -- 87.2% 87.3% --	--	--	System Intact Rubicon – Hustisford 138-kV line Hustisford – Hubbard 138-kV line Rubicon – Hustisford – Hubbard 138-kV line Hartford – St. Lawrence 138-kV line	Adjust Hubbard 138/69-kV transformer LTC
3	Fox Lake, North Beaver Dam and Beaver Dam East 138-kV buses	--	89.2 – 89.3%	--	--	--	--	--	--	North Randolph – Fox Lake 138-kV line	Adjust North Beaver Dam 138/69-kV transformer LTC
3	Fitchburg 138-kV bus	--	--	--	--	--	96.0%	--	--	System Intact	Femrite and Kegonsa 138-kV capacitor banks
3	Huiskamp 138-kV bus	--	--	--	88.6%	--	88.4%	--	--	Huiskamp – North Madison 138-kV line	Adjust Huiskamp 138/69-kV transformer LTC
3	Verona and Fitchburg 138-kV buses	--	--	--	--	--	91.8 – 91.9%	--	--	Columbia generator #1	Femrite and Kegonsa 138-kV capacitor banks
3	Nelson Dewey 161/138-kV transformer	--	--	--	--	95.6% 95.4%	--	--	--	CE Byron generator #1 CE Byron generator #2	Mitigated by generation adjustments
3	Nelson Dewey – Cassville 161-kV line	--	--	--	--	99.6% 95.8%	--	--	--	DPC Genoa generator #3 Columbia generator #2	DPC line limitation / further study needed
3	Fitchburg – Syene 69-kV line	104.9%	--	95.3%	--	--	--	--	--	Royster – AGA Tap 69-kV line	Short term Operating Guide / Nine Springs, Pflaum area project
3	Royster – AGA Gas Tap 69-kV line	103.0%	--	--	--	--	--	--	--	Fitchburg – Syene 69-kV line	Short term Operating Guide / Nine Springs, Pflaum area project
3	Verona 138-kV bus	--	95.7% 90.2%	--	-- 90.2%	--	--	--	-- 114.8%	System Intact Verona – Oak Ridge 138-kV line	Adjust Verona 138/69-kV transformer LTC / Verona 69-kV capacitor bank project
3	Fitchburg, Cross County, Oak Ridge and Pleasant View 138-kV buses	--	95.3 – 95.9%	--	--	--	--	--	--	System Intact	Femrite and Kegonsa 138-kV capacitor banks
3	Verona, Oak Ridge, Pleasant View, Cross Country, Pleasant View, and Fitchburg 138-kV buses	--	--	--	95.0 – 95.9%	--	--	--	--	System Intact	Femrite and Kegonsa 138-kV capacitor banks
3	REC Harmony, Milton Tap and Milton 69-kV buses	--	91.9 – 92.0%	--	--	--	--	--	--	McCue – Harmony 69-kV line	Lamar 69-kV capacitor bank project
4	Base case loading criteria exceeded	FALSE	--	FALSE	--	FALSE	--	FALSE	--	System Intact	
4	Base case voltage criteria exceeded	--	TRUE	--	FALSE	--	FALSE	--	TRUE	System Intact	
4	Badger & Belle Plaine 115-kV buses	--	105.0%	--	--	--	--	--	106.4%	System Intact	Switch Badger 138-kV capacitor banks offline
4	East Krok 138/69-kV transformer	103.2%	--	103.1%	--	98.1%	--	--	--	Canal – East Krok 138-kV line	No project needed Investigation into limiting facility resulted in higher facility ratings
4	Sunset Point – Pearl Avenue 69-kV line	108.2% 107.8%	--	97.1% 97.0%	--	--	--	--	--	Ellinwood 138/69-kV transformer[3] Ellinwood – 12th Avenue 69-kV line	Rebuild line
4	Morgan – Falls 138-kV line	--	--	--	--	105.7%	--	--	--	Morgan – Plains 345-kV line	Mitigated by generation adjustments
4	White Clay 138-kV 1-2 bus tie	--	--	--	--	96.0%	--	--	--	Morgan – Highway 22 345-kV line	Further study needed
4	North Appleton, Apple Hills, Maes, Combined Locks tap & City Limits 138-kV buses	--	--	--	--	--	--	--	104.1 – 105.3%	System Intact	Switch off area capacitor banks

Table ZS-1
2011 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2011 Summer Peak Case		2011 90% Load Case		2011 70% Load Case		2011 Minimum Load Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage		
4	Werner West, Werner & Hintz 138-kV buses	--	--	--	--	--	--	--	105.4 – 105.5%	System Intact	Switch off area capacitor banks
4	City Limits, Lake Park & Forest Junction 138-kV buses	--	--	--	--	--	--	--	104.1 – 105.1%	System Intact	Switch off area capacitor banks
4	Butte des Morts, Northside, Tayco, Melissa, Meadows Kaukauna Central tap & Forest Junction 138-kV buses	--	--	--	--	--	--	--	104.2 – 105.1%	System Intact	Switch off area capacitor banks
4	Kaukauna Central tap, Kaukauna Central, Kaukauna North & North Appleton 138-kV buses	--	--	--	--	--	--	--	104.9 – 105.3%	System Intact	Switch off area capacitor banks
4	Glenview 138-kV bus	--	--	--	--	--	--	--	105.1%	System Intact	Switch off area capacitor banks
5	Base Case Loading Criteria Exceeded	FALSE	--	FALSE	--	FALSE	--	FALSE	--	System Intact	
5	Base Case Voltage Criteria Exceeded	--	TRUE	--	TRUE	--	FALSE	--	TRUE	System Intact	
5	Bluemound 230-kV bus, Allerton, Bark River, Brookdale, Cooney, Cottonwood, Germantown, Hartford, Maple and Summit 138-kV buses	--	94.5 – 96.0%	--	--	--	--	--	--	System Intact	Mitigated by generation adjustments
5	Bluemound 230-kV bus, Bark River, Cooney, Cottonwood, Germantown, Hartford, Mukwonago, Maple and Summit 138-kV buses	--	--	--	94.5 – 95.9%	--	--	--	--	System Intact	Mitigated by generation adjustments
5	Montana, Barland, Valley, Racine, Dewey, Albers, Allerton, Branch, Center, Everett, Fiebrantz, Hayes, Harbor, Haymarket, Kansas, Kenosha, Lincoln, Nicholson, Norwich, Oak Creek, Parkhill, Pennsylvania, Racine, Ramsey, St. Rita, 28th St, and Somers 138-kV buses	--	--	--	--	--	--	--	105.0 – 105.8%	System Intact	Mitigated by generation adjustments
5	Germantown 138-kV bus	--	91.3%	--	--	--	--	--	--	Germantown – Maple 138-kV line	Mitigated by generation adjustments
5	Bark River and Germantown 138-kV buses	--	91.6 – 91.7%	--	--	--	--	--	--	Bark River – Sussex 138-kV line	Mitigated by generation adjustments
5	Bark River, Cottonwood and Germantown 138-kV buses	--	--	--	91.5 – 91.9%	--	--	--	--	Bark River – Sussex 138-kV line	Mitigated by generation adjustments
5	Hartford 138-kV bus	--	90.4%	--	91.9%	--	--	--	--	Hartford – St. Lawrence 138-kV line	Mitigated by generation adjustments
5	Maple, Germantown, Bark River, and Cottonwood 138-kV buses	--	85.8 – 91.6%	--	--	--	--	--	--	Maple – Saukville 138-kV line	Mitigated by generation adjustments
5	Maple and Germantown 138-kV buses	--	--	--	88.7 – 89.1%	--	--	--	--	Maple – Saukville 138-kV line	Mitigated by generation adjustments
5	Bain 345/138-kV transformer #5	159.5% 113.6%	--	159.2% --	--	146.9% --	--	146% --	--	Split Pleasant Prairie 345-kV bus 34 Split Pleasant Prairie 345-kV bus 23	Mitigated by generation adjustments
5	Oak Creek 345/230-kV transformer T895	104.7% 103.4%	--	104.7%	--	--	--	--	--	Split Oak Creek 230-kV bus 78 Split Oak Creek 230-kV bus 67	Mitigated by generation adjustments
5	Arcadian4 – Waukesha1 138-kV line	107.1%	--	131.1%	--	115.0%	--	--	--	Arcadian6 – Waukesha3 138-kV line	Rebuild line
5	Arcadian6 – Waukesha3 138-kV line	110.8%	--	126.7% 111.3%	--	111.2% 99.8%	--	--	--	Arcadian4 – Waukesha1 138-kV line Split Waukesha 138-kV bus 12	Rebuild line
5	Arcadian 345/138-kV transformer #3	101.5%	--	109.9% 105.8%	--	100.3%	--	--	--	Arcadian 345/138-kV transformer #1 Split Arcadian 345-kV bus 12	Replace transformer
5	Arcadian 345/138-kV transformer #2	--	--	101.8% 97.5%	--	--	--	--	--	Arcadian 345/138-kV transformer #1 Split Arcadian 345-kV bus 12	Replace transformer
5	Albers – Kenosha 138-kV line	--	--	102.5%	--	116.0%	--	--	--	Albers – Bain 138-kV line	Mitigated by generation adjustments
5	Waukesha 138-kV bus 12	--	--	98.2%	--	--	--	--	--	Arcadian6 – Waukesha3 138-kV line	Mitigated by generation adjustments
5	Harbor – Kansas 138-kV line	--	--	102.1% 97.4% 97.3% -- -- --	--	108.7% 99.4% 106.3% 106.4% 105.4% 102.4%	--	--	--	Kansas – Norwich 138-kV line Harbor – Norwich 138-kV line Split Dewey 138-kV bus Dewey – Norwich 138-kV line Montana – Dewey 138-kV line Montana – Valley 138-kV line	Mitigated by generation adjustments
5	Granville – Rangeline 138-kV line	--	--	101.2%	--	--	--	--	--	Cornell – Granville 138-kV line	Mitigated by generation adjustments

Table ZS-1
2011 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2011 Summer Peak Case		2011 90% Load Case		2011 70% Load Case		2011 Minimum Load Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage		
5	Oak Creek – Ramsey 138-kV line	--	--	102.1% 101.3% 100.5% 100.0% 97.4%	--	--	--	--	--	Valley generator #1 Edgewater generator #5 Oak Creek – Pennsylvania 138-kV line Edgewater generator #4 System Intact	Mitigated by generation adjustments
5	Edgewood – St. Martins 138-kV line	--	--	--	--	99.9%	--	--	--	Merrill Hills – Waukesha 138-kV line	Mitigated by generation adjustments

Table ZS-1_2011 constraints

Definition of Event Based Contingencies to be included in Appendix:	
1	Arpin - Rocky Run 345-kV line + Port Edwards - Sand Lake 138-kV line + Port Edwards - Hollywood 138-kV line + Council Creek - Council Creek DPC 69-kV line
2	Dead River 345/138-kV xfmr #1 and Dead River 345/138-kV xfmr 1A
3	Ellinwood 138/69 kV xfmr #1 + Ellinwood - Twelfth Ave 69 kV circuit + Ellinwood - Fitzgerald 138 kV circuit +Ellinwood 138 kV bus tie 1-2
4	Whitcomb - CWEC Wittenberg Tap - Wittenberg Tap - Birnamwood Tap - Brooks Corner - Deer Trail 69-kV line
5	M38 – Atlantic 138-kV line + Atlantic 138/69-kV transformer
6	Hiawatha-Engadine 69-kV line + Hiawatha 138/69-kV transformer

Table ZS-2
2015 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2015 Summer Peak Case		2015 70% Load Case		2015 90% Load Case		2015 105% Load Case		2015 High Wind		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage		
1	Base case loading criteria exceeded	TRUE	--	FALSE	--	FALSE	--	TRUE	--	FALSE	--	System Intact	
1	Base case voltage criteria exceeded	--	FALSE	--	FALSE	--	TRUE	--	FALSE	--	FALSE	System Intact	
1	Silver Lake, ACEC Spring Lake, Redgranite, Fountain Valley and River Run 69-kV buses	--	89.5 – 91.6% 91.3 – 91.7% -- --	--	--	--	--	--	88.2 – 91.5% 90.0 – 91.7% 91.1 – 91.9% 91.2 – 91.4%	--	--	Wautoma – Silver Lake Tap 69-kV line Silver Lake – ACEC Spring Lake 69-kV line ACEC Spring Lake – Redgranite 69-kV line Metomen – Ripon 69-kV line	Adjust Sunset Point 138/69-kV transformer LTCs
1	Dartford,Ripon Industrial Park, Northwest Ripon and Ripon 69-kV buses	--	89.0 – 89.7% 90.3 – 91.4%	--	--	--	--	--	87.9 – 89.5% 89.4 – 91.0% 91.2% 91.4% 92.0%	--	--	Metomen – Ripon 69-kV line Ripon – Northwest Ripon Tap 69-kV line Wautoma – Silver Lake Tap 69-kV line Northwest Ripon Tap – Dartford Tap 69-KV line Silver Lake – ACEC Spring Lake 69-KV line	Ripon Capacitor Expansion Project
1	Winneconne, Omro and Omro Industrial Park 69-kV buses	--	91.1 – 91.6%	--	--	--	--	--	90.0% – 90.6%	--	--	Winneconne – Sunset Point 69-kV line	Marginal voltage, no mitigation needed within this timeframe
1	ACEC Brooks and Grand Marsh (PP&L) 69-kV buses	--	--	--	--	--	--	--	91.9% – 92.0% 92.0%	--	--	Necedah Tap – Big Pond 69-kV line Petenwell – Big Pond 69-kV line	Marginal voltage, no mitigation needed within this timeframe
1	Petenwell and Council Creek 138-kV buses	--	95.7% 88.2 – 89.4% 88.2 – 89.4% 88.3 – 89.5% 90.6 – 90.7%	--	91.6% 91.6% 91.7%	--	89.6 – 90.8% 89.5 – 90.8% 89.6 – 90.8%	--	95.8 – 95.9% 87.7 – 88.9% 87.7 – 88.9% 87.8 – 89.0% 90.4 – 90.6%	--	--	System Intact ACEC Badger West – Petenwell 138-kV line Saratoga – Petenwell 138-kV line[1] ACEC Badger West – Saratoga 138-kV line Arpin – Rocky Run 345-kV line[2]	Adjust Council Creek 138/69-kV transformer LTC
1	Necedah, Petenwell, Big Pond, ACEC Dellwood, Friendship, Houghton Rock and McKenna 69-kV buses	--	84.9 – 91.1% 84.9 – 91.1% 85.2 – 91.3% 88.8 – 91.8%	--	90.8% – 91.6% 90.8% – 91.6% 90.7% – 91.6%	--	86.8% – 91.0% 86.8% – 91.0% 86.7% – 91.0% 89.9% – 91.7%	--	84.1 – 90.5% 84.0 – 90.5% 84.0 – 90.4% 88.2 – 91.2%	--	91.5% – 91.6% 91.5% – 91.6% 91.5% – 91.6%	Petenwell 138/69-kV transformer Petenwell – Big Pond 69-kV line Necedah Tap – Big Pond 69-kV line Necedah Tap – Whistling Wings Tap 69-kV line	McKenna Capacitor Expansion Project
1	Okee 69-kV bus	--	--	--	--	--	--	--	91.7%	--	--	Dane – Lodi Tap 69 kV line	Marginal voltage, no mitigation needed within this timeframe
1	ACEC Coloma 69-kV bus	--	--	--	--	--	--	--	91.6%	--	--	Chaffee Creek – Coloma Tap 69-kV line	Marginal voltage, no mitigation needed within this timeframe
1	Brooks Corner 69-kV bus	--	87.4%	--	89.5%	--	87.8%	--	87.5%	--	89.7%	Whitcomb – Deer Trail 69-kV line[3]	Adjust Brooks Corners 69/34.5-kV transformer LTC
1	Badger West 138-kV bus	--	88.3%	--	91.7%	--	89.6%	--	87.7%	--	--	ACEC Badger West – Saratoga 138-kV line	Adjust Council Creek 138/69-kV transformer LTC
1	Arrowhead 345-kV bus	--	--	--	--	--	105.0%	--	--	--	--	System Intact	Switch Arrowhead 230-kV capacitor bank offline
1	Petenwell 138/69-kV transformer	103.3% 111.4% 108.7% 107.0% 105.9% 104.8 – 98.2%	--	--	--	100.9%	--	105.5% 116.7% 111.1% 107.5% 107.6% 108.0 – 102.6%	--	--	--	System Intact McKenna – Houghton Rock 69-kV line Castle Rock – Quincy ACEC 69-kV line McKenna – Quincy ACEC 69-kV line Castle Rock – McKenna 69-kV line Plus other less severe contingencies	Replace Petenwell transformer
1	Castle Rock – ACEC Quincy 69-kV line	104.8% 104.7% 104.6%	--	--	--	--	--	107.9% 107.9% 107.9%	--	--	--	Petenwell 138/69-kV transformer Petenwell – Big Pond 69-kV line Necedah Tap – Big Pond 69-kV line	Uprate Castle Rock – McKenna 69-kV line

Table ZS-2
2015 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2015 Summer Peak Case		2015 70% Load Case		2015 90% Load Case		2015 105% Load Case		2015 High Wind		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage		
1	ACEC Quincy – McKenna 69-kV line	98.3% 98.2% 98.2%	--	--	--	96.0% 96.0% 96.0%	--	101.1% 101.1% 101.1%	--	--	--	Petenwell 138/69-kV transformer Petenwell – Big Pond 69-kV line Necedah Tap – Big Pond 69-kV line	Uprate Castle Rock – McKenna 69-kV line
1	Mauston – Hilltop 69-kV line	--	--	--	--	--	--	--	--	99.3%	--	Arpin – Rocky Run 345-kV line[2]	Marginal issue, no mitigation needed within this timeframe
1	Saratoga – ACEC Badger West 138-kV line	--	--	--	--	--	--	96.9% 96.5% 96.4%	--	--	--	Eau Claire – Arpin 345 kV line[4] King – Arpin 345-kV line[22] King – Eau Claire 345 kV line[5]	Marginal issue, no mitigation needed within this timeframe
1	Caroline 115/69-kV transformer	95.9%	--	--	--	--	--	101.2%	--	--	--	Whitcomb 115/69-kV transformer	Marginal issue, no mitigation needed within this timeframe
1	Chaffee Creek – Coloma Tap 69-kV line	95.0%	--	--	--	--	--	100.7%	--	--	--	Petenwell 138/69-kV transformer	Marginal issue, no mitigation needed within this timeframe
1	Harrison 138/69-kV transformer	99.8%	--	--	--	--	--	102.7%	--	--	--	System Intact	Replace Harrison transformer
1	Metomen 138/69-kV transformer	96.3%	--	--	--	--	--	106.1% 104.6%	--	--	--	System Intact North Fond du Lac 138/69-kV transformer #3[6]	Adjust Metomen 138/69-kV transformer LTC
1	Northwest Ripon – Ripon 69-KV line	--	--	--	--	--	--	95.9%	--	--	--	Winneconne – Sunset Point 69-kV line	Marginal issue, no mitigation needed within this timeframe
1	Sigel – Auburndale 69-kV line	95.4%	--	--	--	--	--	101.1%	--	--	--	System Intact	Higher ratings -- validated
1	Vulcan – Port Edwards 138-kV line #2 Vulcan – Port Edwards 138-kV line #1	123.2% 123.0%	--	123.2% 123.0%	--	122.9% 122.9%	--	123.1% 122.9%	--	123.1% 122.9%	--	Port Edwards – Vulcan Chemical 138-kV #1 line Port Edwards – Vulcan Chemical 138-kV #2 line	Change tap on free standing CT's at Port Edwards
2	Base case loading criteria exceeded	TRUE	--	FALSE	--	FALSE	--	FALSE	--	FALSE	--	System Intact	
2	Base case voltage criteria exceeded	--	TRUE	--	TRUE	--	TRUE	--	TRUE	--	TRUE	System Intact	
2	M38-Atlantic 69-kV line	115.0% – 119.8%	--	--	--	-- -- 108.6%	--	122.2% 122.2% 122.4%	--	--	--	M38 – Atlantic 138-kV line Atlantic 138/69-kV transformer M38 – Atlantic 69-kV line[23]	Mitigated by generation adjustments or uprate line
2	Straits – McGulpin 138-kV line 9901 Straits – McGulpin 138-kV line 9903	--	--	--	--	97.7%	--	--	--	--	--	Straits – McGulpin 138-kV line 9903 Straits – McGulpin 138-kV line 9901	Targeted for mitigation by Eastern U.P. area reinforcements
2	Lakota Road 69-kV bus	--	--	--	--	--	118.1%	--	--	--	118.1%	Lakota Road – Conover 69-kV line	Resolved by transformer model adjustments
2	Brevort, Hiawatha and Lakehead 138-kV buses	--	--	--	--	--	90.8 – 91.0%	--	--	--	--	Straits 138/69-kV transformer	Targeted for mitigation by Eastern U.P. area reinforcements
2	Engadine, Newberry, Newberry Hospital, Roberts, LouPac, Newberry Village, Hulbert and Eckerman 69-kV buses	--	74.6 – 91.9%	--	--	--	84.8 – 90.4%	--	61.9 – 73.3% 80.9 – 86.9%	--	--	Hiawatha – Engadine 69-kV line Engadine – Newberry 69-kV line	Mitigated by generation adjustments
2	Brimley, Goetzville, Pickford, Raco, Magazine and Talentino 69-kV buses	--	--	--	--	--	--	--	79.0 – 89.9% 79.1 – 89.1%	--	--	Hiawatha – Engadine 69-kV line Engadine – Newberry 69-kV line	Mitigated by generation adjustments
2	North Bluff, Bay View, Mead, Gladstone, Masonville, Lakehead, West Side, Escanaba, Delta, Harris and Chandler 69-kV buses	--	89.6 – 91.8%	--	88.0 – 90.7%	--	--	--	87.5 – 89.8%	--	--	Chandler 138/69-kV transformer	Mitigated by generation adjustments
2	Hulbert, Eckerman, LouPac, Newberry Hospital, Newberry Village and Roberts 69-kV buses	--	--	--	--	--	--	--	87.7 – 91.8%	--	--	Newberry – Newberry Hospital 69-kV line	Targeted for mitigation by Eastern U.P. area reinforcements
2	LouPac, Newberry Village, Roberts 69-kV buses	--	--	--	--	--	--	--	89.7 – 90.1% 89.7 – 90.1%	--	--	Hiawatha – Roberts[24] 69-kV line Newberry Hospital – Roberts 69-kV line	Targeted for mitigation by Eastern U.P. area reinforcements
2	Ontonagon, Stone Container and Winona 138-kV buses	--	91.3 – 91.7%	--	--	--	--	--	--	--	--	M38 – Winona 138-kV line	Mitigated by generation adjustments

Table ZS-2
2015 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2015 Summer Peak Case		2015 70% Load Case		2015 90% Load Case		2015 105% Load Case		2015 High Wind		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage		
2	Straits, St. Ignace, Indian Lake, Evergreen, Valley, Glen Jenks, Manistique, Engadine, Hiawatha, Gould City and Curtis 69-kV buses	--	104.0 – 105.3%	--	105.1 – 105.8%	--	--	--	--	--	104.7 – 105.6%	System Intact	Adjust transformer tap settings at Hiawatha, Indian Lake, Straits
2	Nordic – Mountain 69-kV line	--	--	99.7 – 101.3%	--	--	--	100.9% --	--	--	--	Chandler 138/69-kV transformer Plains – Arnold 138-kV line	Mitigated by generation adjustments
2	Rudyard – Pine River 69-kV line Rudyard – Tone 69-kV line Kinchloe – Tone 69-kV line	--	--	--	--	--	--	100.0 – 100.1% 103.3 – 103.4% 97.2 – 97.3%	--	--	--	Hiawatha – Engadine 69-kV line Engadine – Newberry 69-kV line	Mitigated by generation adjustments
2	Hiawatha 138-kV bus	--	--	--	--	--	94.5%	--	--	--	--	System Intact	Targeted for mitigation by Eastern U.P. area reinforcements
2	Straits 69-kV bus	--	--	--	--			--	105.1%	--	--	System Intact	Targeted for mitigation by Eastern U.P. area reinforcements
2	Pine River – Straits 69-kV line Pine River – Evergreen 69-kV line Straits – Evergreen 69-kV line	--	--	--	--	101.4 – 105.2% 101.0 – 104.8% 106.5 -110.5%	--	--	--	--	--	Hiawatha – Straits[25] 138-kV line Straits 138/69-kV transformer	Targeted for mitigation by Eastern U.P. area reinforcements
3	Base case loading criteria exceeded	FALSE	--	FALSE	--	FALSE	--	FALSE	--	FALSE	--	System Intact	
3	Base case voltage criteria exceeded	--	FALSE	--	FALSE	--	FALSE	--	FALSE	--	FALSE	System Intact	
3	Dane – Lodi Tap 69-kV line	--	--	--	--	--	--	98.6%	--	--	--	Island Street – Kirkwood 69-KV line	Marginal issue, no mitigation needed within this timeframe
3	Lake Geneva, Katzenberg, Twin Lakes, and South Lake Geneva 69-kV buses	--	88.6 – 90.2%	--	--	--	--	--	--	--	--	North Lake Geneva – Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Cobblestone 69-kV bus	--	91.4%	--	--	--	--	--	91.2%	--	--	Cobblestone – Brick Church 69-kV line	North Lake Geneva – South Lake Geneva 138-kv line
3	Concord, Brick Church, Williams Bay and Fort Atkinson 138-kV buses+B73	--	--	--	95.6 – 95.9%	--	95.9%	--	--	--	--	System Intact	Marginal voltage, no mitigation needed within this timeframe
3	Lake Geneva 69-kV bus	--	--	--	--	--	91.8%	--	86.6%	--	--	North Lake Geneva – Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kv line
3	Beloit Gateway 138-kV bus	--	--	--	--	--	91.6%	--	--	--	--	Beloit Gateway – Dickinson 138-kV line	Marginal voltage, no mitigation needed within this timeframe
3	Katzenberg, Twin Lakes, and South Lake Geneva 69-kV buses	--	--	--	--	--	--	--	87.6 – 88.3%	--	--	North Lake Geneva – Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Concord 138-kV bus	--	--	--	95.9% --	--	95.4% 91.7%	--	--	--	--	System Intact Jefferson – Crawfish River 138-kV line	Marginal voltage, no mitigation needed within this timeframe
3	Brick Church 138-kV bus	--	--	--	95.6% --	--	95.6% 91.9%	--	--	--	--	System Intact Beloit Gateway – Dickinson 138-kV line	Marginal voltage, no mitigation needed within this timeframe
3	Crawfish River 138-kV bus	--	--	--	--	--	90.7%	--	--	--	--	Jefferson – Crawfish River 138-kV line	Marginal voltage, no mitigation needed within this timeframe
3	Butler Ridge 138-kV bus	--	--	--	--	--	95.9% 91.8%	--	--	--	--	System Intact Hartford – St. Lawrence 138-kV line	Marginal voltage, no mitigation needed within this timeframe
3	Williams Bay, Bristol, Delavan, SW Delavan, Brick Church and Elkhorn 138-kV buses	--	--		91.3 – 91.9%	--	--	--	--	--	--	Wempletown – Paddock 345-kV line	Marginal voltage, no mitigation needed within this timeframe

Table ZS-2
2015 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2015 Summer Peak Case		2015 70% Load Case		2015 90% Load Case		2015 105% Load Case		2015 High Wind		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage		
3	Beloit Gateway, BOC Gas, NW Beloit, RC9, Williams Bay, Bristol, Delavan, West Darien, RC2, Sunrise, Venture, Tichigan, EL&W, Sugar Creek, Burlington, Whitewater, SW Delavan, Rock River, Blackhawk, Paddock, Colley Road, Dickinson, Marine, Brick Church, North Lake Geneva, Elkhorn, Janesville, Russell, McCue, Viking, Townline, Wilcox, Kennedy, Tripp, Air Liquide, University, Bluff Creek, Lakehead-Delavan 138-kV buses	--	--	--	87.8 – 91.8%	--	--	--	--	--	--	Paddock 345/138-kV transformer	Further study needed
3	Beloit Gateway, BOC Gas, NW Beloit, RC9, Williams Bay, Bristol, Delavan, West Darien, RC2, Venture, SW Delavan, Rock River, Blackhawk, Paddock, Colley Road, Dickinson, Marine, Brick Church, Townline 138-kV buses	--	--	--	--	--	--	--	--	--	90.9 – 91.9%	Paddock 345/138-kV transformer	Marginal voltage, no mitigation needed within this timeframe
3	Cobblestone – Zenda Tap 69-kV line	105.0%	--	--	--	--	--	112.7%	--	--	--	North Lake Geneva – Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Colley Road 138/69-kV transformer	96.9%	--	--	--	--	--	100.2%	--	--	--	Paddock 138/69-kV transformer	Marginal issue, no mitigation needed within this timeframe
3	Katzenberg – Zenda Tap 69-kV line	95.3%	--	--	--	--	--	102.2%	--	--	--	North Lake Geneva – Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Paddock – Townline 138-kV line	--	--	102.4% 100.9% 99.9%	--	--	--	--	--	--	--	NW Beloit – Paddock 138-kV line Blackhawk – NW Beloit – Paddock 138-kV line Blackhawk – NW Beloit 138-kv	Mitigated by generation adjustments
3	NW Beloit – Paddock 138-kV line	--	--	97.6%	--	--	--	--	--	--	--	Paddock – Townline 138-kV line	Marginal issue, no mitigation needed within this timeframe
3	Lake Geneva – South Lake Geneva 69-kV line	--	--	--	--	--	--	97.7%	--	--	--	Cobblestone – Brick Church 69-kV line	Marginal issue, no mitigation needed within this timeframe
3	North Monroe – Idle Hour 69-kV line	103.9 – 96.1%	--	--	--	95.4% -- -- -- -- --	--	109.1 – 96.2%	--	--	--	Paddock – Newark 69-kV line Paddock – Brodhead Switching Station 69-kV line[7] Brodhead – Newark 69-kV line Darlington – Gratiot 69-kV line Wiota – Gratiot 69-kV line Darlington 138/69-kV transformer	Bass Creek transformer project
3	McCue – REC Harmony – Milton Tap – Lamar 69-kV line	103.3 – 95.4%	--	--	--	--	--	109.1 – 97.7%	--	--	--	Kegonsa – Stoughton North Tap2 69-kV line Kegonsa 138/69-kV transformer Stoughton North Tap1 – Stoughton North Tap2 69-kV line Stoughton East – Stoughton North 69-kV line	McCue to Lamar line uprate project
3	Sheepskin – Dana 69-kV line	--	--	--	--	--	--	99.9%	--	--	--	McCue – Lamar 69-kV line	Sheepskin terminal upgrade
3	Boscobel – Wauzeka – Gran Grae 69-kV line	--	--	--	--	--	--	98.0 – 96.4%	--	--	--	Spring Green 138/69-kV transformer Spring Green – Lone Rock 69-kV line	Gran Grae line uprate project
3	Wauzeka – Gran Grae 69-kV line	95.3%	--	--	--	--	--	--	--	--	--	Spring Green 138/69-kV transformer	Gran Grae line uprate project
3	Timberlane Tap – West Middleton 69-kV line	101.4%	--	--	--	96.9%	--	108.0%	--	--	--	Spring Green 138/69-kV transformer	West Middleton to Stagecoach line uprate
3	Royster – AGA Gas Tap – Pflaum 69-kV line	111.8 – 95.2%	--	--	--	--	--	117.8 – 99.1%	--	--	--	Fitchburg – Syene 69-kV line Nine Springs – Syene 69-kV line Fitchburg – Nine Springs 69-kV line[8]	Nine Springs, Pflaum area project
3	Royster – AGA Gas Tap	--	--	--	--	101.5%	--	--	--	--	--	Fitchburg – Syene 69-kV line	Nine Springs, Pflaum area project
3	Fitchburg – Syene – Nine Springs 69-kV line	113.4 – 97.3%	--	--	--	--	--	119.3 – 102.4%	--	--	--	Royster – AGA tap 69-kV line Pflaum – AGA tap 69-kV line Royster – AGA tap 69-kV line[9]	Nine Springs, Pflaum area project
3	Fitchburg – Syene 69-kV line	--	--	--	--	102.8%	--	--	--	--	--	Royster – AGA tap 69-kV line	Nine Springs, Pflaum area project

Table ZS-2
2015 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2015 Summer Peak Case		2015 70% Load Case		2015 90% Load Case		2015 105% Load Case		2015 High Wind		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage		
3	Verona 138-kV bus	--	95.4% 87.2%	--	-- 90.05%	--	-- 88.4%	--	95.1% 86.5%	--	-- 91.4%	System Intact Verona – Oak Ridge 138-kV line	Adjust Verona 138/69-kV transformer LTC / Verona 69-kV capacitor bank project
3	Fitchburg 138-kV bus	--	95.9%	--	--	--	--	--	--	--	--	System Intact	Verona 69-kV capacitor bank project
3	Fitchburg and Oak Ridge 138-kV buses	--	--	--	--	--	--	--	95.8 – 95.9%	--	--	System Intact	Verona 69-kV capacitor bank project
3	Southwest Verona 69-kV bus	--	89.6%	--	--	--	91.2%	--	88.5%	--	--	Verona – Southwest Verona 69-kV line	Further study needed
3	Huiskamp 138-kV bus	--	88.9%	--	88.2%	--	87.7%	--	87.8%	--	--	Huiskamp – North Madison 138-kV line	Adjust Huiskamp 138/69-kV transformer LTC
3	Brodhead Muni2, Brodhead Muni3, Brodhead and Brodhead Muni1 69-kV buses	--	91.6 – 91.8%	--	--	--	--	--	--	--	--	Brodhead Switching Station – Brodhead Muni3 69-kV line	Bass Creek transformer project
3	Brodhead Muni2, Brodhead Muni3, Brodhead, Brodhead Muni1, REC Orfordville, Orfordville, Bass Creek and Footville 69-kV buses	--	--	--	--	--	--	--	90.1 – 91.7%	--	--	Brodhead Switching Station – Brodhead Muni3 69-kV line Brodhead Muni 2 – Brodhead Muni3 69-kV line	Bass Creek transformer project
3	REC Harmony, Milton, Milton Tap, Lamar, Fulton and Saunders Creek 69-kV buses	--	88.5 – 91.9%	--	--	--	--	--	86.5 – 91.9%	--	--	McCue – Harmony 69-kV line Milton Tap – Harmony 69-kV line McCue – Lamar 69-kV line[10]	Lamar 69-kV capacitor bank project
3	AGA Gas 69-kV bus	--	--	--	--	--	--	--	92.0%	--	--	Royster – AGA tap 69-kV line	Nine Springs, Pflaum area project
3	McFarland, Femrite and Sprecher 138-kV buses	--	--	--	--	--	--	--	91.2 – 91.5%	--	--	Kegonsa – McFarland 138-kV line Femrite – McFarland 138-kV line Kegonsa – Femrite 138-kV line[11]	Dane County Corrective Plan
3	REC Harmony, Milton, Milton Tap, Lamar, Fulton 69-kV buses	--	--	--	--	--	91.3 – 91.9%	--	--	--	--	McCue – Harmony 69-kV line	Lamar capacitor bank
3	Hubbard and Hustisford 138-kV buses	--	-- 86.2% 86.8% 86.8% --	--	--	--	96.0% 86.8% 87.3% 87.3% 91.8%	--	-- 85.8% 86.5% 86.5% --	--	-- -- 87.4% 87.4% --	System Intact Rubicon – Hustisford 138-kV line Hustisford – Hubbard 138-kV line Rubicon – Hustisford – Hubbard 138-kV line Hartford – Saint Lawrence 138-kV line	Adjust Hubbard 138/69-kV transformer LTC
3	Fox Lake, North Beaver Dam and Beaver Dam East 138-kV buses	--	88.2 – 88.3% 88.9% 88.9%	--	--	--	89.4 – 89.5% -- --	--	87.4 – 87.5% 88.2 – 88.3% 88.2 – 88.3%	--	--	North Randolph – Fox Lake 138-kV line Fox Lake – North Beaver Dam 138-kV line North Randolph – North Beaver Dam 138-kV line[12]	Adjust North Beaver Dam 138/69-kV transformer LTC
3	Nelson Dewey – DPC Cassville 161-kV line	--	--	98.2 – 95.2%	--	--	--	--	--	--	--	Paddock 345/138-kV transformer DPC Genoa generator #3 Columbia generator #1 Columbia generator #2	Mitigation by potential generation adjustments / Futher study needed
3	Nelson Dewey – DPC Cassville 161-kV line	--	--	--	--	--	--	--	--	111.2 – 109.2%	--	DPC Seneca – DPC Genoa 161-kV line Genoa 161/69-kV transformer[13]	DPC line limitation / further study needed
3	Darlington – North Monroe 138-kV line	--	--	--	--	--	--	--	--	109.3 – 95.2%	--	Paddock 345/138-kV transformer Darlington 138/69-kV transformer	Mitigation by potential generation adjustments / Futher study needed
3	Nelson Dewey 161/138-kV transformer	--	--	--	--	--	--	--	--	100.5 – 95.5%	--	ComEd Byron generator #1 ComEd Braidwood generator #1 ComEd Braidwood generator #2 Point Beach generator #1 Point Beach generator #2 Kewaunee generator #1	Mitigation by potential generation adjustments / Futher study needed
3	West Middleton – Black Hawk 69-kV line	--	--	98.5 – 96.3%	--	--	--	--	--			North Madison – Vienna 138-kV line Vienna – Yahara River 138-kV line North Madison – Yahara River 138-kV line[14]	Mitigated by generation adjustments/ Potential Cardinal – Blount 138-kV line
3	Verona, Oak Ridge, and Fitchburg 138-kV buses	--	--	--	95.5 – 95.7%	--	--	--	--	--	--	System Intact	Femrite and Kegonsa 138-kV capacitor banks
4	Base case loading criteria exceeded	FALSE	--	FALSE	--	FALSE	--	FALSE	--	FALSE	--	System Intact	
4	Base case voltage criteria exceeded	--	FALSE	--	FALSE	--	FALSE	--	FALSE	--	FALSE	System Intact	
4	Non Converged Solution	--	--	Applies	--	--	--	--	--	Applies	--	Morgan – Plains 345-kV line[15] Morgan – Plains 345-kV line	Mitigated by generation adjustments
4	Morgan – Falls 138-kV line	--	--	103.4% 103.4%	--	--	--	--	--	96.0% 95.9%	--	Morgan – Plains 345-kV line[15] Morgan – Plains 345-kV line	Mitigated by generation adjustments

Table ZS-2
2015 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2015 Summer Peak Case		2015 70% Load Case		2015 90% Load Case		2015 105% Load Case		2015 High Wind		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage		
4	East Krok 138/69-kV transformer	105.1% -- --	--	99.8% -- --	--	102.7% -- --	--	107.1% 96.5% 95.7%	--	--	--	Canal – East Krok 138-kV line Highway V 138/69-kV transformer #2[16] Highway V – East Krok 138-kV line	No project needed; Investigation into limiting facility resulted in higher facility ratings
4	Sunset Point – Pearl Avenue 69-kV line	116.3% 115.7%	--	--	--	104.6% 103.7%	--	122.6% 121.4%	--	--	--	Ellinwood 138/69-kV transformer[17] Ellinwood – 12th Avenue 69-kV line	Rebuild line
4	Highway V – Ontario 138-kV line	99% --	--	--	--	--	--	103.5% 98.7%	--	--	--	East Krok 138/69-kV transformer[18] Canal 138/69-kV transformer #1[19]	Uprate line
4	Dyckesville – Rosiere 69-kV line	95.0%	--		--	--	--	99.2%	--	--	--	East Krok 138/69-kV transformer[18]	Further study needed
4	White Clay 138-kV 1-2 bus tie	--	--	99.7%	--	--	--	--	--	--	--	Morgan – Highway 22 345-kV line	Further study needed
4	Highway V – Preble 138-kV line	--	--	97.5%	--	--	--	--	--	--	--	Morgan – Highway 22 345-kV line	Further study needed
4	Canal – East Krok 138-kV line	--	--	--	--	--	--	98.0%	--	--	--	Highway V 138/69-kV transformer #1[20]	Further study needed
4	Edgewater – Sauk Trail 138-kV line	--	--	--	--	--	--	96.8%	--	--	--	Edgewater – Huebner 138-kV line	Further study needed
4	East Krok – Kewaunee 138-kV line	--	--	--	--	96.0%	--	--	--	--	--	North Appleton 345/138 kV xfmr #1[21]	Further study needed
4	Manrap – Custer 69-kV line	--	--	--	--	--	--	97.2%	--	--	--	Dewey – Lakefront 69-kV line	Further study needed
5	Base Case Loading Criteria Exceeded	FALSE		FALSE		FALSE		FALSE		FALSE			
5	Base Case Voltage Criteria Exceeded		TRUE		FALSE		TRUE		TRUE		FALSE		
5	Bluemound 230-kV bus, Allerton, Brookdale, Cottonwood, Edgewood, and 28th St 138-kV buses	--	94.6 – 95.9%	--	--	--	--	--	--	--	--	System Intact	Shift Allerton load from T9 to T8
5	Bluemound 230-kV bus, Allerton, Brookdale, Cottonwood, and 28th St 138-kV buses	--	--	--	--	--	--	--	94.6 – 95.8%	--	--	System Intact	Shift Allerton load from T9 to T9
5	Burlington and Tichigan 138-kV buses	--	--	--	90.8 – 91.0%	--	--	--	--	--	--	Split Burlington 138-kV bus	Marginal voltage, no mitigation needed within this timeframe
5	Bark River 138-kV bus	--	--	--	--	--	95.6% 91.3%	--	--	--	--	System Intact Bark River – Sussex 138-kV line	Marginal voltage, no mitigation needed within this timeframe
5	Cottonwood 138-kV bus	--	--	--	--	--	95.3% 91.6%	--	--	--	--	System Intact Bark River – Sussex 138-kV line	Marginal voltage, no mitigation needed within this timeframe
5	Germantown 138-kV bus	--	--	--	-- -- -- 91.9%	--	94.6% 91.9% 91.5% 87.6%	--	--	--	--	System Intact Germantown – Maple 138-kV line Bark River – Sussex 138-kV line Maple – Saukville 138-kV line	Mitigated by generation adjustments
5	Hartford 138-kV bus	--	--	--	--	--	95.8% 91.4%	--	--	--	--	System Intact Hartford – St. Lawrence 138-kV line	Marginal voltage, no mitigation needed within this timeframe
5	Maple 138-kV bus	--	--	--	-- 91.7%	--	94.8% 87.3%	--	--	--	--	System Intact Maple – Saukville 138-kV line	Mitigated by generation adjustments
5	Summit, Cooney and Mukwonago 138-kV buses	--	--	--	--	--	95.5 – 95.8%	--	--	--	--	System Intact	Marginal voltage, no mitigation needed within this timeframe
5	Bain 345/138-kV transformer #5	159.7% 117.9%	--	147.3% --	--	159.3% --	--	159.2% 108.2%	--	147.5% 107.6%	--	Split Pleasant Prairie 345-kV bus 34 Split Pleasant Prairie 345-kV bus 23	Mitigated by generation adjustments
5	Oak Creek 345/230-kV transformer T895	105.0% 105.3%	--	95.3% --	--	104.7% --	--	104.9% 104.5%	--	95.1% --	--	Split Oak Creek 230-kV bus 78 Split Oak Creek 230-kV bus 67	Mitigated by generation adjustments
5	Arcadian4 – Waukesha1 138-kV line	104.8%	--	119.6%	--	134.2%	--	105.2%	--	--	--	Arcadian6 – Waukesha3 138-kV line	Rebuild line
5	Arcadian6 – Waukesha3 138-kV line	101.1% --	--	115.6% 103.5%	--	129.7% 113.6%	--	101.5% --	--	--	--	Arcadian4 – Waukesha1 138-kV line Split Waukesha 138-kV bus 12	Rebuild line
5	Arcadian 345/138-kV transformer #3	-- -- 99.8%	--	101.7% 99.7% 98.3%	--	105.6% 105.2% 110.9%	--	-- -- 101.8%	--	--	--	Split Arcadian 345-kV bus 12 Arcadian 345-kV bus outage Arcadian 345/138-kV transformer #1	Replace transformer
5	Arcadian 345/138-kV transformer #2	--	--	95.7% --	--	97.4% 102.4%	--	--	--	--	--	Split Arcadian 345-kV bus 12 Arcadian 345/138-kV transformer #2	Replace transformer
5	Bain – Kenosha 138-kV line	97.9%	--	--	--	--	--	--	--	--	--	Pleasant Prairie – Zion 345-kV line	Uprate Bain – Kenosha
5	Pleasant Prairie – Zion 345-kV line	95.7% -- -- -- --	--	--	--	--	--	98.1% 96.2% 100.2% 98.5% 95.4%	--	--	--	Zion – Arcadian 345-kV line Cherry Valley – Silver Lake 345-kV line Braidwood generator #1 or #2 Dresden generator #2 or #3 Zion Energy Ctr #1 or #2	Marginal issue, no mitigation needed within this timeframe
5	Granville 345/138-kV transformer #1	--	--	95.0%	--	107.2%	--	--	--	--	--	Split Granville 345-kV bus 23	Mitigated by generation adjustments

Table ZS-2
2015 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2015 Summer Peak Case		2015 70% Load Case		2015 90% Load Case		2015 105% Load Case		2015 High Wind		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage	% of Facility Rating	% of Nominal Bus Voltage		
5	Harbor – Kansas 138-kV line	--	--	109.5% 106.7% 106.6% 105.7% 99.6 – 102.5%	--	--	--	--	--	--	--	Kansas – Norwich 138-kV line Dewey – Norwich 138-kV line Split Dewey 138-kV bus Dewey – Montana 138-kV line Plus Other Less Severe Outages	Mitigated by generation adjustments
5	Albers – Kenosha 138-kV line	--	--	120.3%	--	103.3%	--	100.9%	--	--	--	Albers – Bain 138-kV line	Mitigated by generation adjustments
5	Edgewood – St. Martins 138-kV line	--	--	102.1% 98.8% 97.4% 96.5%	--	--	--	--	--	--	--	Merrill Hills – Waukesha 138-kV line Paris – Air Liquide 138-kV line Paris – Air Liquide – Burlington 138-kV line Burlington – Air Liquide 138-kV line	Mitigated by generation adjustments
5	Oak Creek – Ramsey 138-kV line	--	--	--	--	95.6%	--	--	--	--	--	Oak Creek – Pennsylvania 138-kV line	Marginal issue, no mitigation needed within this timeframe
5	Wauesha 138-kV bus 12	--	--	--	--	100.1%	--	--	--	--	--	Arcadian6 – Waukesha3 138-kV line	Mitigated by generation adjustments
5	Kenosha – Lakeview 138-kV line	--	--	--	--	--	--	100.7%	--	--	--	Pleasant Prairie – Zion 345-kV line	Rebuild line
5	Lakeview – Zion 138-kV line	--	--	--	--	--	--	96.7%	--	--	--	Pleasant Prairie – Zion 345-kV line	Further study needed

Event Based Contingency	Definition of Event Based Contingency
1	Saratoga – ACEC Badger West – Petenwell138-kV line
2	Arpin – Rocky Run 345-kV line + Port Edwards – Sand Lake 138-kV line + Port Edwards – Hollywood 138-kV line + Council Creek – Council Creek DPC 69-kV line
3	Whitcomb – CWEC Wittenberg Tap – Wittenberg Tap – Birnamwood Tap – Brooks Corner – Deer Trail 69-kV line
4	Eau Clare – Arpin 345-kV line + Council Creek DPC – Council Creek 69-kV line + Hilltop – Mauston 69-kV line
5	King – Eau Claire 345-kV line + Eau Clare – Arpin 345-kV line + Eau Clare 345/161-kV transformer + Council Creek DPC – Council Creek 69-kV line + Hilltop – Mauston 69-kV line + Lubin – Lakehead 69-kV line
6	North Fond du Lac 138/69-kV transformer #3 + North Fond du Lac – Hickory Street Tap 69-kV line + North Fond du Lac – Rosendale 69-kV line + North Fond du Lac 69-kV bus capacitor
7	Paddock – REC Newark – Brodhead Switching Station 69-kV line
8	Fitchburg – Syene – Nine Springs 69-kV line
9	Royster – AGA tap – LCI 69-kV line
10	McCue – Harmony – Milton Tap – Lamar 69-kV line
11	Kegonsa – McFarland – Femrite 138-kV line
12	North Randolph – Fox Lake – North Beaver Dam 138-kV line
13	Genoa 161/69-kV transformer + Genoa-Seneca 161-kV line + Genoa-Lansing W 161-kV line+ Genoa-Lac Tap 161-kV line
14	North Madison-Vienna-Yahara River 138-kV line
15	Morgan – Plains 345-kV line + Morgan 24.9 kV reactor + Plains 24.9 kV reactor
16	Highway V 138/69 kV xfmr #2 + Highway V - East Krok 138 kV circuit + Highway V - Mystery Hills 138 kV circuit + Highway V - Oak Street 69 kV circuit
17	Ellinwood 138/69 kV xfmr #1 + Ellinwood - Twelfth Ave 69 kV circuit + Ellinwood - Fitzgerald 138 kV circuit +Ellinwood 138 kV bus tie 1-2
18	East Krok 138/69 kV xfmr + Highway V - East Krok 138 kV circuit + East Krok - Canal 138 kV circuit + East Krok - Kewaunee 138 kV circuit + Beardsely - East Krok 69 kV circuit
19	Canal 138/69 kV xfmr #1 + Canal - East Krok 138 kV circuit + Canal - Sawyer 69 kV circuit + Canal - Algoma 69 kV circuit + Canal 69 kV cap banks, 2 x 16.3 MVAr
20	Highway V 138/69 kV xfmr #1 + Highway V - Ontario 138 kV circuit + Highway V - Preble 138 kV circuit + Highway V - Finger Road 69 kV circuit + Highway V - Rockland 138 kV circuit + Highway V 138 kV cap bank, 2 x 18.9 MVAr
21	North Appleton 345/138 kV xfmr #1 + North Appleton - Kewaunee 345 kV circuit
22	King – Eau Clare 345-kV line + Eau Clare – Arpin 345-kV line + Eau Clare 345/161-kV transformer + Council Creek DPC – Council Creek 69-kV line + Hilltop – Mauston 69-kV line
23	M38-Atlantic 69-kV line + Atlantic 138/69-kV transformer
24	Hiawatha-Engadine-Newberry-Newberry Hospital-Roberts 69-kV line
25	Hiawatha-Lakehead-Brevort-Straits 138-kV line

Table ZS-3
2020 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2020 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
1	Base case loading criteria exceeded	TRUE	--	System Intact	
1	Base case voltage criteria exceeded	--	TRUE	System Intact	
1	Silver Lake, ACEC Spring Lake, Redgranite, Fountain Valley, River Run and Berlin 69-kV buses	--	84.5 – 88.2% 86.6 – 89.6% 87.2 – 90.6% 88.0 – 90.6% 88.6 – 91.9%	Wautoma – Silver Lake Tap 69-kV line Silver Lake – ACEC Spring Lake 69-kV line Metomen – Ripon 69-kV line ACEC Spring Lake – Redgranite 69-kV line Plus other less severe contingencies	Ripon capacitor expansion and Install capacitors at Dartford
1	Dartford, Ripon Industrial Park, Northwest Ripon and Ripon 69-kV buses	--	94.8% 83.2 – 85.1% 85.0 – 86.9% 87.8 – 89.6% 87.9 – 91.6%	System Intact Metomen – Ripon 69-kV line Ripon – Northwest Ripon Tap 69-kV line Wautoma – Silver Lake Tap 69-kV line Plus other less severe contingencies	Ripon capacitor expansion and Install capacitors at Dartford
1	Winneconne, Omro and Omro Industrial Park 69-kV buses	--	84.2 – 85.0% 89.6 – 89.8% 90.5 – 91.2% 91.3 – 91.9% 91.3 – 91.9%	Winneconne – Sunset Point 69-kV line Winniconne – Omro Tap 69-kV line Metomen – Ripon 69-kV line Wautoma – Silver Lake Tap 69-kV line Plus other less severe contingencies	Ripon capacitor expansion and Install capacitors at Dartford
1	Mackford Prairie and Markesan 69-kV bus	--	91.7 – 91.9%	North Randolph – Markesan Tap 69-kV line	Ripon capacitor expansion
1	Metomen – Ripon 69-kV line	96.0% 104.9% 97.0% 95.9%	--	System Intact Winneconne – Sunset Point 69-kV line Winniconne – Omro Tap 69-kV line North Randolph – Markesan Tap 69-kV line	Second Metomen – Ripon 69-kV line
1	Metomen 138/69-kV transformer	109.4% 110.7% 109.2% 103.4% 103.2 – 95.9%	--	System Intact North Fond du Lac 138/69-kV transformer #3[2] North Fond du Lac – Rosendale Tap 69-kV line Metomen – North Fond du Lac 69-kV line[3] Plus other less severe contingencies	Replace Metomen 138/69-kV transformer
1	Northwest Ripon Tap – Ripon 69-kV line	106.8% 95.1%	--	Winneconne – Sunset Point 69-kV line Winneconne – Omro Tap 69-kV line	Uprate line
1	Omro – Winneconne 69-kV line	98.5% 95.1%	--	Ripon – Northwest Ripon Tap 69-kV line Harrison 138/69-kV transformer	Marginal issue, no mitigation needed within this timeframe
1	Winneconne – Sunset Point 69-kV line	103.5% 101.3%	--	Ripon – Northwest Ripon Tap 69-kV line Metomen – Ripon 69-kV line	Uprate line

Table ZS-3
2020 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2020 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
1	ACEC Brooks, Grand Marsh (PP&L) and Lincoln Pumping Station 69-kV buses	--	88.9 – 89.5% 91.2 – 91.6% 91.2 – 91.6%	Necedah Tap – Big Pond 69-kV line Chaffee Creek – Coloma Tap 69-kV line Necedah Tap – Whistling Wings Tap 69-kV line	McKenna capacitor expansion
1	Necedah, Petenwell, Big Pond, ACEC Dellwood, Friendship, ACEC Friendship, Houghton Rock and McKenna 69-kV buses	--	79.3 – 87.0% 84.8 – 89.8% 90.1 – 91.4% 90.3 – 91.5% 90.3 – 91.8%	Necedah Tap – Big Pond 69-kV line Necedah Tap – Whistling Wings Tap 69-kV line Dellwood ACEC – Whistling Wings Tap 69-kV line Petenwell – Big Pond 69-kV line Plus other less severe contingencies	McKenna capacitor expansion, Convert Necedah to 138 kV, redispatch Castle Rock generation
1	ACEC Winnebago, ACEC Glen and Neenah Creek 69-kV bus	--	90.1 – 92.0%	Kilbourn – Winnebago ACEC 69-kV line	Increase capacitance at Neenah Creek
1	ACEC Coloma, Plainfield, Sand Lake, Hancock and ACEC Hancock 69-kV buses	--	89.4 – 90.2% 90.9 – 91.9% 90.9 – 92.0% 90.9 – 92.0% 91.6%	Chaffee Creek – Coloma Tap 69-kV line Wautoma – Port Edwards 138-kV line Sand Lake Tap – Sand Lake 69-kV line Sand Lake 138/69-kV transformer Necedah Tap – Big Pond 69-kV line	McKenna capacitor expansion
1	ACEC Quincy and Castle Rock 69-kV bus	--	91.3 – 91.8%	Necedah Tap – Big Pond 69-kV line	McKenna capacitor expansion
1	Chaffee Creek – Coloma Tap 69-kV line	113.4% 96.3%	--	Necedah Tap – Big Pond 69-kV line Necedah Tap – Whistling Wings Tap 69-kV line	Uprate terminal equipment at Chaffee Creek
1	Castle Rock – ACEC Quincy 69-kV line	125.9% 112.1% 104.6% 104.6% 101.0%	--	Necedah Tap – Big Pond 69-kV line Necedah Tap – Whistling Wings Tap 69-kV line Petenwell – Big Pond 69-kV line Petenwell 138/69-kV Transformer Dellwood ACEC – Whistling Wings Tap 69-kV line	Uprate Castle Rock – McKenna 69-kV line
1	ACEC Quincy – McKenna 69-kV line	119.0% 105.3% 98.0% 98.0%	--	Necedah Tap – Big Pond 69-kV line Necedah Tap – Whistling Wings Tap 69-kV line Petenwell – Big Pond 69-kV line Petenwell 138/69-kV Transformer	Uprate Castle Rock – McKenna 69-kV line
1	Hilltop – Mauston 69kV line	100.3%	--	Arpin – Rocky Run 345-kV line[4]	Mitigated by generation adjustments

Table ZS-3
2020 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2020 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
1	Sigel, Lakehead Pipeline, Port Edwards and Vulcan 138-kV buses	--	90.7 – 91.9%	Sigel – Arpin 138-kV line	Marginal voltage, no mitigation needed in this timeframe
1	Sigel – Auburndale 69-kV line	114.2%	--	System Intact	Line validated with higher rating
1	Rozellville 69-kV bus	--	91.9%	Sigel 138/69-kV transformer	Marginal voltage, no mitigation needed in this timeframe
1	Vulcan – Port Edwards 138-kV line #2 Vulcan – Port Edwards 138-kV line #1	124.2% 123.9%	--	Port Edwards – Vulcan Chemical 138-kV #1 line Port Edwards – Vulcan Chemical 138-kV #2 line	Change tap on free standing CT's at Port Edwards
1	Petenwell and Council Creek 138-kV buses	--	94.7 – 94.9% 89.0 – 89.5% 89.0 – 89.6% 89.0 – 89.6% 89.6 – 91.6%	System Intact ACEC Badger West – Saratoga 138-kV line ACEC Badger West – Petenwell 138-kV line Saratoga – Petenwell 138-kV line[5] Plus other less severe contingencies	Expand capacitors at Council Creek and Adjust Council Creek 138/69-kV transformer LTC
1	Badger West 138-kV bus	--	95.8% 88.1% 91.7% 91.8%	System Intact ACEC Badger West – Saratoga 138-kV line Arpin – Rocky Run 345-kV line[4] Sigel – Arpin 138-kV line	Adjust Council Creek 138/69-kV transformer LTC
1	Petenwell 138/69-kV transformer	116.3% 122.7%	--	System Intact Castle Rock – Quincy ACEC 69-kV line	Replace Petenwell transformer
1	Lakehead Pipeline Portage, Endeavor and Roslin ACEC 69-kV buses	--	91.7 – 91.9%	Portage – Lakehead Pipeline Portage 69-kV line	Marginal voltage, no mitigation needed in this timeframe
1	Fairwater and Brandon 69-kV bus	--	91.2 – 91.5%	Metomen 138/69-kV transformer	Marginal voltage, no mitigation needed in this timeframe
1	Brooks Corner 69-kV bus	--	86.7%	Whitcomb – Deer Trail 69-kV line[6]	Adjust Brooks Corners 69/34.5-kV transformer LTC
1	Harrison 138/69-kV transformer	107.1%	--	System Intact	Replace Harrison 138/69-kV transformer
1	Rocky Run 345/115-kV transformer #3	95.7% 94.6%	--	Rocky Run 345/115-kV transformer #2 Rocky Run 345/115-kV transformer #1	Marginal issue, no mitigation needed within this timeframe

Table ZS-3
2020 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2020 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
1	Caroline 115/69-kV transformer	104.9%	--	Whitcomb 115/69-kV transformer	Replace Caroline 115/69-kV transformer
1	Wautoma 138/69-kV transformer T31	109.5% 103.4% 103.4% 99.7% 98.2 – 95.0%	--	System Intact Sand Lake Tap – Sand Lake 69-kV line Sand Lake 138/69-kV transformer Portage – Lakehead Pipeline Portage 69-kV line Plus other less severe contingencies	Second 138/69-kV Transformer at Wautoma
2	M38 – Atlantic 69-kV line	117.9 – 121.7%	--	M38-Atlantic 138-kV line Atlantic 138/69-kV transformer M38-Atlantic 138-kV line[13]	Uprate M38-Atlantic 69-kV line or mitigated by generation adjustments
2	Engadine, Newberry, Newberry Hospital, Roberts, LouPac, Newberry Village, Hulbert, Eckerman 69-kV buses	--	55.6 – 89.7%	Hiawatha-Engadine 69-kV line Engadine-Newberry 69-kV line Newberry-Newberry Hospital Tap 69-kV line	Mitigated by generation adjustments
2	North Bluff, Bay View, Mead, Gladstone, Masonville, Lakehead, West Side, Escanaba, Harris, Chandler 69-kV buses	--	88.5 – 90.8%	Chandler 138/69-kV transformer	Mitigated by generation adjustments
2	Straits, St. Ignace, Indian Lake, Evergreen, Valley, Glen Jenks, Manistique, Engadine, Hiawatha, Gould City 69-kV buses	--	104.0 – 105.2%	System Intact	Adjust transformer tap settings at Hiawatha, Indian Lake, Straits
2	Straits, Brevort, Lakehead, Hiawatha 138-kV buses	--	90.9 – 91.1%	Livingstone-Emmet 138-kV line	Adjust transformer tap settings at Hiawatha, Straits
3	Base case loading criteria exceeded	FALSE	--	System Intact	
3	Base case voltage criteria exceeded	--	TRUE	System Intact	
3	Okee, Lodi Industrial Park and Lodi 69-kV buses	--	90.2 – 91.4% 92.0%	Dane – Lodi Tap 69-kV line Lodi Tap – Okee Tap 69-kV line	Marginal voltage, no mitigation needed in this timeframe
3	Dane – Lodi Tap 69-kV line	107.9% 95.3% 95.3%	--	Island Street – Kirkwood 69-kV line Baraboo Tap – Moore Street Tap 69-kV line Island Street – Moore Street Tap 69-kV line	Rebuild line
3	Eagle View 69-kV bus	--	91.8%	Island Street – Kirkwood 69-kV line	Marginal voltage, no mitigation needed in this timeframe
3	Island Street, Baraboo, Sauk Prairie, Prairie du Sac Muni, Tower Street, Dam Heights and Prairie du Sac Hydro 69-kV buses	--	90.4 – 91.8%	Island Street – Kirkwood 69-kV line	Marginal voltage, no mitigation needed in this timeframe
3	Stoughton Muni South Tap – Stoughton 69-kV line	98.4%	--	Verona – Oak Ridge 138-kV line Verona 138/69-kV transformer	Potential Y-127 line uprate/ further study needed

Table ZS-3
2020 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2020 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
3	North Monroe – Idle Hour 69-kV line Monroe Tap – Idle Hour 69-kV line	118.5 – 95.4%	--	Paddock – Newark 69-kV line Darlington – Gratiot 69-kV line Brodhead – Newark 69-kV line Paddock – Newark – Brodhead Switching Station 69-kV line Wiota – Gratiot 69-kV line plus other less severe contingencies	Bass Creek transformer project / potential Y-87 line uprate/ further study needed
3	McCue – REC Harmony 69-kV line	101.4 – 98.7%	--	Sheepskin generator Kegonsa – Stoughton North Tap2 69-kV line Kegonsa 138/69-kV transformer	Y-61 line uprate
3	REC Harmony – Milton Tap – Lamar 69-kV line	96.0%	--	Sheepskin generator	Y-61 line uprate
3	Dana Corporation Tap – Sheepskin 69-kV line	111.5 – 103.0%	--	McCue – Harmony 69-kV line Milton Tap – Lamar 69-kV line McCue – Harmony – Milton Tap – Lamar 69-kV line Milton Tap – Harmony 69-kV line	Sheepskin terminal upgrade
3	Wauzeka – Gran Grae 69-kV line Wauzeka – Boscobel 69-kV line	104.8 – 95.0%	--	Spring Green 138/69-kV transformer Nelson Dewey – Lancaster 138-kV line Nelson Dewey – Lancaster – Eden 138-kV line Eden – Lancaster 138-kV line Lone Rock – Spring Green 69-kV line plus other less severe contingencies	Y-40 line uprate
3	Timberlane Tap – West Middleton 69-kV line	112.9 – 95.3%	--	Spring Green 138/69-kV transformer Verona – Southwest Verona 69-kV line Nelson Dewey – Lancaster 138-kV line Verona – Oak Ridge 138-kV line Verona 138/69-kV transformer Eden – Lancaster 138-kV line	6927 line uprate
3	Royster – AGA Gas Tap 69-kV line Pflaum – AGA Gas Tap 69-kV line	125.9 – 105.6%	--	Fitchburg – Syene 69-kV line Nine Springs – Syene 69-kV line Fitchburg – Syene – Nine Springs 69-kV line	Nine Springs, Pflaum area project
3	Royster – Sycamore 69-kV line	99.1%	--	Femrite 138/69-kV transformer	6986 line uprate
3	Fitchburg – Syene 69-kV line Nine Springs – Syene 69-kV line	128.1 – 109.5%	--	Royster – AGA tap 69-kV line Pflaum – AGA tap 69-kV line Royster – AGA tap – Pflaum 69-kV line	Nine Springs, Pflaum area project
3	Verona, Oak Ridge, Hawk Alliant, Hawk, Cross Country, and Fitchburg 138-kV buses	--	94.0 – 96.0%	System Intact	Femrite and Kegonsa 138-kV capacitor banks
3	Southwest verona, Mount Horeb Muni1, Mount Horeb, Mount Horeb Northeast, and Forward 69-kV buses	--	83.4 – 91.7%	Verona – Southwest Verona 69-kV line	Further T-D BVP study needed
3	Idle Hour, Monroe, Monroe Tap, and South Monroe 69-kV buses	--	90.6 – 91.0%	North Monroe – Idle Hour 69-kV line	Further study needed
3	Brodhead Muni3, Brodhead Muni2, Brodhead, and Brodhead Muni1 69-kV buses	--	91.8 – 92.0 %	rodhead Switching Station – Brodhead Muni3 69-kV lin	Bass Creek transformer project

Table ZS-3
2020 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2020 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
3	REC Harmony, Milton, Milton Tap, Lamar, Fulton 69-kV buses	--	88.9 – 91.1%	McCue – Harmony 69-kV line Milton Tap – Harmony 69-kV line Milton Tap – Lamar 69-kV line McCue – Harmony – Milton Tap – Lamar 69-kV line	Lamar 69-kV capacitor bank
3	Reiner, Burke and Burke Tap 69-kV buses	--	91.7 – 91.9%	Reiner – Burke Tap 69-kV line Reiner 138/69-kV transformer	Sun Prairie capacitor bank
3	AGA Gas, Pflaum, AGA Gas Tap, and Pflaum Tap 69-kV buses	--	91.1 – 91.2%	Royster – AGA tap 69-kV line	Nine Springs, Pflaum area project
3	Lancaster, Eden, Wyoming Valley, and Spring Green 138-kV buses	--	87.6 – 91.9%	Nelson Dewey – Lancaster 138-kV line Eden – Lancaster 138-kV line Nelson Dewey – Lancaster – Eden 138-kV line	Eden capacitor bank
3	Wyoming Valley, Spring Green, Troy, and Eden 138-kV buses	--	90.6 – 91.1%	Lake Delton – Trienda 138-kV line	Eden capacitor bank
3	Pleasant View, Hawk Alliant, and Hawk 138-kV buses	--	91.8 – 92.0%	West Middleton – Pleasant View 138-kV line	Femrite and Kegonsa 138-kV capacitor banks
3	Darlington 138-kV bus	--	90.5%	Darlington – Lafayette Wind 138-kV line	North Monroe capacitor bank
3	Verona 138-kV bus, Southwest verona, Sun Valley , and Verona 69-kV buses	--	83.5 – 91.9%	Verona – Oak Ridge 138-kV line Verona 138/69-kV transformer	Further T-D BVP study needed / Verona 69-kV capacitor banks
3	Muscoda, Avoca, and Avoca Tap 69-kV buses	--	91.2%	Lone Rock – Spring Green 69-kV line	Boscobel capacitor bank
3	Pioneer, Mcgregor , Platteville tap, Hillman, Elmo, Cuba City, and Benton 69-kV buses	--	89.5%	Hillman 138/69-kV transformer	Second Hillman transformer
3	Avoca, Muscoda, Avoca Tap, Arena, Spring Green, Lone Rock , Mazomanie Industrial, Mazomanie West, Mazomanie, Blue River Tap, and Blue River 69-kV buses	--	89.8 – 91.7%	Spring Green 138/69-kV transformer	Second Spring Green transformer
3	McFarland, Femrite, Sprecher 138-kV buses	--	91.2 – 91.8%	Kegonsa – McFarland 138-kV line McFarland – Femrite 138-kV line Kegonsa – McFarland – Femrite 138-kV line	Femrite capacitor bank
3	Huiskamp 138-kV bus	--	88.0%	Huiskamp – North Madison 138-kV line	Adjust Huiskamp 138/69-kV transformer LTC
3	Verona, Fitchburg 138-kV buses	--	91.4 – 92.0%	Rockdale – West Middleton 345-kV line West Middleton 345/138-kV transformer	Femrite and Kegonsa 138-kV capacitor banks
3	Verona, Eden, and Wyoming Valley 138-kV buses	--	91.5 – 91.9%	Columbia Generator unit 1 Columbia Generator unit 2	Eden capacitor bank / Dane County corrective plan
3	South Fond du Lac – Koch Oil Tap 69-kV line	95.4%	--	North Randolph – Fox Lake 138-kV line	Further study needed
3	Hubbard and Hustisford 138-kV bus	--	85.7 – 85.8% 86.4% 86.4%	Rubicon – Hustisford 138-kV line Hustisford – Hubbard 138-kV line Rubicon – Hustisford – Hubbard 138-kV line	Adjust Hubbard 138/69-kV transformer LTC
3	Fox Lake, North Beaver Dam and Beaver Dam East 138-kV buses	--	86.1 – 86.2% 87.0 – 87.1% 87.2 – 87.3%	North Randolph – Fox Lake 138-kV line North Randolph – North Beaver Dam 138-kV line[7] Fox Lake – North Beaver Dam 138-kV line	Adjust North Beaver Dam 138/69-kV transformer LTC

Table ZS-3
2020 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2020 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
3	Cobblestone – Zenda Tap 69-kV line	162.3% 99.8% 99.1%	--	North Lake Geneva – Lake Geneva 69-kV line Lake Geneva – South Lake Geneva 69-kV line North Lake Geneva – Lake Geneva – South Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Colley Road 138/69-kV transformer	111.8% 97.4%	--	Paddock 138/69-kV transformer Paddock – Shirland 69-kV line	Bass Creek 138/69-kV transformer
3	Katzenberg – Zenda tap 69-kV line	149.6%	--	North Lake Geneva – Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Katzenberg – South Lake Geneva 69-kV line	113.0%	--	Cobblestone – Brick Church 69-kV line	Third source into area, possibly from Spring Valley
3	North Lake Geneva – Lake Geneva 69-kV line	105.2%	--	Cobblestone – Brick Church 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Lake Geneva – South Lake Geneva 69-kV line	118.8% 95.8%	--	Cobblestone – Brick Church 69-kV line Cobblestone – Zenda tap 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Cobblestone – Brick Church 69-kV line	133.3%	--	North Lake Geneva – Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Brick Church 138/69-kV transformer	105.6% 97.1%	--	North Lake Geneva 138/69-kV transformer North Lake Geneva – Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Enzyme Bio – RC3 69-kV line	96.5%	--	Brick Church 138/69-kV transformer	Line Y-32 rebuild
3	Paddock 138/69-kV transformer	97.3%	--	Colley Road 138/69-kV transformer	Bass Creek 138/69-kV transformer
3	Lake Geneva, Katzenberg, Twin Lakes, and South Lake Geneva, and Zenda 69-kV buses	--	68.6 – 82.0%	North Lake Geneva – Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Twin Lakes, Katzenberg, and South Lake Geneva 69-kV buses	--	90.6 – 91.7%	North Lake Geneva – Lake Geneva – South Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Brick Church 138-kV bus	--	91.6% 91.5% 90.8%	Beloit Gateway – Brick Church 138-kV line Colley Road – Dickinson – Beloit Gateway – Brick Church 138-kV line Dickinson – Beloit Gateway 138-kV line	Brick Church capacitors or third line into the area, possibly from Spring Valley
3	Twin Lakes, Katzenberg, and South Lake Geneva 69-kV buses	--	90.4 – 91.5%	Lake Geneva – South Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Cobblestone, Zenda, Twin Lakes, Katzenberg 69-kV buses	--	87.7 – 91.4%	Cobblestone – Brick Church 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Twin Lakes 69-kV bus	--	91.3%	Katzenberg – South Lake Geneva 69-kV line	Third source into area, possibly from Spring Valley

Table ZS-3
2020 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2020 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
4	Base case loading criteria exceeded	FALSE	--	System Intact	
4	Base case voltage criteria exceeded	--	FALSE	System Intact	
4	Highway V – Ontario 138-kV line	106.7% 102.1%	--	East Krok 138/69-kV transformer[8] Canal 138/69-kV transformer #1[9]	Uprate line
4	Canal – East Krok 138-kV line	101.9% 96.5%	--	Highway V 138/69-kV transformer #1[10] Highway V – Ontario 138-kV line	Uprate line
4	East Krok 138/69-kV transformer	109.4% 99.4% 99.1% 95.6%	--	Canal – East Krok 138-kV line Highway V 138/69-kV transformer #1[10] Highway V – East Krok 138-kV line Highway V 138/69-kV transformer #2[11]	No project needed Investigation into limiting facility resulted in higher facility ratings
4	Dyckesville – Rosiere 69-kV line	95.7%	--	East Krok 138/69-kV transformer[8]	Further study needed
4	Sunset Point – Pearl Avenue 69-kV line	119.1% 118.9%	--	Ellinwood 138/69-kV transformer[12] Ellinwood – 12th Avenue 69-kV line	Rebuild line
4	Edgewater – Sauk Trail 138-kV line	105.8%	--	Edgewater – Huebner 138-kV line	Uprate line
4	Sauk Trail – 20th Street 138-kV line	95.3%	--	Edgewater – Huebner 138-kV line	Uprate line
4	East Krok – Kewaunee 138-kV line	96.0%	--	North Appleton 345/138-kV transformer #1[1]	Further study needed
4	Manrap – Custer 69-kV line	95.4%	--	Dewey – Lakefront 69-kV line	Further study needed
5	Base Case Loading Criteria Exceeded	TRUE		System Intact	
5	Base Case Voltage Criteria Exceeded	--	FALSE	System Intact	
5	Bain 345/138-kV transformer #5	159.6% 108.8%	--	Split Pleasant Prairie 345-kV bus 34 Split Pleasant Prairie 345-kV bus 23	Mitigated by generation adjustments
5	Oak Creek 345/230-kV transformer T895	105.2% 104.9%	--	Split Oak Creek 230-kV bus 78 Split Oak Creek 230-kV bus 67	Mitigated by generation adjustments
5	Arcadian4 – Waukesha1 138-kV line	106.8%	--	Arcadian6 – Waukesha3 138-kV line	Rebuild line
5	Arcadian6 – Waukesha3 138-kV line	103.1%	--	Arcadian4 – Waukesha1 138-kV line	Rebuild line
5	Arcadian 345/138-kV transformer #3	101.9%	--	Arcadian 345/138-kV transformer #1	Replace transformer
5	Pleasant Prairie – Zion 345-kV line	95.6% 95.4%	--	Zion – Arcadian 345-kV line Cherry Valley – Silver Lake 345-kV line	Marginal issue, no mitigation needed within this timeframe
5	Kenosha – Lakeview 138-kV line	102.1%	--	Pleasant Prairie – Zion 345-kV line	Rebuild line. The existing conductor is 477 ACSR and is the limitation.
5	Lakeview – Zion 138-kV line	97.3%	--	Pleasant Prairie – Zion 345-kV line	No overload
5	Albers – Kenosha 138-kV line	106.0%	--	Bain – Kenosha 138-kV line	Uprate the 477 ACSR section of the Kenosha – Albers 138-kV line
5	Bluemound 230-kV bus, Allerton, Bark River, Brookdale, Edgewood, Cottonwood,Germantown, Mukwonago, Maple, O'Connor, and 28th St 138-kV buses	--	94.4 – 96.0%	System Intact	Shift Allerton load from T9 to T8 or connecting KK5063 to Brookdale 138-kV bus
5	Maple and Germantown 138-kV buses	--	90.4 – 90.9%	Saukville – Maple 138-kV line	Mitigated by generation adjustments

Table ZS-3_2020 constraints

Event Based Contingency Number	**Definition of Event Based Contingency**
1	North Appleton 345/138 kV xfmr #1 + North Appleton - Kewaunee 345 kV circuit
2	North Fond du Lac 138/69-kV transformer #3 + North Fond du Lac - Hickory Street Tap 69-kV line + North Fond du Lac - Rosendale 69-kV line + North Fond du Lac 69-kV bus capacitor
3	Metomen - Rosendale - North Fond du Lac 69-kV line
4	Arpin - Rocky run 345-kV line + Port Edwards - Sand Lake 138-kV line + Port Edwards - Hollywood 138-kV line + Council Creek - Council Creek DPC 69-kV line
5	Saratoga – ACEC Badger West - Petenwell 138-kV line
6	Whitcomb - CWEC Wittenberg Tap - Wittenberg Tap - Birnamwood Tap - Brooks Corner - Deer Trail 69-kV line
7	North Randolph – Fox Lake – North Beaver Dam 138-kV line
8	East Krok 138/69 kV xfmr + Highway V - East Krok 138 kV circuit + East Krok - Canal 138 kV circuit + East Krok - Kewaunee 138 kV circuit + Beardsely - East Krok 69 kV circuit
9	Canal 138/69 kV xfmr #1 + Canal - East Krok 138 kV circuit + Canal - Sawyer 69 kV circuit + Canal - Algoma 69 kV circuit + Canal 69 kV cap banks, 2 x 16.3 MVAr
10	Highway V 138/69 kV xfmr #1 + Highway V - Ontario 138 kV circuit + Highway V - Preble 138 kV circuit + Highway V - Finger Road 69 kV circuit + Highway V - Rockland 138 kV circuit + Highway V 138 kV cap bank, 2 x 18.9 MVAr
11	Highway V 138/69 kV xfmr #2 + Highway V - East Krok 138 kV circuit + Highway V - Mystery Hills 138 kV circuit + Highway V - Oak Street 69 kV circuit
12	Ellinwood 138/69 kV xfmr #1 + Ellinwood - Twelfth Ave 69 kV circuit + Ellinwood - Fitzgerald 138 kV circuit +Ellinwood 138 kV bus tie 1-2
13	M38-Atlantic 138-kV line + Atlantic 138/69-kV transformer

Table ZS-4
2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
1	Base case loading criteria exceeded	TRUE	--	System Intact	
1	Base case voltage criteria exceeded	--	FALSE	System Intact	
1	Silver Lake, ACEC Spring Lake, Redgranite, Fountain Valley, River Run, Berlin and Fox River 69-kV buses	--	84.6 – 88.8% 87.2 – 91.9% 87.5 – 90.8% 87.5 – 90.2% 88.8 – 91.9%	Wautoma – Silver Lake Tap 69-kV line Metomen – Ripon 69-kV line Silver Lake – ACEC Spring Lake 69-kV line Winneconne – Sunset Point 69-kV line Plus other less severe contingencies	Ripon capacitor expansion and Install capacitors at Dartford
1	Dartford,Ripon Industrial Park, Northwest Ripon and Ripon 69-kV buses	--	84.9 – 86.1% 87.1 – 88.1% 88.7 – 89.7% 91.1 – 91.9%	Metomen – Ripon 69-kV line Ripon – Northwest Ripon Tap 69-kV line Winneconne – Sunset Point 69-kV line Plus other less severe contingencies	Ripon capacitor expansion and Install capacitors at Dartford
1	Winneconne, Omro and Omro Industrial Park 69-kV buses	--	82.5 – 83.4% 89.6 – 89.9% 90.1 – 90.8% 90.8 – 91.5% 91.0 – 91.7%	Winneconne – Sunset Point 69-kV line Winneconne – Omro Tap 69-kV line Metomen – Ripon 69-kV line Ripon – Northwest Ripon Tap 69-kV line Wautoma – Silver Lake Tap 69-kV line	Ripon capacitor expansion and Install capacitors at Dartford
1	ACEC Brooks, Grand Marsh (PP&L) and Lincoln Pumping Station 69-kV buses	--	85.6 – 86.2% 85.6 – 86.1% 88.6 – 89.1% 90.2 – 90.5% 90.5 – 91.9%	Necedah Tap – Big Pond 69-kV line Chaffee Creek – Coloma Tap 69-kV line Necedah Tap – Whistling Wings Tap 69-kV line Wautoma – Port Edwards 138-kV line Plus other less severe contingencies	McKenna capacitor expansion
1	Sigel, Lakehead Pipeline, Port Edwards, Vulcan and Hollywood 138-kV buses	--	89.8 – 91.8%	Sigel – Arpin 138-kV line	Further Study needed
1	Petenwell and Council Creek 138-kV buses	--	95.8 – 96.4% 90.2 – 91.0% 90.2 – 91.0% 90.3 – 90.8% 91.9%	System Intact King – Arpin 345-kV line[1] Eau Claire to Arpin 345 kV[2] Arpin – Rocky Run 345-kV line[3] Sigel – Arpin 138-kV line	Marginal voltage, no mitigation needed within this timeframe
1	Necedah, Petenwell, Big Pond, ACEC Dellwood, Friendship, ACEC Friendship, Houghton Rock and McKenna 69-kV buses	--	95.8 – 96.1% 74.5 – 83.3% 81.3 – 87.0% 87.0 – 89.9% 87.0 – 89.8% 87.0 – 92.0%	System Intact Necedah Tap – Big Pond 69-kV line Necedah Tap – Whistling Wings Tap 69-kV line Dellwood ACEC – Whistling Wings Tap 69-kV line Petenwell – Big Pond 69-kV line Plus other less severe contingencies	McKenna capacitor expansion, Convert Necedah to 138 kV, redispatch Castle Rock generation

Table ZS-4
2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
1	Lakehead Pipeline Portage, Endeavor, Roslin ACEC and Montello ACEC 69-kV buses	--	89.5 – 90.8% 91.4 – 91.5%	Portage – Lakehead Pipeline Portage 69-kV line Endeavor – Lakehead Pipeline 69-kV line	Further Study needed
1	Sand Lake and Wautoma 138-kV buses	--	95.2 – 95.5% 90.7 – 92.0% 91.2% 92.0%	System Intact Arpin – Rocky Run 345-kV line[3] Sigel – Arpin 138-kV line Port Edwards – Sand Lake 138-kV line	Marginal voltage, no mitigation needed within this timeframe
1	ACEC Winnebago, ACEC Glen, Neenah Creek, ACEC Chateau and Westfield 69-kV buses	--	86.2 – 91.0% 91.2 – 91.8% 91.5% 91.5% 91.2 – 91.8%	Kilbourn – Winnebago ACEC 69-kV line Wautoma – Port Edwards 138-kV line Sand Lake Tap – Sand Lake 69-kV line Sand Lake 138/69-kV transformer Wautoma – Port Edwards 138-kV line	Increase capacitance at Neenah Creek
1	ACEC Coloma, Plainfield, Sand Lake, Hancock and ACEC Hancock 69-kV buses	--	83.4 – 84.5% 86.8 – 90.7% 87.3 – 91.1% 87.3 – 91.1% 88.6 – 89.6% 90.8 – 91.8%	Chaffee Creek – Coloma Tap 69-kV line Wautoma – Port Edwards 138-kV line Sand Lake Tap – Sand Lake 69-kV line Sand Lake 138/69-kV transformer Necedah Tap – Big Pond 69-kV line Plus other less severe contingencies	McKenna capacitor expansion
1	ACEC Quincy and Castle Rock 69-kV bus	--	88.6 – 89.2% 91.0 – 91.4%	Necedah Tap – Big Pond 69-kV line Necedah Tap – Whistling Wings Tap 69-kV line	McKenna capacitor expansion
1	Wittenburg 69-kV bus		92.0%	Whitcomb – Wittenberg CWEC 69 kV line	Marginal voltage, no mitigation needed within this timeframe
1	North Randolph – Markesan 69-kV line	96.6%	--	Metomen – Ripon 69-kV line	Marginal issue, no mitigation needed within this timeframe
1	Markesan – Mackford Pairie 69-kV line	98.4%	--	Metomen – Ripon 69-kV line	Marginal issue, no mitigation needed within this timeframe
1	Arnott 138/69 KV transformer #T31	100.9%	--	Harrison 138/69 kV transformer	Further Study needed
1	Caroline 115/69 KV transformer #T61	116.3%	--	Whitcomb 115/69-kV transformer	Replace Caroline 115/69-kV transformer
1	Chaffee Creek – Coloma Tap 69-kV line	136.3% 115.0% 106.4% 106.3% 106.2% -- 98.2%	--	Necedah Tap – Big Pond 69-kV line Necedah Tap – Whistling Wings Tap 69-kV line King – Eau Claire 345 kV tie line[1] King – Arpin 345-kV line[4] Plus other less severe contingencies	Uprate terminal equipment at Chaffee Creek

Table ZS-4
2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
1	Castle Rock – ACEC Quincy 69-kV line	138.6% 120.7% 112.9% 112.9% 108.1% 105.3% -- 99.5%	--	Necedah Tap – Big Pond 69-kV line Necedah Tap – Whistling Wings Tap 69-kV line Petenwell – Big Pond 69-kV line Petenwell 138/69-kV transformer Dellwood ACEC – Whistling Wings Tap 69-kV line Plus other less severe contingencies	Uprate Castle Rock – McKenna 69-kV line
1	ACEC Quincy – McKenna 69-kV line	131.4% 113.6% 105.9% 105.9% 101.1% 95.2%	--	Necedah Tap – Big Pond 69-kV line Necedah Tap – Whistling Wings Tap 69-kV line Petenwell – Big Pond 69-kV line Petenwell 138/69-kV transformer Dellwood ACEC – Whistling Wings Tap 69-kV line Chaffee Creek – Coloma Tap 69-kV line	Uprate Castle Rock – McKenna 69-kV line
1	Brooks Corners 69-kV bus	--	85.9%	Whitcomb – Deer Trail 69-kV line[22]	Adjust Brooks Corners 69/34.5-kV transformer LTC
1	Harrison – Harrison Tap 69-kV line	116.1% 108.6% 108.1% 106.0% 105.7 – 100.3%	--	Wautoma 138/69-kV transformer Winneconne – Sunset Point 69-kV line Portage – Lakehead Pipeline Portage 69-kV line Endeavor – Lakehead Pipeline 69-kV line Plus other less severe contingencies	Further Study needed
1	Harrison 138/69 KV transformer #T1	124.1% 104.8% 100.7% 100.7% 100.0 – 97.2%	--	System Intact Arnott 138/69-kV transformer Whitcomb – Rosholt Tap 69-kV line Arnott 69-kV bus Plus other less severe contingencies	Replace Harrison 138/69-kV transformer
1	Hilltop – Mauston 69-kV line	106.7%	--	Arpin – Rocky Run 345-kV line3	Further Study needed
1	Metomen – Ripon 69-kV line	106.5% 118.8% 109.7% 104.2% 103.9 -- 95.8%	--	System Intact Winneconne – Sunset Point 69-kV line Winneconne – Omro Tap 69-kV line North Randolph – Markesan Tap 69-kV line Plus other less severe contingencies	Second Metomen – Ripon 69-kV line

Table ZS-4
2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
1	Metomen 138/69 KV transformer #T31	109.8% 117.5% 115.7% 109.1% 108.9 – 97.0%	--	System Intact North Fond du Lac 138/69-kV transformer #3[5] North Fond du Lac – Rosendale Tap 69-kV line Metomen – North Fond du Lac 69 kV line[6] Plus other less severe contingencies	Replace Metomen 138/69-kV transformer
1	Northwest Ripon – Ripon 69-kV line	119.4% 105.2% 97.0%	--	Winneconne – Sunset Point 69-kV line Winneconne – Omro Tap 69-kV line Omro – Omro Industrial Tap 69-kV line	Uprate line
1	NW Ripon – Dartford 69-kV line	100.9%	--	Winneconne – Sunset Point 69-kV line	Further Study needed
1	Omro – Winneconne 69-kV line	102.2% 113.1% 112.4% 100.9%	--	System Intact Ripon – Northwest Ripon Tap 69-kV line Metomen – Ripon 69-kV line Northwest Ripon Tap – Dartford Tap 69-kV line	Further Study needed
1	Petenwell – ACEC Badger West 138-kV line	104.9% 104.9% 104.5% 104.4%	--	Eau Claire to Arpin 345 kV line[2] Eau Claire to Arpin 345 kV line[7] King – Arpin 345-kV line[1] King – Eau Claire 345-kV line[4]	Further Study needed
1	Petenwell 138/69-kV transformer	101.0% 107.6% 107.1% 104.9% 104.0% 104.0 – 97.1%	--	System Intact McKenna – Houghton Rock 69-kV line Castle Rock – Quincy ACEC 69-kV line Hilltop – Buckhorn Tap 69-kV line McKenna – Quincy ACEC 69-kV line Plus other less severe contingencies	Replace Petenwell transformer
1	Sand Lake 138/69-kV transformer	103.0% 99.9% 95.2%	--	System Intact Wautoma 138/69-kV transformer Necedah Tap – Big Pond 69-kV line	Further Study needed
1	Sand Lake – Sand Lake Tap 69-kV line	106.3% 112.5% 111.5% 107.6% 107.0 – 99.3%	--	System Intact Wautoma 138/69-kV Transformer Necedah Tap – Big Pond 69-kV line Trienda – Lewiston ACEC 138-kV line Plus other less severe contingencies	Further Study needed

Table ZS-4
2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
1	Saratoga – ACEC Badger West 138-kV line	109.3% 109.3% 108.9% 108.8%	--	Eau Claire to Arpin 345-kV tie line[2] Eau Claire to Arpin 345-kV line[2] King – Arpin 345-kV line[1] King – Eau Claire 345 kV tie line[4]	Further Study needed
1	Sigel – Auburndale 69-kV line	130.2%	--	System Intact	Line validated with higher rating
1	Vulcan – Port Edwards 1 138-kV line	123.8%	--	Vulcan – Port Edwards 138-kV line #2	Change tap on free standing CT's at Port Edwards
1	Vulcan – Port Edwards 2 138-kV line	123.8%	--	Vulcan – Port Edwards 138-kV line #1	Change tap on free standing CT's at Port Edwards
1	Rocky Run 345/115-kV transformer #T4	99.8% 99.6% 98.7% 95.2%	--	Rocky Run 345/115-kV transformer #T2 Sigel – Arpin 138-kV line Rocky Run 345/115-kV transformer #T1 Arpin 345/138-kV transformer	Marginal issue, no mitigation needed in this timeframe
1	Wautoma 138/69-kV transformer #T31	118.1% 113.9% 113.9% 105.8% 105.0 – 95.9%	--	System Intact Sand Lake Tap – Sand Lake 69-kV line Sand Lake 138/69-kV transformer Portage – Lakehead Pipeline Portage 69-kV line Plus other less severe contingencies	Second 138/69-kV Transformer at Wautoma
1	Whitcomb 115/69-kV transformer #T31	99.4%	--	System Intact	Marginal issue, no mitigatin needed in this timeframe
1	Winneconne – Sunset Point 69-kV line	118.6% 118.2% 107.2% 102.2% 97.1%	--	Ripon – Northwest Ripon Tap 69-kV line Metomen – Ripon 69-kV line Northwest Ripon Tap – Dartford Tap 69-kV line Wautoma – Silver Lake Tap 69-kV line Silver Lake – ACEC Spring Lake 69-kV line	Uprate line
2	Base case loading criteria exceeded	FALSE	--	System Intact	
2	Base case voltage criteria exceeded	--	FALSE	System Intact	
2	Atlantic – M38 69-kV line	121.7% 121.6% 117.9%	--	M38 – Atlantic 138-kV line[23] Atlantic 138/69-kV transformer Roberts – Newberry Hospital 69-kV line	Uprate line
2	Nordic – Mountain 69-kV line	102.4%	--	Chandler 138/69-kV transformer	Targeted for mitigation by Escanaba area reinforcements

Table ZS-4
2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
2	Rudyard – Pine River 69-kV line Rudyard – Tone 69-kV line Kinchloe – Tone 69-kV line	111.4% 114.7% 107.9%	--	Engadine – Newberry 69-kV line	Mitigated by generation adjustments
2	Hulbert, Brimley, Detour, Eckermann, Goetzville, Pickford, Raco, Lou-Pac, Newberry Village, Roberts, Talantino 69-kV buses	--	75.4 – 90.4%	Hiawatha – Roberts 69-kV line 6911[24]	Targeted for mitigation by Eastern U.P. area reinforcements
2	Lakota Road 69-kV bus	--	118.1%	Lakota – Conover 138/69-kV transformer	Resolved by transformer model adjustments
2	Chandler, Delta, Escanaba 1, Escanaba 2, Masonville, Mead, Gladstone, West, North Bluff, Lakehead, Bay View, Cornell, Harris 69-kV buses	--	87.1 – 90.2%	Chandler 138/69-kV transformer	Targeted for mitigation by Escanaba area reinforcements
2	Detour 69-kV bus, Brevort, Hiawatha, Lakehead 138-kV buses	--	90.9 – 91.9%	Straits 138/69-kV transformer	Targeted for mitigation by Eastern U.P. area reinforcements
2	Hulbert, Sault, Brimley, Dafter, Detour, Eckermann, Goetzville, Newberry, Pickford, Raco, Lou-Pac, Newberry Hospital, Newberry Village, Roberts, Three Mile, ESE Hydro, Magazine, Nine Mile, Kinchloe, Rockview, Michigan Limestone, Pine Grove, Tone, Talantino 69-kV buses	--	56.3 – 88.2%	Engadine – Newberry 69-kV line	Targeted for mitigation by Eastern U.P. area reinforcements
2	Hulbert, Brimley, Detour, Eckermann, Goetzville, Pickford, Raco, Lou-Pac, Newberry Hospital, Newberry Village, Roberts, Talantino 69-kV buses	--	72.9 -88.9%	Newberry – Newberry Hospital 69-kV line	Targeted for mitigation by Eastern U.P. area reinforcements
2	Hulbert, Brimley, Detour, Eckermann, Goetzville, Pickford, Raco, Lou-Pac, Newberry Village, Roberts, Three Mile, Magazine, Michigan Limestone, Pine Grove, Talantino 69-kV buses	--	71.6 – 90.2%	Newberry Hospital – Roberts 69-kV line	Targeted for mitigation by Eastern U.P. area reinforcements
3	Base case loading criteria exceeded	TRUE	--	System Intact	
3	Base case voltage criteria exceeded	--	TRUE	System Intact	
3	Kilbourn, Loch Mirror, Birchwood, Dell Creek, Zobel, Nishan, Artesian, Rock Springs 138-kV bus	--	95.6 – 96.6% 86.3 – 89.0% 86.9 – 89.4% 86.9 – 89.4% 89.0 – 90.8% 91.1 – 92.0%	System Intact Trienda – Lewiston ACEC 138-kV line Kilbourn – Lewiston ACEC 138-kV line Trienda – Kilbourn 138-kV line Lake Delton – Trienda 138-kV line Plus other less severe contingencies	
3	Okee, Lodi Industrial Park and Lodi 69-kV buses	--	88.3 – 89.7% 90.2 – 91.6%	Dane – Lodi Tap 69-kV line Lodi Tap – Okee Tap 69-kV line	

Table ZS-4
2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
3	Kirkwood and Lake Delton 138-kV buses	--	95.0 – 95.1% 87.2 – 87.3% 90.0% 90.3 – 90.7% 90.4% 90.6 – 90.9% 90.6 – 90.9%	System Intact Lake Delton – Trienda 138-kV line Lake Delton – Kirkwood 138-kV line Trienda – Lewiston ACEC 138-kV line Trienda – Kirkwood 138-kV line8 Kilbourn – Lewiston ACEC 138-kV line Trienda – Kilbourn 138-kV line	
3	Island Street, Baraboo, Sauk Prairie, Prairie du Sac Muni, Tower Street, Dam Heights and Prairie du Sac Hydro 69-kV buses	--	88.2 – 90.2% 91.9% 91.9%	Island Street – Kirkwood 69-kV line Baraboo Tap – Moore Street Tap 69 kV line Island Street – Moore Street Tap 69-kV line	
3	Artesian – Rock Springs 138-KV line	101.9% 99.7% 99.7%	--	Trienda – Lewiston ACEC 138-kV line Kilbourn – Lewiston ACEC 138-kV line Trienda – Kilbourn 138-kV line	
3	Kirkwood – Rock Springs 138-KV line	105.4% 103.3% 103.2%	--	Trienda – Lewiston ACEC 138-kV line Trienda – Kilbourn 138-kV line Kilbourn – Lewiston ACEC 138-kV line	
3	Kilbourn – Lewiston 138-kV line	100.7%	--	Lake Delton – Trienda 138-kV line	
3	Trienda – Lewiston 138-kV line	102.6% 96.2% 95.0%	--	Lake Delton – Trienda 138-kV line Trienda – Kirkwood 138-kV line8 Lake Delton – Kirkwood 138-kV line	
3	Dane – Lodi Tap 69-kV line	122.5% 111.3% 108.7% 108.7% 102.9 – 96.5%	--	Island Street – Kirkwood 69-kV line Lake Delton – Trienda 138-kV line Baraboo Tap – Moore Street Tap 69-kV line Island Street – Moore Street Tap 69-kV line Plus other less severe contingencies	
3	Kilbourn 138/69-kV transformer #T32	99.3%	--	Kilbourn 138/69-kV transformer T31	
3	Portage – Columbia 1 138-kV line	100.5%	--	Portage – Columbia 2 138-kV line	
3	Portage – Columbia 2 138-kV line	100.5%	--	Portage – Columbia 1 138-kV line	
3	Portage – Trienda 1 138-kV line	97.5%	--	Portage – Trienda 2 138-kV line	
3	Portage – Trienda 2 138-kV line	107.4%	--	Portage – Trienda 1 138-kV line	
3	Cobblestone – Zenda Tap 69-kV line	218.6% 134.0% 132.3%	--	North Lake Geneva – Lake Geneva 69-kV line Lake Geneva – South Lake Geneva 69-kV line North Lake Geneva – Lake Geneva – South Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line

Table ZS-4
2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
3	Colley Road 138/69-kV transformer	127.8% 109.7% 106.4% 106.1% 103.3 – 98.5%	--	Paddock 138/69-kV transformer Paddock – Shirland 69-kV line System Intact Brick Church 138/69-kV transformer Plus other less severe outages	Bass Creek 138/69-kV transformer
3	Katzenberg – Zenda tap 69-kV line	201.5% 119.4% 117.8%	--	North Lake Geneva – Lake Geneva 69-kV line Lake Geneva – South Lake Geneva 69-kV line North Lake Geneva – Lake Geneva – South Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Katzenberg – South Lake Geneva 69-kV line	138.6% 104.3% 103.9%	--	Cobblestone – Brick Church 69-kV line North Lake Geneva – Lake Geneva 69-kV line Cobblestone – Zenda Tap 69-kV line	Third source into area, possibliy from Spring Valley
3	North Lake Geneva – Lake Geneva 69-kV line	126.7% 105.1%	--	Cobblestone – Brick Church 69-kV line Cobblestone – Zenda tap 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	North Lake Geneva 138/69-kV transformer	106.8%	--	Brick Church 138/69-kV transformer	North Lake Geneva – South Lake Geneva 138-kV line
3	Lake Geneva – South Lake Geneva 69-kV line	146.0% 116.9% 101.6%	--	Cobblestone – Brick Church 69-kV line Cobblestone – Zenda tap 69-kV line Katzenberg – Zenda tap 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Cobblestone – Brick Church 69-kV line	178.0% 114.7% 113.3%	--	North Lake Geneva – Lake Geneva 69-kV line Lake Geneva – South Lake Geneva 69-kV line North Lake Geneva – Lake Geneva – South Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Brick Church 138/69-kV transformer	126.8% 109.1% 97.0%	--	North Lake Geneva 138/69-kV transformer North Lake Geneva – Lake Geneva 69-kV line System Intact	North Lake Geneva – South Lake Geneva 138-kV line
3	Brick Church – Walworth 69-kV line	118.8%	--	North Lake Geneva 138/69-kV transformer	North Lake Geneva – South Lake Geneva 138-kV line
3	Enzyme Bio – RC3 69-kV line	104.1%	--	Brick Church 138/69-kV transformer	Line Y-32 rebuild
3	RC3 – Clinton Tap 69-kV line	97.2%	--	Brick Church 138/69-kV transformer	Line Y-32 rebuild
3	Paddock 138/69-kV transformer	112.5% 112.3% 104.2% 96.3%	--	Colley Road 138/69-kV transformer Intact System Colley Road – Park Street 69-kV line Park Street – East Rockton 69-kV line	Bass Creek 138/69-kV transformer
3	Walworth – Schofield tap 69-kV line	97.6%	--	North Lake Geneva – Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Schofield tap – North Lake Geneva 69-kV line	96.9%	--	North Lake Geneva – Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Paddock – Shirland Ave 69-kV line	105.2%	--	Colley Road 138/69-kV transformer	Further Study needed
3	Shaw – East Rockton 69-kV line	105.1%	--	Paddock 138/69-kV transformer	Bass Creek 138/69-kV transformer
3	East Rockton – Park St 69-kV line	98.5%	--	Paddock 138/69-kV transformer	Bass Creek 138/69-kV transformer

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2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
3	Colley Road – Park St 69-kV line	109.4%	--	Paddock 138/69-kV transformer	Bass Creek 138/69-kV transformer
3	McCue – Milton Lawns 69-kV line	100.6%	--	Janesville 138/69-kV transformer	Further Study needed
3	Lake Geneva, South Lake Geneva, Twin Lakes, Katzenberg, Zenda, Cobblestone, Brick Church, Sharon, Walworth, Lakehead-Walworth 69-kV buses, Brick Church and Williams Bay 138-kV buses	--	47.1 – 92.0%	North Lake Geneva – Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Twin Lakes, Katzenberg, South Lake Geneva, and Zenda 69-kV buses	--	80.9 – 89.2%	North Lake Geneva – Lake Geneva – South Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Twin Lakes and Zenda 69-kV buses	--	91.3 – 91.8%	Cobblestone – Zenda tap 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Twin Lakes, Katzenberg, South Lake Geneva and Zenda 69-kV buses	--	79.9 – 88.3%	Lake Geneva – South Lake Geneva 69-kV line	North Lake Geneva – South Lake Geneva 138-kV line
3	Cobblestone, Zenda, Twin Lakes, Katzenberg 69-kV buses	--	84.4 – 88.8%	Cobblestone – Brick Church 69-kV line	North Lake Geneva – South Lake Geneva 138kV line
3	Twin Lakes and Katzenberg 138-kV buses	--	87.1 -88.3%	Katzenberg – South Lake Geneva 69-kV line	Third source into area, possibliy from Spring Valley
3	Twin Lakes, Katzenberg, South Lake Geneva, Lake Geneva, North Lake Geneva, Zenda, and Schofield 69-kV buses	--	83.9 – 90.4%	North Lake Geneva 138/69-kV transformer	North Lake Geneva – South Lake Geneva 138-kV line
3	Brick Church and Williams Bay 138-kV buses	--	90.3 – 91.6%	Colley Road – Dickinson – Beloit Gateway – Brick Church 138-kV line	Y-32 line rebuild
3	Brick Church, Dickinson and Williams Bay 138-kV buses	--	90.6 – 91.6%	Colley Road – Dickinson 138-kV line	Y-32 line rebuild
3	Concord 5 138-kV bus	--	91.6%	Split Concord 138-kV bus	Marginal voltage, no mitigation needed within this timeframe
3	RC9 , RC2, West Darien and SW Delavan 138-kV buses	--	91.6 – 91.9%	RC9 – Rock River 138-kV line	Y-32 line rebuild
3	Brick Church and Williams Bay 138-kV buses	--	89.3 – 90.7%	Beloit Gateway – Dickinson 138-kV line	Y-32 line rebuild
3	Brick Church and Williams Bay 138-kV buses	--	90.3 – 91.5%	Beloit Gateway – Brick Church 138-kV line	Y-32 line rebuild
3	South Fond du Lac – Koch Oil Tap 69-kV line	101.0% 96.5% 96.3%	--	North Randolph – Fox Lake 138-kV line Fox Lake – North Beaver Dam 138-kV line North Randolph – North Beaver Dam 138-kV line[9]	Further study needed
3	Kock Oil Tap – Waupun 69-kV line	96.8%	--	North Randolph – Fox Lake 138-kV line	Further study needed
3	Hubbard and Hustisford 138-kV bus	--	85.3% 86.1% 86.1%	Rubicon – Hustisford 138-kV line Hustisford – Hubbard 138-kV line Rubicon – Hustisford – Hubbard 138-kV line	Adjust Hubbard 138/69-kV transformer LTC

Table ZS-4
2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
3	Fox Lake, North Beaver Dam and Beaver Dam East 138-kV buses	--	95.9 – 96.1% 84.6 – 84.7% 85.6 – 85.7% 85.6 – 85.7% 90.4 – 92.0%	System Intact North Randolph – Fox Lake 138-kV line Fox Lake – North Beaver Dam 138-kV line North Randolph – North Beaver Dam 138-kV line[9] Plus other less severe contingencies	Adjust North Beaver Dam 138/69-kV transformer LTC
3	North Randolph and Academy 138-kV bus	--	95.8 – 95.9% 91.1%	System Intact Boxelder – Academy 138-kV line	Further study needed
3	Koch Oil, Waupun and Alto Dairy 69-kV bus	--	91.0 – 91.1% 91.7 – 91.8%	South Fond du Lac – Koch Oil Tap 69-kV line Waupan – Koch Oil Tap 69-kV line	Further study needed
3	Horicon Industrial Park, Horicon and Juneau 69-kV bus	--	91.2 – 91.4% 91.7 – 91.8%	Hubbard – Horicon Industrial Park 69-kV line South Fond du Lac – Waupun 69-kV line[10]	Further study needed
3	Randolph and Didion Ethanol 69-kV bus	--	91.5 – 91.7%	North Randolph – Randolph Tap 69-kV line	Further study needed
3	McCue – REC Harmony 69-kV line	95.9%	--	System Intact	Second McCue-Lamar line
3	Hillman 138/69-kV transformer	100.0%	--	System Intact	Second Hillman transformer
3	North Monroe 138/69-kV transformer	113.0%	--	System Intact	Bass Creek transformer
3	REC Newark – Paddock 69-kV line	97.0%	--	System Intact	Bass Creek transformer
3	Timberlane Tap – West Middleton 69-kV line	106.0%	--	System Intact	Further Study needed
3	Verona 138/69-kV transformer	112.7 – 96%	--	Stoughton South – Stoughton 69-kV line Oregon – Stoughton 69-kV line Stoughton South tap – Oregon 69-kV line North Monroe 138/69-kV transformer West Middleton – Timberlane 69-kV line plus other less severe contingencies	Bass Creek and potential second Verona transformer
3	Stoughton – Stoughton Muni South Tap – Oregon 69-kV line	122.8 – 106.9%	--	Verona – Oak Ridge 138-kV line Verona 138/69-kV transformer	Y127 line uprate
3	Mount Horeb Northeast – Stagecoach 69-kV line	98.2%	--	Verona – Southwest Verona 69-kV line	Further Study needed
3	Sun Valley Tap – Oregon 69-kV line	102.1%	--	Stoughton South – Stoughton 69-kV line	Y119 rebuild and potential Oregon terminal upgrade
3	Hillman 138/69-kV transformer	122.1 – 95.4%	--	DPC Galena – Pilot NB 69-kV line DPC Terr Tap – Pilot NB 69-kV line DPC LNGHLLW8 – Terr Tap 69-kV line DPC LNGHLLW8 – Galna T8 69-kV line DPC Galna – Guilford 69-kV line plus other less severe contingencies	Secnd Hillman transformer

Table ZS-4
2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
3	North Monroe – Idle Hour – Monroe Tap 69-kV line	139.3 – 95.9%	--	Paddock – Newark 69-kV line Brodhead – Newark 69-kV line Paddock – Brodhead Switching Station 69-kV line[12] Darlington – Gratiot 69-kV line Spring Grove – Brodhead Switching Station 69-kV line Plus other less severe outages	Bass Creek transformer and potential Y87 line uprate
3	North Monroe 138/69-kV transformer	114.7 – 95.3%	--	Columbia generator #1 Columbia generator #2 Darlington 138/69-kV transformer	Bass Creek transformer
3	Jennings Switching Station – Wiota – DPC Gratiot Tap 69-kV line	104.5 – 97.5%	--	North Monroe – Idle Hour 69-kV line North Monroe 138/69-kV transformer	Y34 line uprate
3	Brodhead Switching Station – REC Newark – Paddock 69-kV line	112.2 – 95.3%	--	North Monroe – Idle Hour 69-kV line North Monroe 138/69-kV transformer Idel Hour – Monroe Central tap 69-kV line Albany – Townline 138-kV line	Bass Creek transformer
3	McCue – REC Harmony – Milton Tap – Lamar 69-kV line	115.6 – 95.6%	--	Kegonsa – Stoughton North Tap2 69-kV line Kegonsa 138/69-kV transformer Stoughton North Tap1 – Stoughton North Tap2 69-kV line Stoughton East – Stoughton North 69-kV line Stoughton East – Stoughton 69-kV line plus other less severe contingencies	Second McCue-Lamar line
3	Dana Corporation Tap – Sheepskin 69-kV line	137.1 – 125.4%	--	McCue – Harmony 69-kV line Milton Tap – Lamar 69-kV line McCue – Lamar 69-kV line[13] Milton Tap – Harmony 69-kV line	Y62 line uprate and second McCue-Lamar line
3	Gran Grae – Wauzeka – Boscobel 69-kV line	110.2 – 95.1%	--	Spring Green 138/69-kV transformer Nelson Dewey – Lancaster 138-kV line Nelson Dewey – Eden 138-kV line Eden – Lancaster 138-kV line Eden – Wyoming Valley 138-kV line Columbia generator #1 plus other less severe contingencies	Y40 line uprate
3	Boscobel – Blue River Tap 69-kV line	99.0 – 96.3%	--	Nelson Dewey – Lancaster 138-kV line Spring Green 138/69-kV transformer Nelson Dewey – Eden 138-kV line[11] Eden – Lancaster 138-kV line	Y124 line uprate
3	Spring Green 138/69-kV transformer	95.7%	--	Gran Grae – Wauzeka 69-kV line	Second Spring Green transformer

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2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
3	Black Earth – Stagecoach 69-kV line	103.2%	--	Spring Green 138/69-kV transformer	Second Spring Green transformer
3	Stagecoach – Timberlane Tap – West Middleton 69-kV line	132.2 – 95.7%	--	Spring Green 138/69-kV transformer Verona – Southwest Verona 69-kV line Verona – Oak Ridge 138-kV line Verona 138/69-kV transformer Nelson Dewey – Lancaster 138-kV line plus other less severe contingencies	Further Study needed
3	Dane – North Madison 69-kV line	102.8 – 95.4%	--	Huiskamp 138/69-kV transformer Huiskamp – North Madison 138-kV line North Madison – Huiscamp 138-kV line Waunakee Industrial Park – Huiskamp 69-kV line North Madison – Deforest 69-kV line	Potential Huiskamp-Blount 138-kV line
3	Waunakee Industrial Park – Huiskamp 69-kV line	97.7%	--	North Madison 138/69-kV transformer	Y132 GOAB uprate
3	West Middleton – Pheasant Branch 69-kV line	98.5%	--	Waunakee Switching – Waunakee Municipal 2 69-kV line	6963 line uprate
3	West Middleton 138/69-kV transformer	103.8%	--	West Middleton 138/69-kV transformer	Cardinal-Blount 138-kV line
3	Westport – Waunakee Muni2 69-kV line	102.3%	--	West Middleton – Pheasant Branch 69-kV line	Y131 line uprate
3	Royster – Sycamore 69-kV line	104.1%	--	Femrite 138/69-kV transformer	Royster – Sycamore line uprate or second Femrite transformer
3	East Towne – Sycamore 69-kV line 2	98.7%	--	East Towne – Sycamore 69-kV line 1	Potential line uprate
3	East Towne – Sycamore 69-kV line 1	98.7%	--	East Towne – Sycamore 69-kV line 2	Potential line uprate
3	Nelson Dewey – Cassville 161-kV line	102.9 – 100.8%	--	Genoa 161/69-kV transformer DPC Seneca – Genoa 161-kV line	Further study needed
3	North Monroe – Albany – Townline Road 138-kV line	101.3 – 95.3%	--	Darlington – Lafayette Wind 138-kV line Nelson Dewey – Potosi 138-kV line Potosi – Hillman 138-kV line Hillman – Nelson Dewey 138-kV line[14]	Potential X-12 rebuild
3	Verona, Oak Ridge, Hawk Alliant, Hawk, Cross Country and Fitchburg 138-kV buses	--	93.6 – 95.8%	System Intact	Potential Oak Ridge capacitor bank
3	North Monroe 138-kV bus	--	95.7%	System Intact	North Monroe capacitor bank
3	Spring Green, Wyoming Valley and Troy 138-kV buses	--	95.5 – 95.7%	System Intact	Further study needed
3	Miner, Shullsburg, Benton, Cuba City and Elmo 69-kV buses	--	85.8 – 91.8%	DPC Galena – Pilot NB 69-kV line DPC Terr Tap – Pilot NB 69-kV line DPC LNGHLLW8 – Terr Tap 69-kV line	Further Study needed

Table ZS-4
2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
3	Southwest verona, Mount Horeb Muni1, Mount Horeb, Mount Horeb Northeast, Forward and Blanchardville 69-kV buses	--	77.8 – 91.6%	Verona – Southwest Verona 69-kV line	SW Verona Unity Power factor correction and 1-16.33 Mvar 69-kV capacitor bank
3	Aaker Road, Stoughton Muni South Tap and Brooklyn 69-kV buses	--	91.7 – 91.8%	Stoughton South – Stoughton 69-kV line	SW Verona Unity Power factor correction and 1-16.33 Mvar 69-kV capacitor bank
3	Huiskamp 138-kV bus	--	88.2%	Huiskamp – North Madison 138-kV line	Adjust Huiskamp 138/69-kV transformer LTC
3	Rewey and Belmont 69-kV buses	--	90.6 – 91.4%	Eden – Rewey 69-kV line Belmont – Rewey 69-kV line	Further Study needed
3	Idle Hour, Monroe, Monroe Tap, South Monroe, Blacksmith, Blacksmith Tap, Browntown and Spring Grove 69-kV buses	--	85.5 – 91.6%	North Monroe – Idle Hour 69-kV line Idel Hour – Monroe Central tap 69-kV line	Further study needed
3	Brodhead Muni3, Brodhead Muni2, Brodhead, Brodhead Muni1, REC Orfordville, Orfordville, Bass Creek and Footville 69-kV buses	--	90.3 – 92%	Brodhead Switching Station – Brodhead Muni3 69-kV line Brodhead Muni3 – Brodhead Muni2 69-kV line	Bass Creek transformer
3	REC Newark and Brodhead Muni2 69-kV buses	--	91.9 – 92%	Paddock – Newark 69-kV line	Bass Creek transformer
3	REC Harmony, Milton, Milton Tap, Lamar, Fulton, Saunders Creek, Dana corporation, Dana Corporation Tap, REC Edgerton, Sheepskin, Evansville and Union Townline 69-kV buses	--	83.8 – 92%	McCue – Harmony 69-kV line Milton Tap – Harmony 69-kV line Milton Tap – Lamar 69-kV line McCue – Lamar 69-kV line[13]	Second McCue-Lamar line
3	Arena 69-kV bus	--	91.5%	Spring Green – Arena 69-kV line	Mazomanie capacitor bank
3	Cottage Grove and Gaston Road 69-kV buses	--	90.4%	Kegonsa – Cottage Grove 69-kV line	Sun Prairie capacitor bank
3	Lancaster, Eden, Wyoming Valley, Spring Green and Troy 138-kV buses	--	87.4 – 91.9%	Nelson Dewey – Lancaster 138-kV line Eden – Lancaster 138-kV line Nelson Dewey – Eden 138-kV line[11]	Potential Y105 conversion
3	Albany and North Monroe 138-kV buses	--	90.2 – 91%	Albany – Townline 138-kV line North Monroe – Albany 138-kV line Townline Road – North Monroe 138-kV line[15]	North Monroe capacitor bank
3	Pleasant View, Hawk Alliant and Hawk 138-kV buses	--	91.6 – 91.8%	West Middleton – Pleasant View 138-kV line	Further study needed
3	Verona, Fitchburg, Oak Ridge and Cross Country 138-kV buses	--	90.7 – 91.9%	Rockdale – West Middleton 345-kV line	Potential Oak Ridge capacitor bank
3	Darlington and North Monroe 138-kV buses	--	87.4 – 90.3%	Darlington – Lafayette Wind 138-kV line	North Monroe capacitor bank
3	Muscoda, Avoca and Avoca Tap 69-kV buses	--	91.1 – 91.3%	Lone Rock – Spring Green 69-kV line	Boscobel capacitor bank
3	Mcgregor, Pioneer, Platteville tap, Hillman, Elmo, Cuba City, Benton, Belmont, Miner and Shullsburg 69-kV buses	--	85.5 – 90.5%	Hillman 138/69-kV transformer	Second Hillman transformer

Table ZS-4
2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
3	Idle Hour, Monroe, Monroe Tap, South Monroe, North Monroe, Monticello, Monticello Tap, New Glarus, Blacksmith, Blacksmith Tap, Belleville, and Browntown 69-kV buses	--	88.2 – 91.9%	North Monroe 138/69-kV transformer	North Monroe capacitor bank
3	Burke, Reiner, Burke Tap and Colorado 69-kV buses	--	90.9 – 91.5%	Reiner 138/69-kV transformer Reiner – Burke Tap 69-kV line	Sun Prairie capacitor bank
3	Avoca, Muscoda, Avoca Tap, Spring Green, Arena, Lone Rock, Mazomanie Industrial, Mazomanie West, Mazomanie , Blue River Tap, Blue River and Black Earth 69-kV buses	--	87.7 – 91.4%	Spring Green 138/69-kV transformer	Second Spring Green transformer
3	Southwest verona, Sun Valley, Verona, Sun Valley Tap, Brooklyn, Belleville, Oregon, Mount Horeb Muni1 and Mount Horeb 69-kV buses	--	87.3 – 91.9%	Verona 138/69-kV transformer Verona – Oak Ridge 138-kV line	SW Verona Unity Power factor correction and 1-16.33 Mvar 69-kV capacitor bank
3	Verona, Fitchburg and Oak Ridge 138-kV buses	--	90.9 – 92.0%	West Middleton 138/69-kV transformer	Potential Oak Ridge capacitor bank
3	Verona, Eden, Spring Green, Troy and Wyoming Valley 138-kV buses	--	90.3 – 91.8%	Columbia Generator Unit 1 Columbia Generator Unit 2	Potential Oak Ridge capacitor bank
4	Base case loading criteria exceeded	TRUE	--	System Intact	
4	Base case voltage criteria exceeded	--	FALSE	System Intact	
4	Highway V – Ontario 138-kV line	115.2% 110.6% 102.8%	--	East Krok 138/69-kV transformer[16] Canal 138/69-kV transformer #1[17] Canal – East Krok 138-kV line	Uprate line
4	Canal – East Krok 138-kV line	106.9% 101.0%	--	Highway V 138/69-kV transformer #1[18] Highway V – Ontario 138-kV line	Uprate line
4	East Krok 138/69-kV transformer	109.5% 99.3% 98.2% 97.7%	--	Canal – East Krok 138-kV line Highway V 138/69-kV transformer #1[18] Highway V – East Krok 138-kV line Highway V 138/69-kV transformer #2[19]	No project needed Investigation into limiting facility resulted in higher facility ratings
4	Dyckesville – Rosiere 69-kV line	96.0%	--	East Krok 138/69-kV transformer[16]	Further study needed
4	Sunset Point – Pearl Avenue 69-kV line	122.1% 121.9%	--	Ellinwood 138/69-kV transformer[20] Ellinwood – 12th Avenue 69-kV line	Rebuild line
4	Sunset Point 138/69-kV transformer #1	105.1%	--	Sunset Point 138/69-kV transformer #2	Replace transformer
4	Sunset Point 138/69-kV transformer #2	95.7%	--	Sunset Point 138/69-kV transformer #1	Further study needed
4	Neevin – Woodenshoe 138-kV line	97.5%	--	Fitzgerald 345/138-kV transformer #1[21]	Further study needed
4	Edgewater 345/138-kV transformer #1	95.1%	--	Edgewater 345/138-kV transformer #2	Further study needed
4	Edgewater 138/69-kV transformer #1	102.0% 99.0%	--	System Intact Edgewater 138/69-kV transformer #2	Replace transformer
4	Edgewater 138/69-kV transformer #2	100.0%	--	System Intact	Replace transformer
4	Edgewater – Sauk Trail 138-kV line	118.4% 95.0%	--	Edgewater – Huebner 138-kV line Lodestar – Huebner 138-kV line	Uprate line
4	Sauk Trail – 20th Street 138-kV line	107.0%	--	Edgewater – Huebner 138-kV line	Further study needed

Table ZS-4
2025 Limitations and Performance Criteria Exceeded

Planning Zone	Criteria Exceeded/Need	2025 Summer Peak Case		Facility Outage(s)	Project/Mitigation
		% of Facility Rating	% of Nominal Bus Voltage		
4	Manrap – Custer 69-kV line	98.2%	--	Dewey – Lakefront 69-kV line	Further study needed
4	Bluestone 69-kV bus	--	90.5%	Finger Road – Bluestone 69-kV line	Further study needed
5	Base Case Loading Criteria Exceeded	FALSE		System Intact	
5	Base Case Voltage Criteria Exceeded	--	FALSE	System Intact	
5	Bain 345/138-kV transformer #5	159.4% 106.5%	--	Split Pleasant Prairie 345-kV bus 34 Split Pleasant Prairie 345-kV bus 23	Mitigated by generation adjustments
5	Oak Creek 345/230-kV transformer T895	105.0% 104.8%	--	Split Oak Creek 230-kV bus 67 Split Oak Creek 230-kV bus 78	Mitigated by generation adjustments
5	Arcadian 345/138-kV transformer #3	95.5%	--	Arcadian 345/138-kV transformer #1	Replace Arcadian transformer
5	Pleasant Prairie – Zion 345-kV line	101.9% 98.7% 95.4%	--	Zion – Arcadian 345-kV line Cherry Valley – Silver Lake 345-kV line Kenosha – Lakeview 138-kV line	Uprate line

Event Based Contingencies

Event Based Contingency Number	Definition of Event Based Contingency
1	King - Eau Claire 345-kV line + Eau Claire - Arpin 345-kV line + Eau Claire 345/161-kV transformer + Council Creek DPC - Council Creek 69-kV line + Hilltop - Mauston 69-kV line
2	Eau Claire - Arpin 345-kV line + Council Creek DPC - Council Creek 69-kV line + Hilltop - Mauston 69-kV line
3	Arpin - Rocky Run 345-kV line + Port Edwards - Sand Lake 138-kV line + Port Edwards - Hollywood 138-kV line + Council Creek - Council Creek DPC 69-kV line
4	King - Eau Claire 345-kV line + Eau Claire - Arpin 345-kV line + Eau Claire 345/161-kV transformer + Council Creek DPC - Council Creek 69-kV line + Hilltop - Mauston 69-kV line + Lubin - Lakehead 69-kV line
5	North Fond du Lac 138/69-kV transformer #3 + North Fond du Lac - Hickory Street Tap 69-kV line + North Fond du Lac - Rosendale 69-kV line + North Fond du Lac 69-kV bus capacitor
6	Metomen - Rosendale - North Fond du Lac 69-kV line
7	Eau Claire - Arpin 345-kV line + Council Creek DPC - Council Creek 69-kV line + Hilltop - Mauston 69-kV line + Lubin - Lakehead 69-kV line
8	Trienda - Lake Delton 138-kV line + Lake Delton - Kirkwood 138-kV line
9	North Randolph – Fox Lake – North Beaver Dam 138-kV line
10	South Fond du Lac - Koch Oil tap 69 kV circuit + Koch Oil tap - Waupun 69 kV circuit + Koch Oil tap - Koch Oil 69 kV circuit
11	Nelson Dewey – Lancaster – Eden 138-kV line
12	Paddock - Brodhead Switching Station 69-kV line
13	McCue – Harmony – Milton Tap – Lamar 69-kV line
14	Hillman – Potosi – Nelson Dewey 138-kV line
15	Townline Road – Albany – North Monroe 138-kV line
16	East Krok 138/69 kV xfmr + Highway V - East Krok 138 kV circuit + East Krok - Canal 138 kV circuit + East Krok - Kewaunee 138 kV circuit + Beardsely - East Krok 69 kV circuit
17	Canal 138/69 kV xfmr #1 + Canal - East Krok 138 kV circuit + Canal - Sawyer 69 kV circuit + Canal - Algoma 69 kV circuit + Canal 69 kV cap banks, 2 x 16.3 MVAr
18	Highway V 138/69 kV xfmr #1 + Highway V - Ontario 138 kV circuit + Highway V - Preble 138 kV circuit + Highway V - Finger Road 69 kV circuit + Highway V - Rockland 138 kV circuit + Highway V 138 kV cap bank, 2 x 18.9 MVAr
19	Highway V 138/69 kV xfmr #2 + Highway V - East Krok 138 kV circuit + Highway V - Mystery Hills 138 kV circuit + Highway V - Oak Street 69 kV circuit
20	Ellinwood 138/69 kV xfmr #1 + Ellinwood - Twelfth Ave 69 kV circuit + Ellinwood - Fitzgerald 138 kV circuit +Ellinwood 138 kV bus tie 1-2
21	Fitzgerald 345/138 kV xfmr + Fitzgerald - North Appleton 345 kV circuit + Fitzgerald - South Fond du Lac 345 kV circuit
22	Whitcomb - CWEC Wittenberg Tap - Wittenberg Tap - Birnamwood Tap - Brooks Corner - Deer Trail 69-kV line
23	Atlantic 138/69-kV transformer + M38 – Atlantic 138-kV line
24	Hiawatha – Engadine – Newberry – Roberts 69-kV line

Table ZS-7: ATC System Angular Stability Assessment for 2010 10-Year Assessment

	Facility Studied	# Units	Total Capacity (MW)	Last Year 0f Detail Study	Response Selected NERC Category B2-3, C3, C5, C8-9 and D2-3 Outages (NERC Reliability Criteria)				SPS	Note
					2010	2011~2014	2015	Appropriate for 2016~2020		
	Existing Units									
1	Pleasant Prairie	2	1208.0	2007	Acceptable (2, 3)	Acceptable (2, 3)	Acceptable (2, 3)	Yes	No	IPO Breakers; See note (4)
2	Paris	4	400.0	2008	Acceptable (2, 3)	Acceptable (2, 3)	Acceptable (2, 3)	Yes	No	
3	Oak Creak	7	1138.0	2007	Acceptable (5)	Acceptable (5)	Acceptable (5)	Yes	No	
4	Valley	2	280.0	2009	Acceptable (3)	Acceptable (3)	Acceptable (3)	Yes	No	See note (6)
5	Germantown	5	345.0	2005	Acceptable	Acceptable	Acceptable	Yes	No	See notes (7, 8)
6	Port Washington CC1	6	1080.0	2009	Acceptable (3)	Acceptable (3)	Acceptable (3)	Yes	No	
7	Point Beach	2	512; 514	2009	Acceptable (9)	Acceptable (9)	Acceptable (9)	Yes	Yes	
8	Kewaunee	1	579.0	2009	Acceptable (3)	Acceptable (3)	Acceptable (3)	Yes	No	IPO Breakers
9	Edgewater	3	773.0	2005	Acceptable	Acceptable	Acceptable	Yes	Yes	See Notes (10, 11)
10	S. Fond du Lac	4	352.0	2005	Acceptable	Acceptable	Acceptable	Yes	No	See Note (12)
11	Neevin	2	300.0	2005	Acceptable (1, 2, 3)	Acceptable (1, 2, 3)	Acceptable (1, 2, 3)	Yes	No	
12	De Pere	1	185.0	2005	Acceptable	Acceptable	Acceptable	Yes	No	See Notes (13, 14)
13	Pulliam	6	459.0	2005	Acceptable (1, 2, 3)	Acceptable (1, 2, 3)	Acceptable (1, 2, 3)	Yes	No	
14	West Marinette	4	240.0	2009	Acceptable (3)	Acceptable (3)	Acceptable (3)	Yes	No	
15	Fox Energy	3	672.3	2008	Acceptable (2, 3)	Acceptable (2, 3)	Acceptable (2, 3)	Yes	No	IPO Breakers
16	Sheboygan Energy	2	343.0	2005	Acceptable (1, 2, 3)	Acceptable (1, 2, 3)	Acceptable (1, 2, 3)	Yes	No	
17	Cypress	88	145.2	2009	Acceptable (3)	Acceptable (3)	Acceptable (3)	Yes	No	
18	Forward Energy Center	86	129.0	2008	Acceptable (2, 3)	Acceptable (2, 3)	Acceptable (2, 3)	Yes	No	
19	Columbia	2	1050.0	2005	Acceptable (1, 2, 3)	Acceptable (1, 2, 3)	Acceptable (1, 2, 3)	Yes	No	IPO Breakers
20	Christiana	3	544.5	2005	Acceptable (1, 2, 3)	Acceptable (1, 2, 3)	Acceptable (1, 2, 3)	Yes	No	
21	Riverside	3	659.1	2005	Acceptable	Acceptable	Acceptable	Yes	No	See Notes (15, 16)
22	Rock River	5	132.0	2005	Acceptable	Acceptable	Acceptable	Yes	No	See Notes (17, 18)
23	Nelson Dewey	2	226.0	2010	Acceptable (2, 3)	Acceptable (2, 3)	Acceptable (2, 3)	Yes	No	See Note (19)
24	University	2	236.0	2008	Acceptable (2, 3)	Acceptable (2, 3)	Acceptable (2, 3)	Yes	No	
25	Concord	4	400.0	2008	Acceptable (2, 3)	Acceptable (2, 3)	Acceptable (2, 3)	Yes	No	
26	West Campus	3	147.2	2009	Acceptable (3)	Acceptable (3)	Acceptable (3)	Yes	No	
27	Presque Isle	5	431.0	2007	Acceptable (3, 20)	Acceptable (3, 20)	Acceptable (3, 20)	Yes	Yes	
28	Weston	5	552.6	2005	Acceptable (3, 21)	Acceptable (3, 21)	Acceptable (3, 21)	Yes	No	IPO Breakers, See Note (22)
	New / Future Units									
29	Elm Road Phase I	1	615.0	2007	Acceptable (6)	Acceptable (6)	Acceptable (6)	Acceptable (6)	No	IPO Breakers
30	Elm Road Phase II	1	615.0	2007		Acceptable (6)	Acceptable (6)	Acceptable (6)	No	IPO Breakers
31	Green Lake (wind)	108	160.0	2006		Acceptable (23)	Acceptable (23)	Acceptable (23)	No	
32	Bowers Road (wind)	70	105.0	2006		Acceptable (24)	Acceptable (24)	Acceptable (24)	No	
33	EcoMet (wind)	67	100.5	2008		Acceptable (25)	Acceptable (25)	Acceptable (25)	No	
34	Ledge (wind)	100	150.0	2008			Acceptable (26)	Acceptable (26)	No	

These shaded rows represent units at plants in which there have been a significant system topological change near the plant or significant parameter changes or updates to the dynamic models used in stability studies and are to be studied in the 2010 TYA as part the system angular stability analysis

Notes:

(1) Comparing 2008 TYA models with 2005 TYA models, no significant change has occurred near the generation station, other than the local load growth. Therefore, the stability results from the 2005 TYA are still applicable and are acceptable in the following years.

(2) Comparing 2009 TYA models with 2008 TYA models, no significant change has occurred near the generation station, other than the local load growth. Therefore, the stability results from the 2008 TYA are still applicable and are acceptable in the following years.

(3) Comparing 2010 TYA models with 2009 TYA models, no significant change has occurred near the generation station, other than the local load growth. Therefore, the stability results from the 2009 TYA are still applicable and are acceptable in the following years.

(4) Since 2009 TYA Pleasant Prairie Special Protection Scheme (SPS) study was completed on May 27, 2009 and concluded the SPS was no longer required and could be retired.

(5) "Final Facility Study Update – Revision 2 Phase I, II & III Milwaukee County, Wisconsin MISO #G051 (#36760-01)" dated January 15, 2007.

(6) Since 2009 TYA study work proceding to replace breaker failure relays with SEL-352 relays on lines 301, 302 and 311 and replace the existing three cycle oil breakers with two cycle gas breakers at positions 314, 321, and 324.

(7) Germantown plant data provided by the generator owner showed the parameter values for the exciter model of unit 5 had changed from current values in use.

(8) Stability simulations for the Germantown plant did not meet ATC requirements for single-phase to ground faults (C8-9) or three-phase faults with delayed clearing (D2). Action plan involves addition of redundent bus differential relays and reduction of delayed clearing times for zone 2 relaying or breaker failure.

(9) "Final ISIS Report Point Beach Generators Manitowoc County, Wisconsin MISO #G833/J022 (#39297-01), G834/J023 (#39297-02)" dated October 2, 2009.

(10) Edgewater plant data provided by the generator owner showed replacement of the exciter model on units 3 and 4. Inaddition, needed to evaluate performance since

not all 345 kV breakers are IPO breakers along with topological changes on 1-345 and 1-138 kV line.

(11) Stability simulations for the Edgewater plant did not meet ATC requirements for single-phase to ground faults (C9) with delayed clearing. Action plan involves addition of redundent bus differential relays by 2013 and in the interim improvement of clearing times to maintain stability.

Notes (Continued):

(12) South Fond du Lac plant data provided by the generator owner showed capacity changes for all 4 units. Inaddition, needed to evaluate performance since 345 kV breakers are not IPO breakers.

(13) De Pere plant data had significant 138 kV line impedance changes near plant, as well as capacity changes and the plant approaching the 5-year time line criteria.

(14) Stability simulations for the De Pere plant did not meet ATC requirements for single-phase to ground faults (C9) with delayed clearing. Action plan involves addition of redundent bus differential relays or reducing zone 2 clearing times at De Pere terminal.

(15) Riverside plant data provided by the generator owner showed the parameter values for the power system stabilizier (PSS) model of the steam unit had changed from current values in use. In addition, the PSS equipment for the combustion turbines units 1 and 2 are not active and hence required the current modeling in use be removed.

(16) Stability simulations for the Riverside plant did not meet ATC requirements for single-phase to ground faults (C9) with delayed clearing. Action plan involves addition of redundent bus differential relays or reducing zone 2 clearing times at Townline Road terminal.

(17) Rock River plant data had significant 138 kV line impedance changes near plant, as well as capacity changes with units G1 and G2 retired and the plant approaching the 5-year time line criteria.

(18) Stability simulations for the Rock River plant did not meet ATC requirements for single-phase to ground faults (C9) or three-phase faults with delayed clearing (D2-3). Action plan involves addition of redundent bus differential relays and reduction of delayed clearing times for zone 2 relaying or breaker failure.

(19) "Interconnection System Impact Study Report 50 MW Wind Generation Grant County, Wisconsin J084" dated June 24, 2010

(20) "Presque Isle Special Protection System “Remedial Action Tripping Scheme” (RATS)" Version 3.0 dated December 17, 2007. http://oasis.midwestiso.org/documents/ATC/PresqueIsleSPS-v3.pdf

(21) "Generator Interconnection Facility Study Report 550 MW Coal Generation - Addendum IV, Marathon County, Wisconsin; MISO #G144 (#37187-02)" dated June 16, 2005.

(22) "Weston Unit 4 Special Protection System Review Final Draft" Report, dated February 9, 2009 concluded SPS could be retired.

(23) "Interconnection System Impact Study Report - Addendum II 160 MW Wind Generation Green Lake; Fond du Lac County, Wisconsin - MISO #G376 (#37935-03)" dated May 31, 2006.

(24) "G546 Interconnection System Impact Study Report Revision 2 100 MW Wind Generation; Walworth County - MISO #G546 (#38605-01)" dated December 13, 2006.

(25) "Interconnection System Impact Study Report 99 MW Wind Generation; Calumet County, Wisconsin" - MISO #G611 (#38791-01)" dated October 24, 2008.

(26) "Interconnection System Impact Study Report 150 MW Wind Generation; Brown County, Wisconsin" - MISO #G773 (#39168-01)" dated June 30, 2008.