STUDY SUMMARY
MILL ROAD – ROCKDALE
345 kV LINE
DELAY

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BY

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Introduction

The original studies conducted using the 2004 series system models (2004, 2008, 2012) for the study area assumed that available generation at Concord and Germantown substations would not be operating at time of system peak because of a 2180 MW net increase of more efficient and economical generation being installed at Port Washington (gas-fired combined-cycle) and Oak Creek/Elm Road (coal-fired). Concord Substation generation is comprised of four gas-fired combustion turbine units and Germantown Substation generation includes one gas-fired combustion turbine unit and four diesel-fired units. Initial thoughts were that a re-dispatch of the generation would be too expensive to run and that 2015 planning projections indicated that even if all nine generating units were operating at Concord and Germantown area voltages would still drop below the 95% acceptable level under system intact conditions.

The assumption that the available generation at Concord and Germantown substations would not be operating during system peak became an issue as part of the Southeastern Energy Initiative discussions. We energies indicated they would expect at least some of these units to be economically dispatched during system peak. In addition, since the original study, the Midwest Independent operator (MISO) took over dispatching generation in the region and as a result even though the area generation may be more expensive than other generation on We Energies system, they appear to be less expensive than other power resources available to MISO and have been economically dispatched to meet regional needs. Thus, if the generation was being economically dispatched it would be available to support area voltages without added expense. If not, would the ability to operate them for system load conditions requiring voltage support in the area be cost effective to the construction of the Mill Road – Rockdale 345 kV line and possibly the Mill Road Substation as well? As a result it was decided to conduct power flow studies to determine how much area generation would be required to support the area voltage under system intact and single contingency conditions for summer peak and off-peak conditions.

Study

Power flow analysis conducted as part of the Southeastern Wisconsin Energy Initiative indicated that dispatching existing gas fired generation at Concord and Germantown substations were able to eliminate the low voltage problems in the study area under intact and contingency conditions. Generation at Concord Substation includes four units each with a capability of 94 MW and 70.5 MVAr, plus one gas fired unit at Germantown with a capability of rated 90.8 MW and 56 MVAr for a total of 466.8 MW and 338 MVAr. In addition, another four oil-fired units at located at Germantown Substation totaling 252 MW and 100 MVAr, but are significantly more expensive to run then the gas-fired units.

The power flow analysis was made using the 2010 summer peak and shoulder-peak (70% of peak) models from the 2006 series of models (2006, 2010, 2014) developed for the ten-year assessment modified to remove the Mill Road – Bark River – Concord – Rockdale 345 kV line and the associated 345/138 transformers and 345 kV buses at Concord and Bark River substations. Results indicated that re-dispatching three units for a total of 233 MW and 145.7 MVAr at peak would essentially eliminate the low voltage problems in the study area in the 2010 model. The generation re-dispatch included two Concord units at 94 MW each with 63.9 MVAr and the one gas-fired Germantown unit at 45 MW and 30.8 MVAr. Voltages ranged from above 95% to above 98% for intact peak conditions and except for one contingency (splitting the Concord 138 kV bus with bus tie 5-6 being opened 89.9%) voltages remained above the 90% acceptable limit under single contingency conditions. The shoulder-peak model indicated that no generation was required in 2010 to maintain voltages above 95% for intact system conditions and 90% for single contingency conditions. Voltages ranged from 97% to above 100% for intact peak conditions and remained above 90% under single contingency conditions.

The next point of interest of the study was to determine at what load level above the shoulder-peak model (e.g. 75%, 80%, 85% etc) would generation need to be brought on-line and what amount of generation would be required at that level plus what incremental increases in generation would be needed at load levels in between this level and peak. In addition, to compare the cost of operating this generation with the carrying cost of the Mill Road – Rockdale 345 kV Line Project and/or with carrying cost of the Mill Road Substation Project in order to determine the least cost option. Another point of interest in the study was to determine how far out in time could the generation reliably support area voltages before its capability was fully utilized.

Generation Cost Analysis

An analysis was made using a modified TYA 2010 Summer peak model to determine the load level at which the generation at Concord and Germantown would need to be on line to address voltage issues in the study area for the Mill Road Project. The model was run with neither the Mill Road Substation nor Mill Road-Rockdale 345 kV line in service and no generation on line at either Concord or Germantown. Load in the planning zones 3 and 5 were reduced to determine the defined load levels in the study area. Only the loads in these zones were adjusted to reduce the level of work in rescheduling generation for the entire ATC footprint.

An 85% of peak load 2010 model indicated no 138 kV substation voltages below 95% under intact system conditions, although Concord Substation was close at 95.1%, and only two substations (Crawfish River and Cottonwood) exhibited voltages between 91-92% under two different single contingency conditions. Results of a 2010 model at 86% of peak load indicated only the Concord Substation exhibited a 138 kV voltage below 95% (94.7%) under intact system conditions and 1-3 substations experiencing voltages between 91-92% for 3 different 138 kV contingencies. The conditions in the 86% 2010 model required only one Concord unit on-line with minimum generation of 38 MW but 58 MVAr output.

Additional analysis was conducted at 90%, 95% and 100% load levels to determine what level of generation at Concord and Germantown is needed to support voltage in the study area. The results showed that the 90% case needed one Concord unit on-line at minimum generation of 38 MW with MVAr output at 69.6 to maintain area voltages above acceptable voltage limits for intact and single contingency system conditions. The 95% case required one Concord unit and one Germantown unit on-line at minimum generation of 38 MW and 45 MW, respectively, and reactive power outputs at 70.5 MVAr (maximum) and 43.5 MVAr (maximum is 56), respectively. The 2010 peak case required two Concord units and one Germantown unit on-line all at maximum power and reactive power outputs of 94 MW and 70.5 MVAr for each Concord unit and 90.8 MW and 56 MVAr for a Germantown unit #5. These results are summarized as follows:

	Concord			Germantown		
% Load	# Units	MW per Unit	MVAr per Unit	# Units	MW per Unit	MVAr per Unit
< 85	0	0.0	0.0	0	0.0	0.0
> 85-90	1	38.0	69.6	0	0.0	0.0
> 90-95	1	38.0	70.5	1	45.0	43.5
> 95-100	2	94.0	70.5	1	90.8	56.0

The above results constitute the power output and number of units to be used in combination the number of hours the generation would need to operate on-line for each of these load levels. A duration curve from the PROMOD model was used to determine the number of hours the generation would be operating at the identified load levels as follows:

Load Level %	# Hours
85-90	92
90-95	84
95-100	37

A spreadsheet is included that provides an analysis of the generation costs using the above power output, number of units and hours of operation for the Concord and Germantown combustion turbine units determined from the 2010 model. This cost can then be compared with the carrying cost of the Mill Road – Rockdale 345 kV line project (~ $8.0 M), Mill Road Substation Project (~ $3.5 M) or both ($11.5 M).

The first analysis includes varying the fuel cost only with no start-up costs or adjusting unit generation to maintain a rated power factor on the units. As the results indicate the price for gas would need to approach $12.79/MBTU to yield a generation cost comparable to the substation carrying charge. In each analyzes the varied factor is shown in red type. The $6.89 price for gas is the value used in the 2013 run in PROMOD.

The second analysis includes varying the fuel cost and adjusting the MW power output on the units to rated power factor but excludes start-up costs. The results show that increasing the power factor has a more significant impact on the costs because of the increased generation, but would require the price for gas to increase to $8.24/MBTU to yield a generation cost comparable to the substation carrying charge.

The third analysis varies the fuel cost and includes start-up costs, but excludes adjustment of the unit power factors. The results show the inclusion of start-up costs does not have a significant impact on the overall costs with the price for gas needing to approach $12.36/MBTU to yield a generation cost comparable to the substation carrying charge. Ten start-ups were assumed for the year and are based on a peak period of 4.0 hours which would cover the 37 hours in the 95-100% load level range. A decrease in start-ups would slightly reduce the costs and an increase in start-ups would slightly increase the costs.

The final analysis varies the fuel cost, adjusts the MW power output on the units to rated power factor and includes start-up costs. The results show again that increasing the power factor has a more significant impact on the costs because of the increased generation, but would require the price for gas to increase to $7.98/MBTU to yield a generation cost comparable to the substation carrying charge. The inclusion of the start-up costs assists in bringing the price for gas closer to the 2013 PROMOD value.

The price for gas in the fourth analysis and the second analysis require gas prices slightly above that used in the 2013 PROMOD analysis to yield a generation cost near the carry charge for just the substation project let alone the line project or a combination. It should be noted that power flows conducted for the Energy Initiative with the Mill Road Substation in-service in the 2010 peak model required the same three units on line but with lower reactive power output. These results indicate that by 2010 the Mill Road Substation is not sufficient to support area voltage without generation being on-line or installation of the 345 kV line. It stands to reason that the substation would need to be in service prior to 2010 to be effective without requiring generation to be on-line. It also stands to reason that amount of generation required to support area voltage prior to 2010 would probably be less and would reduce the generation cost again below the $3.5 M carrying charge of the substation making the generation re-dispatch the least cost option. Moreover, by 2010 if the substation and the Mill Road-Rockdale 345 kV line are both required the carrying charge to off-set the generation cost would be closer to $11.5 M ($3.5 M + 8.0 M) The cost for re-dispatching the generation would increase with the need to run the other two units over time and probably operating for a longer duration, but would probably not exceed the $11.5 M carry charge for the line and substation.

Duration of Generation Option

The next study issue was to determine when the Concord and Germantown generation would no longer be adequate to support area voltages. The 2014 model from the 2006 series of models built for the Ten Year Assessment and the 2016 and 2019 models developed for the 20-year analysis from the 2014 model were initial used to study this issue. The 2014 summer peak model indicated that 3 -4 units on-line were adequate to essentially maintain system voltages under intact and single contingency (n-1) conditions. In the 2016 summer peak model showed that 4 units were adequate to essentially provide sufficient voltage support in the study area for both intact and single contingency conditions. The 2019 summer peak model, however, indicated that even with all 5 gas-fired combustion turbine units on line at Concord and Germantown substations these were not able to maintain acceptable voltage limits within the study area under either intact or single contingency conditions. Two substations (Cottonwood and Merrill Hills) were below the 95% voltage limit under intact system conditions and 4 contingencies resulted in one or more substations in the study area being at or below the 90% voltage limit.

In order to determine the exact year between 2016 and 2019 that running the available gas fired units would not be sufficient to support the study area two more summer models were constructed from the 2016 model for 2017 and 2018. The 2018 summer peak model showed the 5 gas-fired units were able to maintain acceptable voltages for intact conditions, but resulted in two substations below 90% voltage under single contingency conditions. In the 2017 summer peak model, the results indicated that four gas-fired units on line were essentially sufficient to maintain voltage support for the study area under intact and single contingency conditions. A summary of these results is provided in the following table.

			Acceptable Voltage limits	
Study Year	Concord Units	Germantown Units	Intact > 95%	Contingency > 90%
2014	2-3	1	Yes	Yes [1]
2016	3	1	Yes	Yes [1]
2017	3	1	Yes	Yes [1]
2018	4	1	Yes	No
2019	4	1	No	No

[1] Only Concord bus section 6 below was 90% for a Concord open bus tie 5-6.

Conclusions

These study results indicate that by 2018 the 5 gas-fired units at the Concord and Germantown substations are not sufficient to support system voltages in the study. The cost analysis conducted for the 2010 models show running the gas-fired generation was less than the carrying cost ($3.5 M) of the Mill Road Substation. As noted previously, it stands to reason that the substation would need to be in service prior to 2010 to be effective without requiring generation to be on-line. It also stands to reason that amount of generation required to support area voltage prior to 2010 would probably be less and would reduce the generation cost again below the $3.5 M carrying charge of the substation making the generation re-dispatch the least cost option. Moreover, by 2010 if the substation and the Mill Road-Rockdale 345 kV line are both required the carrying charge to off-set the generation cost would be closer to $11.5 M ($3.5 M + 8.0 M) The cost for re-dispatching the generation would increase with the need to run the other two units over time and probably need to operate for a longer duration with time, but would probably not exceed the $11.5 M carry charge for the line and substation.

The use of generation to support the area appears to be the least cost plan until 2018 or there is a change in its availability. If the generation is on line for other reasons (e.g. requested by MISO) then the generation cost is $0 for area voltage support!