Attachment C

Wisconsin's
Electric Transmission Interconnection Capacity Requirements

WISCONSIN'S
ELECTRIC TRANSMISSION INTERCONNECTION
CAPACITY REQUIREMENTS

INTRODUCTION

The primary operational goal of Wisconsin's electric utilities is to maintain an uninterrupted supply of electric power to their customers. A prerequisite for attaining this goal is a reliable bulk electric system. The reliability of the bulk electric system - its ability to maintain an uninterrupted supply to customers at all times and under a variety of system conditions - is dependent upon a number of factors. The key requirements for bulk electric system reliability are maintaining sufficient power generation capacity, having sufficient transmission facilities and interconnection capacity with neighboring power systems, and employing well-conceived and coordinated system operating practices. This document addresses Wisconsin's need for additional transmission interconnection (or interface) capacity with surrounding states and, in particular, the need for such capacity given the reliability situation in eastern Wisconsin.

The Wisconsin utilities have been investigating the need and options for construction of additional transmission facilities interconnecting the transmission grid in Wisconsin to neighboring states for more than a decade. Having adequate transmission interconnection facilities is important both for reasons of reliability and economics. The electric utilities in the Midwest region depend on each other to help maintain the reliable operation of their systems. In the event of routine contingencies as well as abnormal situations – such as extensive generation and/or transmission outages, storm damage to generation and/or transmission facilities, fuel shortages or fuel delivery complications, large scale shutdowns of nuclear facilities - adequate interconnection facilities provide critical access to alternative sources of electric power, a commodity which is vital to the social and economic well being of our society. These interconnection facilities are needed, first and foremost, to help Wisconsin utilities maintain the reliable operation of their systems. Such facilities also are important for enabling the Wisconsin utilities to provide reciprocal support to utilities in neighboring states.

In addition to the need for adequate interface capacity for reliability purposes, such facilities are necessary for Wisconsin to effectively participate in the regional power markets. Effective participation in the regional power markets is important for keeping the cost of power to consumers in Wisconsin and throughout the region low and will become a prerequisite to the success of deregulation in Wisconsin. Unless adequate interface capacity is constructed, power supply options for consumers and resource and siting options for power suppliers will be limited, and market power issues will remain a concern. Adequate interface facilities will alleviate not only the state's reliability concerns but also help provide a reliable bulk power system to enable effective competitive power markets.

In order for the Wisconsin utilities to continue to provide reliable electric service to their customers, it is prudent to increase the capacity of their transmission interconnections with neighboring systems. The need for additional interconnection capacity is especially critical for eastern Wisconsin, which experienced reliability problems and high power costs during 1997 and 1998 as a result of Wisconsin and regional nuclear unit outages and a lack of adequate transmission capacity to import power. The situation was sufficiently critical that the available transmission capacity to import power into eastern Wisconsin during 1997 and 1998 was minimal or negligible for extensive periods leaving consumers in eastern Wisconsin exposed to above normal risks of power outages. Although much of the affected nuclear generation has returned to an operational status, the reliability situation in eastern Wisconsin has not been resolved. A lack of sufficient transmission interconnection capacity leaves the eastern Wisconsin utilities and consumers with a situation where they are still exposed to unacceptable risks of power outages. The constraints on interface capacity also impede the ability of the eastern Wisconsin utilities and other suppliers to supply power to their customers on the most cost-effective basis.

The most critical aspect of the reliability problem is a lack of sufficient transmission interconnection capacity between eastern Wisconsin and the Mid-Continent Area Power Pool (MAPP) region to the west of Wisconsin. Currently, there is only one extra high voltage (345 kV) interconnection between eastern Wisconsin and MAPP. This interconnection is not sufficient to maintain a stable link between MAPP and eastern Wisconsin during high power transfer conditions. This lack of stability poses a threat to the reliability of service not only in eastern Wisconsin, but to north central and western Wisconsin as well, and is a direct result of Wisconsin's lack of sufficient transmission interconnection capacity.

The reliability problems experienced in 1997 led the State of Wisconsin to pass the Wisconsin Reliability Act (Wisconsin Act 204) in April 1998. A subsequent report to the Wisconsin legislature on the regional electric transmission system by the Wisconsin PSC (which was mandated by the Wisconsin Reliability Act) presented a number of system enhancements that would mitigate identified constraints and provide a simultaneous power transfer capability into Wisconsin of 3,000 MW; either 2,000 MW from the west and 1,000 MW from the south, or 1,000 MW from the west and 2,000 MW from the south. The 3,000 MW target was established based on reliability needs, considering the uncertainty of future generation development in Wisconsin and considering the uncertainty of nuclear plant operating performance in the future.

The focus of this document is to explain the need for the 3,000 MW simultaneous power transfer capability level identified in the PSC Study. The discussion and analyses presented in this document provide:

- a historical perspective on issues related to bulk electric system evolution and reliability,
- the results of analyses performed to determine the current and future generation and import capability needed to achieve an acceptable level of bulk system reliability in eastern Wisconsin, and
- a discussion of other factors affecting bulk system reliability.

BACKGROUND

The bulk electric system in Wisconsin and throughout the U.S. has evolved over time from localized generation and transmission systems serving urban areas to a vast transmission network interconnecting those localized systems. These transmission interconnections were developed by utilities, primarily between 1950 and1980, in order to: (i) improve reliability and lower costs by sharing reserve generating capacity, (ii) transmit power from new generation located remote from load centers and (iii) allow economic transactions between utilities.

With the enactment of the Energy Policy Act of 1992 and FERC Orders 888 and 889, promoting wholesale competition in the generation and transmission sectors of the electric industry, the use of the transmission network throughout the U.S. has both increased dramatically and changed in ways it was not designed for. For most of the 20th century, power flows scheduled across interconnections between utilities occurred primarily in times of system emergencies. The transmission system is now being used both for extensive economic transactions conducted on a regional basis and for reliability purposes, and those uses often compete for the same capacity. The increase in use of the transmission system for economic transactions between power suppliers and transmission customers has in numerous instances resulted in an oversubscription of transmission system capacity. The increased demand on the transmission system combined with declining generation reserve margins has resulted in a reduction in the level of reliability in many parts of the U.S., and particularly in Wisconsin.

The North American Electric Reliability Council (NERC) is charged with overseeing and ensuring the reliability of the interconnected bulk electric systems of the U.S., Canada and part of Mexico. In its 1998-2007 Reliability Assessment Report, NERC states:

> "*Transmission systems [are] increasingly challenged to accommodate [the] demands of evolving competitive energy markets. Market-driven changes in transmission usage patterns, the number and complexity of transactions, and the need to deliver replacement power to capacity-deficient areas are causing new transmission limitations to appear in different and unexpected locations*." (p.6)

As transfer capability between regions is increasingly utilized for transactions, the reliability of the bulk electric system is being further compromised.

Currently, the firm transfer capability into Wisconsin is approximately 1,000 MW. This amount varies with system conditions, but reflects a reasonable approximation of the amount of power that can be dependably transferred into Wisconsin without interruption throughout the year. This amount of transfer capability is well short of the 3,000 MW simultaneous transfer level identified in the PSCW report to the Wisconsin legislature.

RECENT RELIABILITY PROBLEMS IN WISCONSIN

The lack of sufficient interface capacity between Wisconsin and neighboring states affects not only Wisconsin, but the neighboring states as well. At the present time, the eastern Wisconsin utilities (EWU) lack the internal generating capacity and import capability to achieve an acceptable level of reliability (loss of load expectation of 0.1 day/year – see discussion under ASSESSING RELIABILITY). In 1997 and 1998, several nuclear power plants in the upper Midwest experienced extended outages that not only decreased the generating capability available but also substantially contributed to a decrease in power transfer capability throughout the upper Midwest. While most of the nuclear power plants that experienced outages in 1997 and/or 1998 have since returned to service, a few in Illinois have not. These experiences have raised concerns about the viability of nuclear generation in the future. Perhaps most crucial to the EWU was the permanent closing of Commonwealth Edison's Zion nuclear plant in northern Illinois, which severely limits the capability of the transmission system to import power into Wisconsin from Illinois.

The reliability problems caused by the lack of sufficient interface capacity have become apparent on more than one occasion in recent years.

- During two particularly hot days in July 1995, the capacity reserve margins the EWU strive to maintain for reliability purposes became alarmingly low when the major transmission facility interconnecting Wisconsin to Minnesota (a 345 kV line) was out of service on July 13th and a nuclear unit in Wisconsin was out of service on July 14th.
- Capacity reserve margins were well below levels needed for adequate reliability throughout the spring and summer of 1997, and periodically during the summer of 1998.
- On June 11, 1997, an outage of the Wisconsin-Minnesota 345 kV transmission interconnection during the middle of the night caused by large southward power transfers from MAPP resulted in a scramble by utility operators to maintain the stability of the bulk electric system. As a result of this experience, a new, lower transfer limit (775 MW) on that transmission interconnection has been established.
- On June 25, 1998, an outage of that same 345 kV transmission interconnection occurred while several transmission facilities in the Midwest were already out of service due to weather related events. The end result was that a large region to the west of Wisconsin was electrically separated from adjacent regions, generation within the isolated area went out of service, blackouts occurred in parts of Canada, service to certain industrial customers in Minnesota was interrupted and the integrity of the transmission system in the upper Midwest was severely jeopardized.
- More recently, on March 15, 1999, a scheduled maintenance outage of the Arpin-Rocky Run 345 kV transmission line had to be cancelled when loop flows across the Wisconsin-Minnesota 345 kV interconnection overloaded the 345/138 kV transformer at Arpin, causing damage to a portion of the transformer apparatus.

ASSESSING RELIABILITY

Utilities use a computer simulation of the operation of their electric systems to measure the "loss of load expectation", or "LOLE", of those systems. LOLE studies usually cover a time period of ten years or more. LOLE simulations calculate the probability that customer demand will exceed available internal generating capacity and imported generation capability for a specific period of time. The sum of these probabilities over the study period defines the LOLE for the study period. The industry standard for reliability is an LOLE of 1 day in 10 years (or 0.1 day/year). This criterion is used for planning purposes to insure that electric supply exceeds customer demand for a variety of weather conditions and bulk electric system conditions. Thus, if the sum of the probabilities from an LOLE analysis for a 1-year period is less than 0.1, the criterion has been met. If greater than 0.1, additional resources (generation and/or imports) must be added.

By conducting LOLE analyses, utilities can determine combinations of internal generating capacity and imported generation capability needed to meet the 0.1 day/year criterion over the study period. Within the Mid-American Interconnected Network (MAIN) Reliability Council, results of LOLE analyses conducted during 1998 by the MAIN Guide 6 Task Force suggest that a capacity reserve margin of 15-20% is necessary to meet the 0.1 day/year criterion for the MAIN region. The PSCW currently requires that Wisconsin utilities maintain an 18% planning reserve margin.

It should be noted that in the MAIN Guide 6 Task Force's LOLE studies, it was assumed that there were no constraints on the ability to transfer power into and within the MAIN region and thus, MAIN is able to benefit from diversity between MAIN and surrounding reliability councils. This assumption is not valid for the eastern Wisconsin portion of MAIN since import capability into eastern Wisconsin is limited.

EWU LOLE ANALYSIS: APPROACH, KEY ASSUMPTIONS AND RESULTS

As noted above, the difference between the transfer capability situation in eastern Wisconsin and that in MAIN warranted different approaches in conducting LOLE analysis to determine reliability-based transfer capability requirements. LOLE studies conducted by the Wisconsin Reliability Assessment Organization (WRAO) focused on determining the amount of transfer capability into eastern Wisconsin needed to achieve the 0.1 day/year criterion under normal contingency expectations given certain assumptions regarding construction of new generation in eastern Wisconsin. Given the uncertainty associated with the development of new generating capacity in eastern Wisconsin, two LOLE simulation scenarios were selected in an attempt to provide a range on the minimal need for import capability into eastern Wisconsin. It should be noted that these LOLE simulations did not address the impact on LOLE of extraordinary events such as large scale generation outages, weather-related transmission system outages or fuel supply delivery problems. Such impacts were considered qualitatively and discussed later in this document. The two LOLE scenarios selected were:

Case 1: All generation projects in eastern Wisconsin previously approved by the PSCW for 1999 and 2000 are constructed. New generating capacity is added as needed in order for the EWU to maintain an 18% reserve margin in each year. Purchases from outside of eastern Wisconsin are added as needed to achieve 0.1 day/year LOLE. The amount of purchases required in each year corresponds to the amount of transfer capability the EWU needs for this generation scenario. This scenario was selected to reflect the minimum amount of reliability-based transfer capability needed by eastern Wisconsin.

Case 2: All generation projects in eastern Wisconsin previously approved by the PSCW for 1999 and 2000 are constructed. No new generating capacity is added beyond the PSCW-approved projects. Purchases from outside of eastern Wisconsin are added as needed to achieve 0.1 day/year LOLE. The amount of purchases required in each year corresponds to the amount of transfer capability that the EWU needs for this generation scenario. This scenario was selected to reflect an upper bound of the minimum range of reliability-based transfer capability needed by eastern Wisconsin.

Key assumptions made for the LOLE analysis are as follows:

- Transfer capability requirements determined through LOLE analysis are absolute, not incremental. Existing transfer capability or purchases utilizing that import capability were not included.
- All existing non-nuclear Wisconsin generating units operate at average historic performance levels for all units in the Midwest as computed by NERC, with equivalent availabilities that range from 85% to 99.4%, depending on the technology and size of each generating unit.
- All Wisconsin nuclear generating units operate at the average of the actual availability for each unit for the period 1994-1998. The average forced outage rate for the three Wisconsin nuclear units during that time period was 14%.
- All new utility and non-utility generation added in 1999 and 2000 are the technologies proposed by the generation developer.
- All new non-utility generation added beyond year 2000 is assumed to be a 50/50% combination of combined cycle and combustion turbine technologies with an equivalent availability of 95.5%.
- All new generation is assumed to be in-service as of June 1 of the year it is added.
- Purchases added were assumed to be unit participation-type purchases and have availabilities equivalent to coal-fired units (93.4% for peak season purchases; for 12-month purchases, 92.5% for the summer season, 85% for the remainder of the year). Transfer capability to deliver purchases was modeled as being 100% available.
- Purchases were assumed to be split 50/50% between 12-month purchases and peak season (summer and winter) only.

A summary of the results of the LOLE analysis is provided in Table C-1. As shown in Table C-1, the supply system in eastern Wisconsin does not currently meet the 0.1 day/year criterion as evidenced by the need for over 1,900 MW of capacity purchases (transfer capability) in both 1999 and 2000. Current simultaneous transfer capability into eastern Wisconsin is approximately 1,000 MW based on the amount of transmission service sold for the summer of 1999. It is not anticipated that this level will increase dramatically in year 2000.

TABLE C-1
SUMMARY OF RESULTS OF LOLE ANALYSIS FOR THE EWU

Case 1
Generation Added to Meet 18% Reserve Margin, Import Capability Added to Meet LOLE Criterion

Line No.		1999	2000	2001	2002	2003	2004	2005	2006	2007
1a	Net Operable Generation Capacity at the Beginning of Each Year	11,005	11,339	12,314	12,484	12,694	12,924	13,174	13,434	13,654
1b	New Approved NUG Generation Installed by 6/1 of Each Year	179	750	-	-	-	-	-	-	-
1c	New Committed Utility-Owned Generation Operable by 6/1 of Each Year	155	225	-	-	-	-	-	-	-
1d	Total Operable Generation as of 6/1 of Each Year	11,339	12,314	12,314	12,484	12,694	12,924	13,174	13,434	13,654
1e	Projected Peak Demand Net of Interruptible Loads	10,215	10,374	10,582	10,757	10,953	11,161	11,387	11,573	11,754
1f	Reserve Margin Before Other Capacity Additions	11.0%	18.7%	16.4%	16.1%	15.9%	15.8%	15.7%	16.1%	16.2%
1g	Generation Added to Meet an 18% Reserve Margin	-	-	170	210	230	250	260	220	220
1h	LOLE (days/year) Before Capacity Purchases	7.01	3.77	1.20	1.38	1.38	1.17	1.10	1.00	0.92
1i	Capacity Purchases (Import Capability) Needed to Meet 0.1 day/year LOLE	1,920	1,960	1,030	1,150	990	1,070	1,020	950	910
1j	Total Capacity (1d + 1g + 1i)	13,259	14,274	13,514	13,844	13,914	14,244	14,454	14,604	14,784
1k	Reserve Margin Required to Meet 0.1 day/year LOLE	29.8%	37.6%	27.7%	28.7%	27.0%	27.6%	26.9%	26.2%	25.8%
	Cumulative Generation Capacity Added	334	1,309	1,479	1,689	1,919	2,169	2,429	2,649	2,869

Case 2
No Generation Added Beyond 2000, Import Capability Added to Meet LOLE Criterion

Line No.		1999	2000	2001	2002	2003	2004	2005	2006	2007
2a	Net Operable Generation Capacity at the Beginning of Each Year	11,005	11,339	12,314	12,314	12,314	12,314	12,314	12,314	12,314
2b	New Approved NUG Generation Installed by 6/1 of Each Year	179	750	-	-	-	-	-	-	-
2c	New Committed Utility-Owned Generation Operable by 6/1 of Each Year	155	225	-	-	-	-	-	-	-
2d	Total Operable Generation as of 6/1 of Each Year	11,339	12,314	12,314	12,314	12,314	12,314	12,314	12,314	12,314
2e	Projected Peak Demand Net of Interruptible Loads	10,215	10,374	10,582	10,757	10,953	11,161	11,387	11,573	11,754
2f	Reserve Margin Before Other Capacity Additions	11.0%	18.7%	16.4%	14.5%	12.4%	10.3%	8.1%	6.4%	4.8%
2g	LOLE (days/year) Before Capacity Purchases	7.01	3.77	1.74	3.20	5.56	7.73	11.85	16.34	21.99
2h	Capacity Purchases (Import Capability) Needed to Meet 0.1 day/year LOLE	1,920	1,960	1,190	1,580	1,710	2,260	2,670	3,030	3,410
2i	Total Capacity (2d + 2h)	13,259	14,274	13,504	13,894	14,024	14,574	14,984	15,344	15,724
2j	Reserve Margin Required to Meet 0.1 day/year LOLE	29.8%	37.6%	27.6%	29.2%	28.0%	30.6%	31.6%	32.6%	33.8%
	Cumulative Generation Capacity Added	334	1,309	1,309	1,309	1,309	1,309	1,309	1,309	1,309

As shown in the results for Case 1, under the assumptions made for this case, eastern Wisconsin would need to add approximately 2,870 MW of new generating capacity by 2007 to maintain an 18% reserve margin, and would need to maintain between 910 and 1,150 MW of transfer capability from 2001 through 2007 in order to achieve the 0.1 day/year LOLE criterion. The average transfer capability needed from 2001 through 2007 was 1,017 MW. The relatively high (1,920 MW and 1,960 MW) transfer capability need shown for 1999 and 2000 was disregarded in computing the transfer capability range and average above since there is no practical means of achieving that level of transfer capability in that timeframe. It would appear that if new generating capacity was developed in eastern Wisconsin sufficient to maintain an 18% reserve margin beyond 2007 (accounting for plant retirements), the minimum transfer capability needed for reliability alone under normal contingency conditions would decrease slowly over time.

As shown in the results for Case 2, eastern Wisconsin will, by 2000, be adding approximately 1,300 MW of new generating capacity, and would need the transfer capability to grow from 1,190 MW in 2001 to 3,410 MW by 2007 in order to achieve the 0.1 day/year LOLE criterion. The average transfer capability needed in that timeframe is 2,264 MW. As in Case 1, the transfer capability need shown in 1999 and 2000 in Case 2 was ignored. Absent any new generation developed in eastern Wisconsin through 2007 and beyond, eastern Wisconsin's minimal need for reliability-based transfer capability under normal contingency conditions would increase by an average of 370 MW annually.

The results of the LOLE analysis indicate that an additional 940 MW of capacity resources (generation and purchases) would be required by 2007 in Case 2 compared with the Case 1 in order to achieve the 0.1 day/year criterion. Hence, the reserve margin requirement in 2007 for Case 2 would be 33.8% versus 25.8% in Case 1. This difference in results emanates from the modeling of power purchases. As noted in the assumptions above, it was assumed that half of the power purchases modeled would be 12-month purchases and the other half would cover only the summer and winter peak seasons. This assumption was made as a proxy for the wide range of transactions made in the wholesale power markets, ranging from 1 hour to several years. Regardless of its duration or type, any transaction to be used for capacity purposes (count for purposes of determining reserve margin) must have firm transmission service.

In the LOLE analysis, however, the peak season purchases do not contribute to the resource mix in the spring and fall generation maintenance seasons. As a result, the LOLE is greater during those periods than it would be if all power purchases were assumed to be 12-month purchases. Thus, while this modeling assumption has a significant impact on the LOLE results, the fact that transfer capability must accomodate a wide range of capacity transaction types of varying durations is indisputable.

In summary, the minimal transfer capability needed by eastern Wisconsin for reliability purposes alone under normal contingency conditions through 2007 is projected to range from about 1,000 MW to as much as 3,400 MW. The specific amount needed for this purpose through 2007 and beyond, will depend on the amount of generation developed within eastern Wisconsin. The average of the range of transfer capability need is approximately 2,200 MW.

OTHER RELIABILITY CONSIDERATIONS

The LOLE analysis described above involved a statistical assessment of the transfer capability needs to serve eastern Wisconsin load reliably. In addition to the reliability-based needs determined in the generation-based LOLE analysis, there are a number of other factors that need to be accounted for in order to insure a robust bulk electric system for a variety of system conditions that are not reflected in that analysis. As discussed below, most of those factors have a tangible impact on transfer capability requirements. Those factors include:

- extraordinary contingencies,
- multiple contingencies,
- parallel path flows,
- age of facilities,
- dynamic stability of the regional transmission system,
- operating limitations,
- diversity of supply, and
- geographic limitations.

Extraordinary Contingencies

The primary reason that the reliability issue came to the forefront in Wisconsin in 1997, prompting utilities, regulators and legislators to address the reliability issue, is that eastern Wisconsin experienced an extraordinary contingency: the prolonged outage of all three nuclear reactors in Wisconsin. This first-time event virtually eliminated capacity reserve margins and exposed the weakness of the ability of the transmission system in Wisconsin to import power.

Wisconsin was not alone in suffering from the prolonged outages of its nuclear power plants. Utilities in Illinois, in particular, were faced with the loss of numerous nuclear power plants during the same time frame, and the situation in Illinois exacerbated the reliability problems facing Wisconsin.

While this situation constituted an extraordinary event, it highlighted the need for an electric system that is flexible enough to withstand extraordinary events that could affect reliability. Other events such as extensive multiple outages of generation and/or transmission facilities due to storms or equipment failures, fuel shortages, fuel delivery problems, or a permanent or temporary shut-down of nuclear plants, all could have a crippling effect on Wisconsin utilities' ability to serve its customers and emphasizes the need for adequate transmission interconnection capacity to accommodate power transfers during such events.

Multiple System Contingencies

As part of evaluating bulk electric system performance, system planners consider operation of the system under normal conditions with all generation and transmission facilities operating and under contingency conditions, when a key facility is out of service. Based on historical system operation, at virtually all times, at least one generation and/or transmission facility is out of service in a given region and an adjacent region. As such, while single contingency planning is the criterion used by the Wisconsin utilities to evaluate transmission system additions, the reality is that the broader regional bulk electric system is subject to multiple contingencies a vast majority of the time.

As mentioned above, multiple contingencies are not considered in Wisconsin utility transmission system planning efforts, but they are a part of the MAPP planning criteria for firm transmission service. They are also being considered as one of the new NERC Planning Standards, though a final determination has not been made by NERC.

Given the broad region in which system conditions affect the Wisconsin electric system and vise versa, some consideration of multiple contingencies is warranted when evaluating bulk system reliability . Thus, some margin in the transfer capability targets for new interconnections with regions adjacent to Wisconsin should be included. While certain contingencies could have a crippling effect on Wisconsin transfer capability, the likelihood that such contingencies will occur simultaneous with other highly limiting contingencies is low. However, there are a large number of possible contingencies that, coupled with the contingency that is most limiting, would result in a significant reduction in transfer capability into eastern Wisconsin. As such, the minimum threshold transfer capability margin should be high enough to cover a wide range of simultaneous contingencies. The range of reduction from simultaneous contingencies could be from 0 MW to as much as 1,000 MW. Considering the magnitude of this range and the associated probabilities of occurrence, 200 MW has been deemed to be a reasonable amount to account for simultaneous contingencies.

Parallel Path Flows

When MAPP utilities are exporting large blocks of power to utilities to the south or east of MAPP, a portion of the exported power flows through the Wisconsin-Minnesota transmission interconnection. These parallel power flows reduce the amount of power that utilities in eastern Wisconsin can purchase from MAPP suppliers and may actually require curtailment or interruption of purchases, both firm and non-firm, already established between MAPP and eastern Wisconsin. Operating experience has shown that as much as 600 MW of parallel path flows can occur over the Wisconsin-Minnesota transmission interface. In addition, the frequency of significant parallel path flows suggest that a transfer capability margin of 600 MW to account for the impact of these flows is warranted. Further, new transmission interconnections between MAPP and eastern Wisconsin would significantly increase transfer capability between the regions but will also increase the magnitude of these parallel path flows. Transfer capability targets for such new interconnections should be planned considering the level of historical parallel path flows and the likelihood these flows will increase in the future.

Aging Facilities

As both generation and transmission facilities within a region increase in age, particularly beyond their design life, the forced outage rates of such facilities in most instances will increase. This will result in a lower level of system reliability within that region. Strong, new transmission interconnections with adjacent regions would compensate for the lowering of system reliability due to aging facilities.

In eastern Wisconsin, coal-fired generating units, which provide a majority of the energy produced in the region, range from 14 to 64 years in service, average 39 years in service, and over half these units are beyond their design life. In addition, a majority of the major transmission facilities are at least 25 years old. Perhaps most importantly, the EWU's nuclear units are over 20 years old with operating licenses that expire within the next 15 years. Given the recent history (extended outages, premature retirements) of other nuclear units in the U.S., nuclear units pose a significant threat to reliability due to their relative size and the uncertainty associated with their continued operation. As demonstrated in 1997 when the EWU experienced extended outages of its nuclear units, transfer capability is significantly impaired without the generation provided by the nuclear units. New transmission facilities interconnecting eastern Wisconsin to adjacent regions that improve transfer capability would be prudent insurance for the potential sudden, permanent or temporary loss of generation in eastern Wisconsin along with the planned retirement of other aging generation facilities. In addition, the target for transfer capability should account for the relative age of Wisconsin's generating facilities.

Dynamic Stability

The dynamic stability of the bulk electric system is the system's ability to continue to operate during and after disturbances, such as sudden loss of generation and/or transmission facilities, without causing damage to equipment or causing regions adjacent to the disturbance to be adversely affected. It has been established in practice that loss of the Wisconsin-Minnesota 345 kV transmission interconnection during various system conditions results in unacceptable dynamic stability performance of the bulk electric system. Potential solutions include limiting power transfers between regions, constructing generation at particular locations and constructing transmission facilities between particular locations. Limiting power transfers between regions at well below thermal limits is not an efficient use of resources and hence, not a desirable long-term solution. In addition, there may be significant monetary implications associated with such limitations. Constructing generation at particular locations selected to improve dynamic stability may not be viable because the location(s) may not be suitable for generation. In addition, depending on the location, new generation could potentially exacerbate a stability problem. Further, depending on the type of generation constructed (i.e., peaker), the generation may not be operated in a mode to significantly improve dynamic stability. Constructing transmission facilities designed to address system operating constraints due to dynamic stability is the most robust long term solution.

Operating Limitations

Currently, the Wisconsin utilities monitor the amount of power flowing on the 345 kV Wisconsin-Minnesota transmission interconnection and take measures to limit flows to 775 MW in order to remain within safe operating conditions. This limitation was imposed due to system stability considerations and requires increased vigilance on the part of utilities' operators. This limitation can significantly impede commerce between Wisconsin and MAPP utilities. New transmission interconnections between MAPP and Wisconsin will reduce or negate the need for this limitation.

Diversity of Supply

One key factor to maintaining reliability is having diversity in the bulk electric supply system. This diversity is achieved by having generation of various types, sizes, locations, fuel sources and delivery mechanisms, and having access to generation sources outside of eastern Wisconsin. Access to markets outside of eastern Wisconsin is a benefit since it allows adjacent regions to take advantage of diversity in weather and system conditions.

In addition, since new generation is generally added within a region based on projected need within that region, there are often periods of capacity surplus and capacity deficit within regions. The ability to transfer power between regions is necessary for the regions to exchange power during respective surplus and deficit periods.

Geographic Limitations

Unlike most regions of its size in the U.S., Eastern Wisconsin is limited to developing substantial transmission interconnections to the west and south due to the fact that Lake Superior and Lake Michigan effectively prevent economical transmission interconnections to the north and east, respectively. As such, it is crucial that eastern Wisconsin transmission interconnections to the west and south are sufficient to provide adequate transfer capability, minimize operating limitations and maintain dynamic stability for a variety of system conditions.

QUANTIFYING WISCONSIN'S TRANSFER CAPABILITY NEEDS

As summarized in the discussion of the results of the LOLE analysis above, eastern Wisconsin is projected to need a minimum of between 910 MW (Case 1) and 3,410 MW (Case 2) of interface transfer capability by 2007, depending on the generation development scenario, in order to achieve the 0.1 day/year LOLE criterion.

There are tradeoffs between meeting future capacity requirements with new, internal generation versus power imported from outside of eastern Wisconsin. The generation-only approach is limiting since all of the potential benefits of transmission interconnections with surrounding areas cannot be exploited.

Access to low cost power from areas that may have surplus power from time to time would remain limited. Further, this approach puts eastern Wisconsin in a position of lacking flexibility in terms of the timing and siting of new generation. This is especially problematic as generation becomes increasingly deregulated and more and more new generation is constructed as merchant facilities. Without strong transmission ties enabling siting flexibility, the siting options for merchant plants serving loads in eastern Wisconsin would be limited to sites in eastern Wisconsin. Thus, options for both merchant plant developers in terms of siting plants and options for power purchasers in terms of power purchase alternatives would be limited, with resulting adverse economic consequences for consumers.

The transmission-only approach is less limiting since it offers both the reliability and economic benefits of access to surplus power markets, yet does not preclude, and may be enhanced by, development of new generation within eastern Wisconsin. Having new transmission interconnections should help keep the cost of power purchased by the EWU and new generation in eastern Wisconsin competitive.

There are other factors that support increasing transfer capability into eastern Wisconsin which cannot easily be translated by technical analysis into some amount of import capability.   First, given the recent changes in regulation and the uncertainty associated with deregulation, many utilities are reluctant to make significant investments in new generation. Merchant plant developers tend to view the generation market from a regional perspective and may or may not locate new generation in Wisconsin. Absent future orders by the PSCW for the EWU to construct new generation within eastern Wisconsin, the 1,300 MW of new generation to be added in 1999 and 2000 will allow the EWU to meet the 18% reserve margin target only through 2000. What's more, given the limited transfer capability into eastern Wisconsin, these additions are not sufficient to achieve the 0.1 day/year LOLE criterion through the year 2000. Given the uncertainty associated with the development of new generation in Wisconsin and the region, both as to timing and location, additional transfer capability is needed to help to ensure that adequate reliability could be achieved even if generation development does not keep pace with load growth.

Second, the current average simultaneous firm transfer capability into eastern Wisconsin is only approximately 1,000 MW. This amount represents only about 10% of the EWU peak demand. In a deregulated environment, only about 10% of customer load would have the option of accessing power markets outside of eastern Wisconsin. Thus, the prospects for vigorous competition of electric supply in eastern Wisconsin absent the ability to choose suppliers from outside eastern Wisconsin are limited at current transfer capability levels. Lack of access to power markets outside of Wisconsin will continue to raise concerns about market power within Wisconsin.

Third, participation in the regional power markets is a prerequisite for Wisconsin utilities to remain competitive. Without access to power markets outside of Wisconsin, suppliers within Wisconsin will be at a distinct disadvantage.

As previously discussed, a minimum of 3,400 MW of transfer capability into eastern Wisconsin would be needed to achieve the 0.1 day/year reliability criterion by 2007 absent any new generation in eastern Wisconsin beyond that already approved by the PSCW or committed to by the EWU. Obviously, the likelihood that no new generation will be developed in eastern Wisconsin after year 2000 is low. However, there is no certainty that enough generation will be developed in eastern Wisconsin to maintain 18% reserves beyond year 2000. And, to what degree new generation will be developed in a deregulated market is impossible to predict. Using the average of the bounds of import capability needs, 2,200 MW, appears to be a reasonable target for reliability-based need given the uncertainty regarding generation development in the future.

This reliability-based need (2,200 MW), coupled with the margins previously suggested for parallel path flows based on historical operating experience (600 MW) and for multiple contingencies (200 MW), alone suggest a transfer capability target of 3,000 MW into eastern Wisconsin. Considering the numerous other factors which have not been quantified (extraordinary contingencies, age of facilities, siting flexibility for merchant plants, etc.), a target of 3,000 MW should be considered a minimum. Setting 3,000 MW as the target for expansion of Wisconsin's simultaneous transfer capability would provide the Wisconsin utilities with the flexibility needed for capacity procurement and yet does not preclude the possibility or reduce the benefits of new, internal generation.

CONCLUSIONS

- At the present time, the EWU lack sufficient internal generating capacity and transfer capability to achieve the level of reliability of 0.1 day/year LOLE specified by the PSCW.
- Based on LOLE analysis, eastern Wisconsin is projected to require a minimum of between 910 MW and 3,410 MW of reliability-based transfer capability by 2007 just to achieve a 0.1 day/year LOLE criterion.
- The minimum reliability-based transfer capability requirements do not account for that needed (a) to enable Wisconsin and the region to withstand extraordinary contingencies, (b) to accommodate parallel path flows, (c) considering multiple system contingencies, (d) to allow Wisconsin utilities and customers to participate fully in the regional power markets and (e) to provide flexibility in the timing and siting of new generation.
- There is considerable uncertainty regarding how much new generation will be developed in eastern Wisconsin beyond the year 2000.
- Additional transfer capability would provide Wisconsin and the region the most flexibility in terms of resource procurement and the siting of new generation in the future. Siting flexibility is important since much of the future generation is expected to be developed as merchant plants.
- A minimum target for simultaneous transfer capability into Wisconsin of 3,000 MW is reasonable based on reliability needs, accounting for parallel path flows and multiple system contingencies, and considering the potential for extraordinary contingencies, the uncertainty associated with the siting of new generation and the requirements for meaningful access to, and participation in, the power markets.