

## **Summary**

Primarily due to recent data revisions for MISO generator interconnection requests G833, G834, J022 and J023, the previously completed stability analysis described in the Interim Operation and Impacts Study report dated December 30, 2008 was re-performed to identify the impact of these modifications and to provide interim operating limitations and/or interim system upgrades needed to maximize the output of G833/834 until completion of a long term solution. Key modification includes

- In-service date of new generator step-up transformer of Unit 2 (October 2009)
- MW output increased by 6 MW per unit (total 642.96 MW gross per unit)
- Dynamic models of unit 1 and 2

G833/J022 and G834/J023, with an expected in-service date of May 31, 2011 and May 31, 2010, respectively, are now 59 MW increases to each of the existing Point Beach nuclear units.

For this updated Interim Operation and Impacts Study, no new thermal analysis has been performed since the plant impact will not change substantially. No significant impact is expected due to additional 12 MW output increase. In addition, ATC has not performed voltage analysis at this time due to focused effort on the transient instability issues previously identified.

Three different scenarios were studied for the stability analysis, which are

- Interim 1 (2010~2011) representing a scenario with G834/J023 and without G833/J022
- Interim 2A (2011 and beyond) representing a scenario with all four requests and without Kewaunee bus reconfiguration project
- Interim 2B (2011 and beyond) representing a scenario with all four requests and with Kewaunee bus reconfiguration project

Different generation patterns and load levels were considered for each scenario. Consistent with the G833/4 Interconnection System Impact Study (ISIS), both high and low Fox Valley generation scenarios were studied to evaluate angular stability for the scenarios.

This study assumes the Point Beach generator and turbine improvements submitted for J022/023 (MISO queue dates: January 16 and 14, 2009). The limitations and solutions summarized in this report may not be valid if the Point Beach data changes.

### ***Key Assumption:***

Prior to performing the stability analysis, ATC investigated and reviewed historical reactive power outputs from both the Point Beach and Kewaunee plants. Reactive power output from a synchronous machine has an impact on the transient stability of the unit. Therefore, for the interim study, ATC wanted to review the assumptions for building the study models. ATC selected a unit reactive power output level that is generally consistent

with historical levels and corresponds to the low end of the preferred voltage range at the Point Beach power plant.

As a result, 352 kV (1.0203 pu) is assumed as the voltage schedule of both the Point Beach and Kewaunee generating units. The voltage schedule is consistent with the lowest value of the preferred voltage range of Point Beach (see Attachment H of OP 2A Revision 64). The table below shows the MVAR output (gross) from the Point Beach and Kewaunee units in each studied scenario. These study assumptions need to be discussed further with the plant owner. These assumptions will be altered for the long-term upgrade analysis (i.e. the formal restudy of the ISIS) to ensure a wider operating envelope for the local transmission system and the interconnected generators.

Table 1. MVAR outputs (gross) from Point Beach and Kewaunee

Stability Study Cases	MVAR outputs (gross) from Point Beach and Kewaunee with 352 kV voltage schedule assumed	
	Low Generation Scenario	High Generation Scenario
Interim 1 (with G834/J023 and without G833/J022, without Kewaunee project)	47.4 MVAR at Point Beach G1 47.4 MVAR at Point Beach G2 30.4 MVAR at Kewaunee	75.6 MVAR at Point Beach G1 75.6 MVAR at Point Beach G2 62.2 MVAR at Kewaunee
Interim 2a (with G833/J022 and G834/J023, without Kewaunee project)	60.1 MVAR at Point Beach G1 60.1 MVAR at Point Beach G2 35.8 MVAR at Kewaunee	85.7 MVAR at Point Beach G1 85.7 MVAR at Point Beach G2 68.2 MVAR at Kewaunee
Interim 2b (with G833/J022 and G834/J023, with Kewaunee project)	60.1 MVAR at Point Beach G1 60.1 MVAR at Point Beach G2 35.8 MVAR at Kewaunee	85.7 MVAR at Point Beach G1 85.7 MVAR at Point Beach G2 68.2 MVAR at Kewaunee

***Study Results and Interim System Upgrades:***

The following pages describe the study results and interim system upgrades identified using the assumptions described above. ATC is continuing to examine the feasibility of constructing the interim system upgrades in the noted timeframes as well as identifying preliminary, good faith estimate of cost for these upgrades.

As described in the previously posted Interim Operation and Impacts Study report, the thermal upgrades are needed for certain system scenarios but not all scenarios. The most critical upgrade is the improvement required to 345-kV line 111 from Point Beach to Sheboygan Energy Center, which has also been independently identified by ATC for improvement due to MISO energy market impacts.

The stability related upgrades are required for increased plant operation during all hours in the year. In addition, the identified stability upgrades do not eliminate all restrictions

on the upgraded Point Beach units since operating restrictions will exist during each interim period for certain prior outage conditions. These restrictions are described following the stability upgrades.

**Required Interim Upgrades:**

Thermal Upgrades:

<b>Location</b>	<b>Facilities</b>	<b>Reason</b>	<b>In-service Date</b>	<b>Good Faith Cost Estimate (Y2009)</b>
<b>Cypress-Arcadian 345-kV line</b>	Look at plan and profile and Patrol to observe any close wire crossings and adjust to obtain a minimum Summer Emergency rating of 572 MVA (957.3 A).	Injection Limit	5/1/2010	\$
<b>Point Beach-Sheboygan Energy Center 345-kV line</b>	L111 requires a minimum summer emergency rating of 592 MVA (990.8 A). An existing ATC project (PRF PR03208) requires a minimum summer emergency rating of 1120 MVA with a proposed in-service date of Spring 2010. Completion of PRF PR03208 accomplishes the requirements for G833/J022 and G834/J023.	Injection Limit	5/1/2010	\$

Stability Upgrades:

Required Timeframe	Upgrade Description	Cost (\$M)	Constructability Issues
By EPU Unit #1 Synchronization	North Appleton R-304 Circuit Breaker Replacement with 2 cycle Circuit Breaker implemented for Independent Pole Operation		
By EPU Unit #2 Synchronization	Point Beach L111 SBF Breaker Failure Relay replacement with an SEL-352 and the existing Line 111 SEL-221F backup relay replacement with an SEL-421.		
	Point Beach L151 SBF Breaker Failure Relay replacement with an SEL-352 and the existing Line 151 SEL-221F backup relay replacement with an SEL-421.		
	Point Beach 345 kV Circuit Breaker Addition in series with the existing Q-303 Circuit Breaker to isolate line fault in primary time <sup>1</sup>		
	Relay setting change (without Breaker Failure relay replacement) for Failure of Point Beach Bus Tie 2-3 to no more than 11 cycle total breaker failure clearing time for bus faults		
	L121 SEL-221F backup relay replacement with SEL-421. Although it is not due to Point Beach uprates, the relay replacement is proposed to provide better maintenance and operations flexibility during a L121 relay outage.		

1. Proposed if installing a series breaker is feasible. If it is not feasible, replace existing Position 131 SBF breaker failure relay with an SEL-352, and replace the existing Line Q303 SEL-221F backup relay with an SEL-421 in order to improve existing breaker failure clearing time. With the relays upgraded, Point Beach G2 will need to be restricted to 600 MW at all times (with 8.0 cycle BF clearing time, previously 580 MW with 8.25 BF clearing time) from May 2011 until completion of the Kewaunee reconfiguration project (roughly 18 months).
2. Kewaunee 345 kV bus reconfiguration project addresses some of the stability issues (see the table shown in the study result section).
3. Under certain prior outage conditions, G834/J023 and/or G833/J022 will need to be restricted in anticipation of next contingency (see also the table shown in the study result section).

## Identified Operating Restrictions after Stability Upgrades

With the stability upgrades and thermal upgrades assumed in-service, generation restrictions identified for each interim period are

- a. During Interim 1 period (2010-2011)
  - i. G1 at 560 MW (gross) under prior outage condition of 6832 (North Appleton-Fox River 345 kV line)
  - ii. G1 at 580 MW (gross) under prior outage condition of Point Beach Bus Tie 23
  
- b. During Interim 2a period (2011-beyond without Kewaunee project)
  - i. G2 at 620 MW (gross) under prior outage of 121 (Point Beach-Forest Junction 345 kV line)
  - ii. G2 at 620 MW (gross) under prior outage of 151 (Point Beach-Fox River 345 kV line)
  - iii. G2 at 600 MW (gross) under prior outage of R304 (Kewaunee-North Appleton 345 kV line)
  - iv. Both G1 and G2 at 540 MW (gross) under prior outage of 6832 (North Appleton-Fox River 345 kV line)
  - v. G2 at 580 MW (gross) under prior outage of SEC31 (Sheboygan Energy Center-Granville 345 kV line)
  - vi. G1 at 580 MW (gross) under prior outage of Point Beach Bus Tie 23
  - vii. G2 at 620 MW (gross) under prior outage of Point Beach Bus Tie 45
  
- c. During Interim 2b period (2011-beyond with Kewaunee project)
  - i. G2 at 600 MW (gross) under prior outage condition of 6832 (North Appleton-Fox River 345 kV line)
  - ii. G1 at 580 MW (gross) under prior outage condition of Point Beach Bus Tie 23

***Study Result:***

Please see the table from the next page.

DRAFT G833/834 & J022/023 Interim Year Results

Type of Fault	Fault causing problems	Prior Outage	Interim Period 1 (G834 - 642.96 MW gross)				Interim Period 2 (G834-3 - each 642.96 MW gross, with existing KEW)				Interim Period 2 (G834-3 - each 642.96 MW gross, with New KEW)							
			System Problem	Potential Solutions		Tested Clearing Time with potential solutions	Comments	System Problem	Potential Solutions		Tested Clearing Time with potential solutions	Comments	System Problem	Potential Solutions		tested clearing time with potential solutions	Comments	
				Generation Restriction (MW gross)	Other Upgrade				Generation Restriction (MW gross)	Other Upgrade Required				Generation Restriction (MW gross)	Other Upgrade Required			
Breaker failure	L111 @ P		none					K,P	G2 620 at all times (see comments)	SEL 352 and SEL 421 relay (see comment)	3.5/9.25/4.5	9.0 tested clearing time is needed to avoid G2 restriction. Per ATC Protection, 9.0 tested clearing time can be achieved with the relay upgrade	K,P	G2 620 at all times (see comments)	SEL 352 and SEL 421 relay (see comments)	3.5/9.25/4.5	9.0 tested clearing time is needed to avoid G2 restriction. Per ATC Protection, 9.0 tested clearing time can be achieved with the relay upgrade	
	L151 @ P						K,P		SEL 352 and SEL 421 relay	3.5/9.5/4.5		K,P		SEL 352 and SEL 421 relay	3.5/9.5/4.5			
	Q303 @ P						K,P	G2 580 at all times (see comments)	SEL 352 and SEL 421 relay (see comment)	3.5/9.25/6.5	P2 tripped even at 8.0 cycle tested clearing time. To avoid G2 restriction, install a series breaker.	K,P		SEL 352 and SEL 421 relay	3.5/9.25/4.5			
	R304 @ K						none					K,P		Replace R304 breaker at NAP	3.5/9.5/4.5	W/ Kewaunee project, breaker failure clearing time becomes 8.5 cycles (i.e. 9.5 cycle with 1 cycle margin)		
Intact primary																		
Intact system double circuit fault																		
Fault under prior outage	R304 @ K	111							K,P,F		Replace R304 breaker at NAP	5.5/4.5		none				
	T10 @ H	111							P		None. 5.0 cycle is existing clearing time per ATC Protection.	6.0/8.5						
	R304 @ K	121							K,P	G2 620	Replace R304 breaker at NAP	5.5/4.5	5.0 cycle tested clearing time to avoid G2 restriction					
	T10 @ H	121							P		None. 5.0 cycle is existing clearing time per ATC Protection.	6.0/8.5						
	R304 @ K	151						K,P	G2 620	Replace R304 breaker at NAP	5.5/4.5	5.0/4.5 tested clearing time to avoid G2 restriction. At 5.5/4.5 tested clearing time with G2 at full output POB trips due to voltage sag (P1 1.513s for 19KV, P2 1.521s for 19KV, B1B5 1st 1.083s, B1B5 2nd 1.575s). Thus, if time delay can be readjusted, only thing needs to be done is replacing R304 breaker at NAP						
	T10 @ H	151						P		None. 5.0 cycle is existing clearing time per ATC Protection.	6.0/8.5							
	6832 @ Fox	R304						K,P,F	G2 600			4.0/4.5 tested clearing time to avoid G2 restriction. At 4.5/4.5 with G2 620 MW gross, 345 kV 2nd criteria is violated: B1: 1.583s and B2: 1.583s. Readjusting time delay is needed for 620 MW.						
	R304 @ K	6832	K,P,F,S	G1 560	Replace R304 breaker at NAP	5.5/4.5		K,P,F,S	Both G1 and G2 at 540	Replace R304 breaker at NAP	5.5/4.5	Even 4.5/4.5 tested clearing time trips gen. See also the restriction w/ new Kewaunee	K,P,F		G2 600	Replace R304 breaker at NAP	4.5/4.5	

DRAFT G833/834 & J022/023 Interim Year Results

Type of Fault	Fault causing problems	Prior Outage	Interim Period 1 (G834 - 642.96 MW gross)				Interim Period 2 (G834-3 - each 642.96 MW gross, with existing KEW)				Interim Period 2 (G834-3 - each 642.96 MW gross, with New KEW)								
			System Problem	Potential Solutions			System Problem	Potential Solutions			System Problem	Potential Solutions							
				Generation Restriction (MW gross)	Other Upgrade	Tested Clearing Time with potential solutions		Comments	Generation Restriction (MW gross)	Other Upgrade Required		Tested Clearing Time with potential solutions	Comments	Generation Restriction (MW gross)	Other Upgrade Required	tested clearing time with potential solutions	Comments		
	T10 @ H	6832	P,F		None. 5.0 cycle is existing clearing time per ATC Protection.	6.0/8.5		P,F	G2 580	5.0 cycle is existing clearing time per ATC Protection	6.0/8.5	5.0/8.5 tested clearing time to avoid G2 restriction	none						
	R304 @ K	SEC31	K,P,F,S		Replace R304 breaker at NAP	5.5/4.5		K,P,F,S	G2 580	Replace R304 breaker at NAP	5.5/4.5								
	T10 @ H	SEC31	K,P,S,F,T H23		None. 5.0 cycle is existing clearing time per ATC Protection	6.0/8.5		K,P,F,S	G2 580	5.0 cycle is existing clearing time per ATC Protection	6.0/8.5	5.5/8.5 tested clearing time to avoid G2 restriction							
	R304 @ K	POB12	none					K,P,Fs		Replace R304 breaker at NAP	5.5/4.5								
	T10 @ H	POB12						P		None. 5.0 cycle is existing clearing time per ATC Protection	6.0/8.5								
	121 @ P	POB23		P1	G1 580		4.5/4.5	Open bus tie during G1 refueling outage	P1	G1 580		4.5/4.5		Open bus tie during G1 refueling outage	P1	G1 580		4.5/4.5	Open bus tie during G1 refueling outage
	R304 @ K	POB45	none					K,P	G2 620	Replace R304 breaker at NAP	5.5/4.5								
T10 @ H	POB45						P		None. 5.0 cycle is existing clearing time per ATC Protection	6.0/8.5									
POB SLG Bus Fault with breaker failure	B2, B3BF							P2		relay setting change	4.75/12.0		none						
Primary Aux Fault	AUX 1	121	none					K,P				CCT - 5.5/6.0							
	AUX 1	R304						K,P					CCT - 5.5/6.0	K,P				CCT - 5.5/6.0	
	AUX 1	6832						K,P,F					CCT - 5.0/6.0	K,P,F				CCT - 5.0/6.0	
	AUX 1	CYP31						K,P,F					CCT - 5.0/6.0	K,P,F				CCT - 5.0/6.0	
	AUX 1	NAPL71						K,P,F					CCT - 5.5/6.0	K,P,F				CCT - 5.5/6.0	
	AUX 1	311						K,P,F					CCT - 5.5/6.0	K,P,F				CCT - 5.5/6.0	
	AUX 2	111						K,P					CCT - 5.5/6.0	P				At 5.75/6.1 tested clearing time - UV trip P (19kV 1.521s, 345kV 1st 1.096s, 345kV 2nd 1.562s) CCT - 5.5/6.0	
	AUX 2	121						K,P					CCT - 5.0/6.0	K,P				CCT - 5.0/6.0	
	AUX 2	R304						K,P					CCT - 5.0/6.0	K,P				CCT - 5.0/6.0	
	AUX 2	SEC31						K,P,S					CCT - 5.0/6.0	K,P,S				CCT - 5.0/6.0	
AUX 2	B12					K,P					CCT - 5.5/6.0	K,P				CCT - 5.5/6.0			
Primary Aux Fault with breaker failure													none						
Primary GSU fault																			
GSU breaker failure																			
Unit Trip																			

**Nomenclature**

<i>K: Kewaunee</i>	L111: Point Beach-Sheboygan Energy Center 345 kV line	NAPL71: North Appleton-Werner West 345 kV line	H: <i>High side</i>
<i>P: Point Beach (P1, P2)</i>	L121: Point Beach-Forest Junction 345 kV line	CYP31: Cypress-Arcadian 345 kV line	POBxy: Point Beach bus tie xy
<i>S: Sheboygan Energy</i>	Q303: Point Beach-Kewaunee 345 kV line	6832: North Appleton-Fox Energy Center 345 kV line	
<i>F: Fox Energy</i>	L151: Point Beach-Fox Energy 345 kV line	T10: Kewaunee T10 345/138 kV transformer	
<i>TH: Thilmany</i>	R304: Kewaunee-North Appleton 345 kV line	SEC31: Sheboygan Energy Center-Granville 345 kV line	

**Note:** Tested clearing times noted in the table includes 1.0 cycle margin. The Planning margin is added to the local primary clearing time for primary clearing simulations and the local breaker failure time for breaker failure simulations.