Generator Validation Study

Sheboygan Falls Energy Facility

MISO #G103 (#37062-04)

Sheboygan County, Wisconsin

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American Transmission Company, LLC

Robert L. Krueger

Transmission Planning and Service

Executive Summary

This study evaluates the performance of the as-built modeling data for the Sheboygan Falls Energy Facility against what was given to ATCLLC at the time the Final Facility Study was performed. This study determined that the Sheboygan Falls Energy Facility is allowed to operate without any restrictions at this time. If the Point beach up-rate proceeds, an additional evaluation will be performed to determine if a new operating restriction will be imposed upon the generator.

Introduction

The purpose of this study is to determine if changes in generator modeling data for the Sheboygan Falls Energy Facility impacts the stability of the transmission system. At the time that this study was performed, it was uncertain if the implementation of the Point Beach up-rate (MISO #G063) would be completed by the time that the Sheboygan Falls Energy Facility would enter into commercial operation. Therefore, all simulations performed for this study did not include the Point Beach up-rate. The studies did include the Kewaunee up-rate (MISO #G165), and the addition of the Fox Energy Center (MISO #G044). The Kewaunee up-rate is currently in place and it is expected that the Fox Energy Center will be operational summer 2005. Due to the relative location of Port Washington to the Sheboygan Falls Energy Facility, the new Port Washington generation (MISO #G093) was not included in this study.

The Sheboygan Falls Energy Facility is located in Sheboygan County, Wisconsin. The total gross plant output is projected to be 370 MW. The generators initially planned for installation of this site had a rating of 222 MVA with a normal ISO rating of 188.7 MW. After the initial studies were completed, the customer chose to only install two of the three units, lowering the net MW output of the plant to 370 MW's, based on the ISO rating of the generation units and projected auxiliary loads. The recently submitted data shows that the machines now have a rating of 204 MVA, with an ISO rating of 173.4 MW. All studies performed for this evaluation have the generators operating at a gross output level of 173.4 MW's (each), minus the total station auxiliary loads of 3.9 MW/2.4 MVAR. The planned in-service date for the project is June 2005. The Sheboygan Falls Energy Facility will be connected to the Point Beach – Granville 345kV line through a proposed 345kV ring-bus substation. Figure 1 shows the one line diagram of the system with the proposed Sheboygan Falls Energy Facility and competing generators, Fox Energy (MISO #G044), Point Beach Up-Rate (MISO #G063), and Port Washington (MISO #G093).

This study reviews the performance of the generators based on updated data supplied to ATCLLC. The modeling data for the generators and the step-up transformers is based on the as-built data of the generation site.

Revised/Updated Information

The competing generators data update

A. Updated Fox Energy center generator data included. Data is not "as-built".

B. Point Beach up-rate and Port Washington Generation was not included in this study.

The generator data update supplied for Sheboygan Falls Energy Facility and Study Assumptions

A. New Generator, exciter and stabilizer data as supplied by the customer. The "EX2000 PSS Tuning Study" supplied by Alliant Energy Resources, dated December 10, 2004 confirms data supplied by the customer.

B. Generator step-up (GSU) and auxiliary transformer information as supplied by the customer. All transformer impedances were converted to 100 MVA base. Resistances were not supplied but approximated using 50:1 ratio of the supplied inductive impedances. The GSU and the auxiliary transformers were studied with tap settings of 353.625 kV and 17.55 kV, respectively, as confirmed by the customer. The generator will normally operate with a scheduled voltage on the 345 kV side of the GSU at 1.02 p.u.

C. Customer did not supply governor data. Generic data was used in place of actual data as directed by customer.

Conclusions

No changes in the required system upgrades were found as a result of the new generator data. The customer did not supply as-built governor data so additional analysis may be required when this data becomes available. However, the governor data should not affect the transient stability results. In addition, it is unlikely that updated transformer resistance will affect the stability of the generator.

The units modeled performed acceptably for all breaker failure and prior outage situations. A special operating scheme at North Appleton substation is currently active to improve stability in the local area until the required 138 kV breakers are replaced at the North Appleton substation. At the present time, it is determined that this generator will not have an operating restriction as was previously identified in the facility study. If the Point Beach up-rate (G063) is completed, then additional study work will be completed to determine if new operating restrictions will be imposed upon the generator.

All simulations showed that the generator rotor oscillations in the local area were damped to less than 1 degree or by 15% or more at the end of a 20 second simulation. This is consistent with ATC criteria regarding acceptable damping of a generator following a large system disturbance.

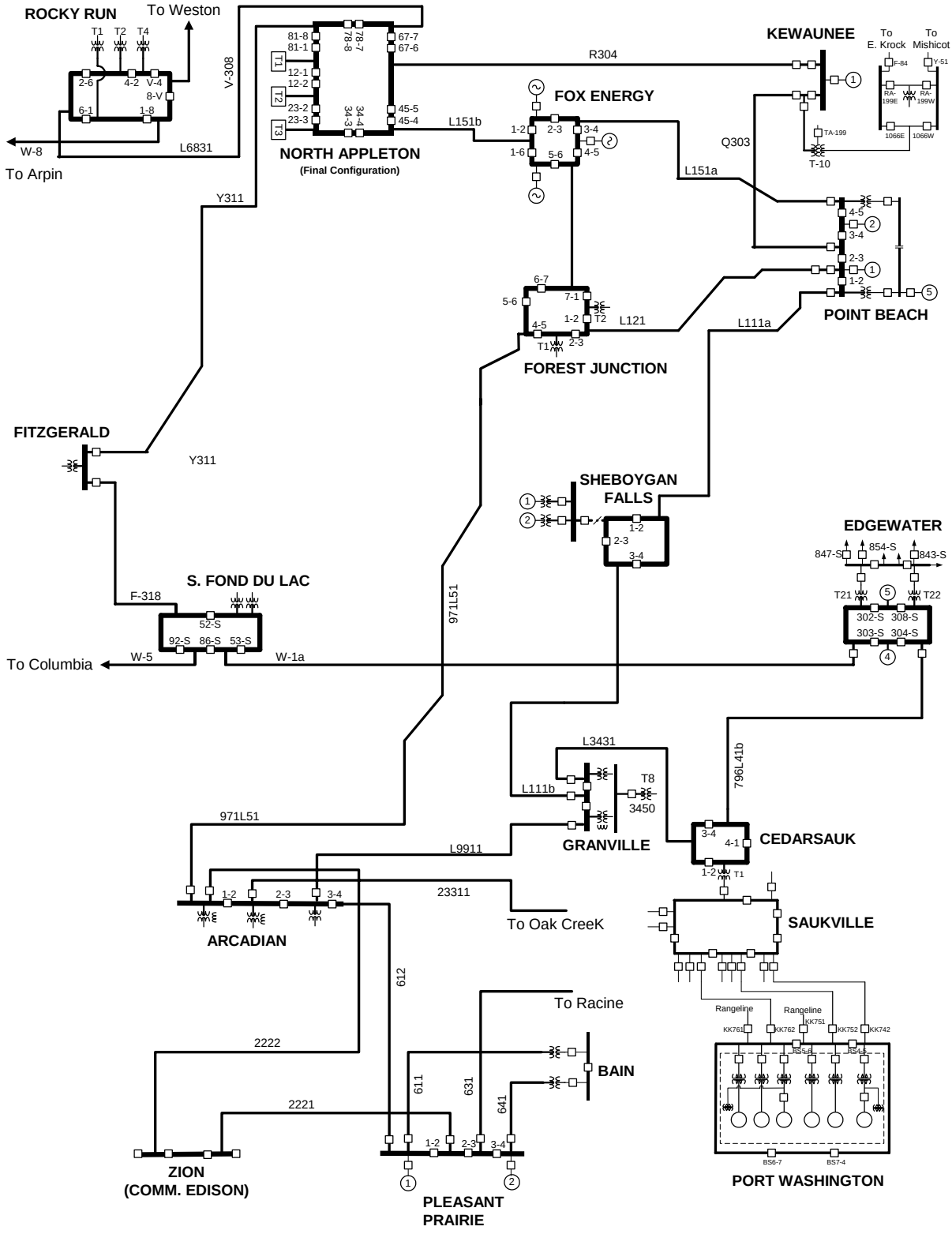

Figure 1 – One Line Diagram of the System After the Addition of the Sheboygan Falls Energy Facility and Competing Requests Fox Energy (G044), Kewaunee Up-Rate (G165/G383) and Port Washington (G093)

Appendix A

Stability Analysis Result

Notes for All Tables:

1. Table abbreviations: ADN – Arcadian, AHL – Apple Hills, BDM – Butte Des Mortes, ELL – Ellington, FOJ – Forest Junction, FOX – Fox Energy, FTZ – Fitzgerald, GVL – Granville, KAU – Kaukauna, KEW – Kewaunee, LDP – Lost Dauphin, MAS – Mason Street, NAP – North Appleton, POB – Point Beach, RRN – Rocky Run, SFE – Sheboygan Falls Energy Facility, SFL – South Fond Du Lac, WCL – White Clay
2. IPO - Three Phase fault degraded to SLG fault via Independent Pole Operated Breaker.
3. Interim – North Appleton 345 kV re-configuration not completed until Spring 2006. Final - North Appleton 345 kV re-configuration completed.
4. The fault is applied at the first named terminal of the faulted element unless otherwise noted (i.e. 90%). All faults modeled were 3-phase bolted faults.
5. Critical = Critical Clearing Time (cycles). Actual = Actual Maximum Expected Clearing Time (cycles). Red cell indicates actual equipment clearing times that times that are inadequate or damping that was found to be inadequate.
6. In the Units Unstable columns, units unstable at a specific generating facility are designated with only the substation name and not with specific units (i.e. POB instead of POB G1-2).
7. Voltage data under "Critical Clearing" column shows at what clearing time did the system have acceptable voltage recovery.
8. Calculated clearing times include a ½ cycle stability margin.
9. Voltage at Point Beach and Kewaunee substations were set to operate at 352 kV.
10. Current clearing time setting with existing breaker and existing relay settings.
11. Clearing times obtainable after breaker failure relays have been reset with existing breakers.
12. Clearing times obtainable after breaker failure relays have been reset and breakers have been replaced with 2 cycle gas type breakers.
13. "cct" is the calculated critical clearing time for which monitored generation maintained synchronism with the ATC transmission system. "Volt" is the calculated clearing time that the bus voltages responded acceptability to current ATC voltage recovery criteria.

Item	Faulted Facilities	Failed Circuit Breaker	Element(s) Cleared In Breaker Failure	Clearing Time			Damping	Units Unstable
				Actual	Critical	Voltage		
1	POB-FOX	POB-FOX @ POB (IPO)	POB BS4-5	8.6	10.5	9.5	Acceptable	POB,KEW @ 11.0
2	POB-KEW	POB-KEW @ POB (IPO)	POB BS3-4, BS2-3	8.6	10.5	9.5	Acceptable	POB,KEW @ 11.0
3	POB-FOJ	POB-FOJ @ POB	POB-FOJ CB#2	Double CB = 4.0	7.5	6.0	Acceptable	POB,KEW @ 8.0
4	POB-SFE	POB-SFE @ POB (IPO)	POB BS1-2	8.6	9.5	8.5	Acceptable	POB,KEW @ 10.0
5	FOJ-FOXa	BS7-1 @ FOJ (IPO)	FOJ T2	12.25	>14.0	13.5	Acceptable	None
6	FOJ-FOXb	BS5-6 @ FOJ (IPO)	FOJ-AD	12.25	>14.0	13.0	Acceptable	None
7	FOJ-POB	BS2-3 @ FOJ (IPO)	FOJ T1	12.25	13.0	11.5	Acceptable	POB,KEW @ 13.5
8	FOJ-ADNa	BS5-6 @ FOJ (IPO)	FOJ-FOX	9.9	12.0	11.0	Acceptable	POB,KEW @ 12.5
9	FOJ-ADNb	BS4-5 @ FOJ (IPO)	FOJ-T1	9.9	12.0	11.0	Acceptable	POB,KEW @ 12.5
10	FOX-POBa	BS3-4 @ FOX (IPO)	CT1	~9.0	11.0	9.5	Acceptable	POB,KEW @ 11.5
11	FOX-POBb	BS2-3 @ FOX (IPO)	ST1	~9.0	11.5	10.0	Acceptable	POB,KEW @ 12.0
12	FOX-FOJa	BS4-5 @ FOX (IPO)	CT1	~9.0	11.5	10.5	Acceptable	POB,KEW @ 12.0
13	FOX-NAPa	BS1-6 @ FOX (IPO)	CT2	~9.0	10.5	9.5	Acceptable	POB,KEW,FOX @ 11.0
14	FOX-NAPb	BS1-2 @ FOX (IPO)	ST1	~9.0	11.5	10.0	Acceptable	POB,KEW @ 12.0
15	NAP-KEWa	NAP 6814	NAP T1, BS81-1, BS12-1 (Interim Configuration)	~5.0	8.5	7.5	Acceptable	POB.KEW @ 9.0
15	NAP-KEWb	DBL CKT BRKR	NONE (Final Configuration)	~5.0	8.5	7.5	Acceptable	POB.KEW @ 9.0
16	NAP-FTZ	DBL CKT BRKR	NONE (Final Configuration)	~5.0	8.5	7.5	Acceptable	POB.KEW,FOX @ 9.0
17	NAP-FOXa	NAP 34-3 @ NAP	NAP T3, BS23-3 (Interim Configuration)	~5.0	9.0	7.5	Acceptable	POB.KEW,FOX @ 9.5
18	NAP-FOXb	DBL CKT BRKR	NONE (Final Configuration)	~5.0	9.0	7.5	Acceptable	POB.KEW,FOX @ 9.5
19	NAP-RRN	DBL CKT BRKR	NONE (Final Configuration)	~5.0	8.0	7.0	Acceptable	POB.KEW,FOX @ 8.5
20	NAPT1a	6814	TRANSFER TRIP TO KEW (Interim Configuration)	~5.0	9.0	7.0	Acceptable	POB.KEW,FOX @ 9.5
21	NAPT1b	DBL CKT BRKR	NONE (Final Configuration)	~5.0	9.0	8.0	Acceptable	POB.KEW @ 9.5
22	NAPT3a	NAP 34-3 @ NAP	TRANSFER TRIP TO FOX (Interim Configuration)	~9.0	9.0	7.5	Acceptable	POB.KEW @ 9.5
23	NAPT3b	DBL CKT BRKR	NONE (Final Configuration)	~5.0	9.0	8.0	Acceptable	POB.KEW @ 9.5
24	KEW-NAP	KEW-NAP @ KEW	KEW-NAP CB#2	Double CB = 5.0	7.5	7.0	Acceptable	POB.KEW @ 8.0
25	KEW-POB	KEW-POB @ KEW	KEW-POB CB#2, T10	Double CB = 5.0	7.0	7.0	Acceptable	KEW @ 7.5

Table A1: Critical Clearing Times, 2005 MMWG (50% Peak Load) Stability Base Case.
Intact System, Breaker Failure Clearing Time. With Sheboygan Falls Energy Facility, Including Fox Energy.

Item	Faulted Element	Failed Circuit Breaker	Element(s) Cleared In Breaker Failure	Clearing Times					Damping All Cases	Units Unstable For 50% Case
				Actual	50% Case	50% Case NAP BS56 Out	50% Case NAP BS45 Out	63% Case		
43	NAP-MAS (138kV)	NAP 6841 (K-37)	T1 (6844), BS45, 6842, 6843, 6845	14.0[10] / (13.5) [11] (~10.0) [12]	12.0 cct 11.0 volt	14.5 cct 13.0 volt	>15.5 cct >15.5 volt	13.5 cct 13.0 volt	Acceptable	POB, KEW
44	NAP-KAU (138kV)	NAP 6842	T1 (6844), BS45, K37, 6843, 6845	13.1[10] / (12.6) [11] (~11.1) [12]	12.0 cct 11.0 volt	14.5 cct 13.0 volt	>15.5 cct >15.5 volt	13.5 cct 13.0 volt	Acceptable	POB, KEW
45	NAP-ELL (138kV)	NAP 6843	T1 (6844), BS45, K37, 6842, 6845	14.0[10] / (13.5) [11] (~10.0) [12]	12.0 cct 11.0 volt	14.5 cct 13.0 volt	>15.5 cct >15.5 volt	13.5 cct 13.0 volt	Acceptable	POB, KEW
46	NAP T1 (138kV)	NAP 6844	BS45, K37, 6842, 6843, 6845	14.0[10] / (13.5) [11]	11.5 cct 10.0 volt	15.0 cct 11.0 volt	>15.5 cct >15.5 volt	13.5 cct 12.5 volt	Acceptable	POB, KEW
46	NAP T1 (138kV)	NAP 6844	BS45, K37, 6842, 6843, 6845 (Final Configuration)	(~10.0) [12]	12.5 cct 12.0 volt	NR	NR	NR	Acceptable	POB, KEW
47	NAP-WCL (138kV)	NAP 6851	T2 (6854), BS45, BS56, 6853, 6855	12.0[10] / (11.5) [11] (~10.0) [12]	12.0 cct 11.0 volt	14.0 cct 13.0 volt	14.0 cct 13.0 volt	13.5 cct 12.5 volt	Acceptable	POB, KEW
48	NAP-BDM (138kV)	NAP 6853	T2 (6854), BS45, BS56, 6851, 6855	15.2[10] / (13.45) [11] (~10.2) [12]	12.0 cct 11.0 volt	14.5 cct 13.0 volt	14.5 cct 13.0 volt	13.5 cct 12.5 volt	Acceptable	POB, KEW
49	NAP T2 (138kV)	NAP 6854	BS45, BS56, 6851, 6853, 6855	12.5[10] / (~10.5) [12]	12.5 cct 12.0 volt	>15.5 cct >15.5 volt	>15.5 cct >15.5 volt	14.5 cct 13.5 volt	Acceptable	POB, KEW
50	NAP-AHL (138kV)	NAP 6862	T3 (6864), BS56, 6863, 6865	14.0[10] / (13.5) [11] (~10.0) [12]	12.0 cct 11.0 volt	>15.5 cct >15.5 volt	14.5 cct 13.0 volt	13.5 cct 13.0 volt	Acceptable	POB, KEW
51	NAP-LDP (138kV)	NAP 6863 (I-113)	T3 (6864), BS56, 6862, 6865	14.0[10] / (13.5) [11] (~10.0) [12]	12.0 cct 11.0 volt	>15.5 cct >15.5 volt	14.5 cct 14.0 volt	14.0 cct 13.0 volt	Acceptable	POB, KEW
52	NAP T3 (138kV)	NAP 6864	BS56, 6862, 6863, 6865	14.0[10] / (13.5) [11] (~10.0) [12]	12.5 cct 12.0 volt	>15.5 cct >15.5 volt	>15.5 cct 15.0 volt	14.5 cct 13.5 volt	Acceptable	POB

Table A1 Continued: Critical Clearing Times, 2005 MMWG (50% and 63% Peak Load) Stability Base Case. Intact System, Breaker Failure Clearing Time. With Sheboygan Falls Energy Facility, Including Fox Energy.

Item	Pre-Existing Outage	Faulted Facilities	Clearing Time				
			Actual	63% Peak Load Case		50% Peak Load Case	
				CCT	Units Unstable	CCT	Units Unstable
1	POB-KEW (2) *	NAP-KEW @ NAP	~4.5	>9.0	None	>9.0	None
2	POB-KEW (2) *	SFE-GVL @ SFE	~4.5	>9.0	None	>9.0	None
3	POB-KEW (2) *	KEW-NAP @ KEW	~5.0	>9.0	None	>9.0	None
4	POB-FOJ (4)	SFE-GVL @ SFE	~4.5	>9.0	None	>9.0	None
5	POB-SFE (8)	POB-FOJ @ POB	~4.5	7.5	POB,KEW,FOX	6.5	POB,KEW
6	KEW-NAP (3) *	SFE-GVL @ SFE	~4.5	>9.0	None	>9.0	None
7	KEW-NAP (3) *	NAP- FOX @ NAP	~4.5	>9.0	None	>9.0	None
8	NAP-KEW (3) *	POB-FOJ @ POB	~4.5	>9.0	None	8.0	POB,KEW
9	NAP-FOX (5)	SFE-GVL @ SFE	~4.5	>9.0	None	>9.0	None
10	NAP-FOX (5)	KEW-NAP @ KEW	~5.0	>9.0	None	>9.0	None
11	NAP-FTZ (10)	SFE-GVL @ SFE	~4.5	>9.0	None	>9.0	None
12	NAP-RRN (11)	SFE-GVL @ SFE	~4.5	>9.0	None	>9.0	None
13	SFE-GVL (9)	NAP-KEW @ NAP	~4.5	7.0	POB,KEW,SFE,FOX	6.0	POB,KEW,SFE,FOX
14	SFE-GVL (9)	POB-KEW @ POB	~4.5	7.5	POB,KEW,SFE	6.5	POB,KEW,SFE,FOX
15	SFE-GVL (9)	POB-FOJ @ POB	~4.5	6.0	POB,KEW,SFE,FOX	5.5	POB,KEW,SFE,FOX
16	SFE-GVL (9)	POB-SFE @ POB	~4.5	8.5	POB,KEW,PUL	7.5	POB,KEW
17	SFE-GVL (9)	FOX-POB @ FOX	~4.5	7.0	POB,KEW,SFE,FOX	6.5	POB,KEW,SFE
18	SFE-GVL (9)	FOX-FOJ @ FOX	~4.5	8.0	POB,KEW,FOX,PUL	7.0	POB,KEW,SFE,FOX
19	SFE-GVL (9)	KEW-NAP @ KEW	~5.0	>9.0	None	>9.0	None
20	SFE-GVL (9)	KEW-POB @ KEW	~5.0	>9.0	None	>9.0	None
21	SFE-GVL (9)	NAP-FOX @ NAP	~4.5	6.0	POB,KEW,SFE,FOX	5.5	POB,KEW,SFE,FOX
22	FOX-FOJ (7)	NAP-FOX @ NAP	~4.5	8.5	POB,KEW,SFE,FOX	6.5	POB,KEW,FOX
23	FOJ-AD (1)	SFE-GVL @ SFE	~4.5	>9.0	None	>9.0	None

Note: All simulations produced acceptable damping results.

Table A2: Critical Clearing Times, 2005 MMWG (50% Peak Load) Stability Base Case. Line Out Of Service, Primary Clearing Time. With Sheboygan Falls Energy Facility, Including Fox Energy.

Appendix B

Generator As-Built Data