

Independent Electricity Market Operator

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*Ontario Transmission System*



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## **1.0 Introduction**

The Ontario Electricity Market Rules (Chapter 5) require that the Independent Electricity Market Operator (IMO) provide forecasts and assessments of the reliability of the existing and committed resources and transmission facilities of the Ontario Market.

These forecasts and assessments of the Ontario Electricity System are contained in the IMO 18-Month and 10-Year Outlooks.

This document is intended to complement the transmission assessments contained in both Outlooks by providing specific details on the Ontario transmission system, including the major internal transmission interfaces and interconnections with neighbouring jurisdictions.

Readers are invited to provide comments and/or suggestions on this document. To do so, please contact our Help Centre: Toll Free: 1-888-448-7777 Tel: 905-403-6900 Fax: 905-403-6921 E-mail: [helpcentre@theIMO.com](mailto:helpcentre@theIMO.com).

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## **2.0 Current Transmission System Configuration**

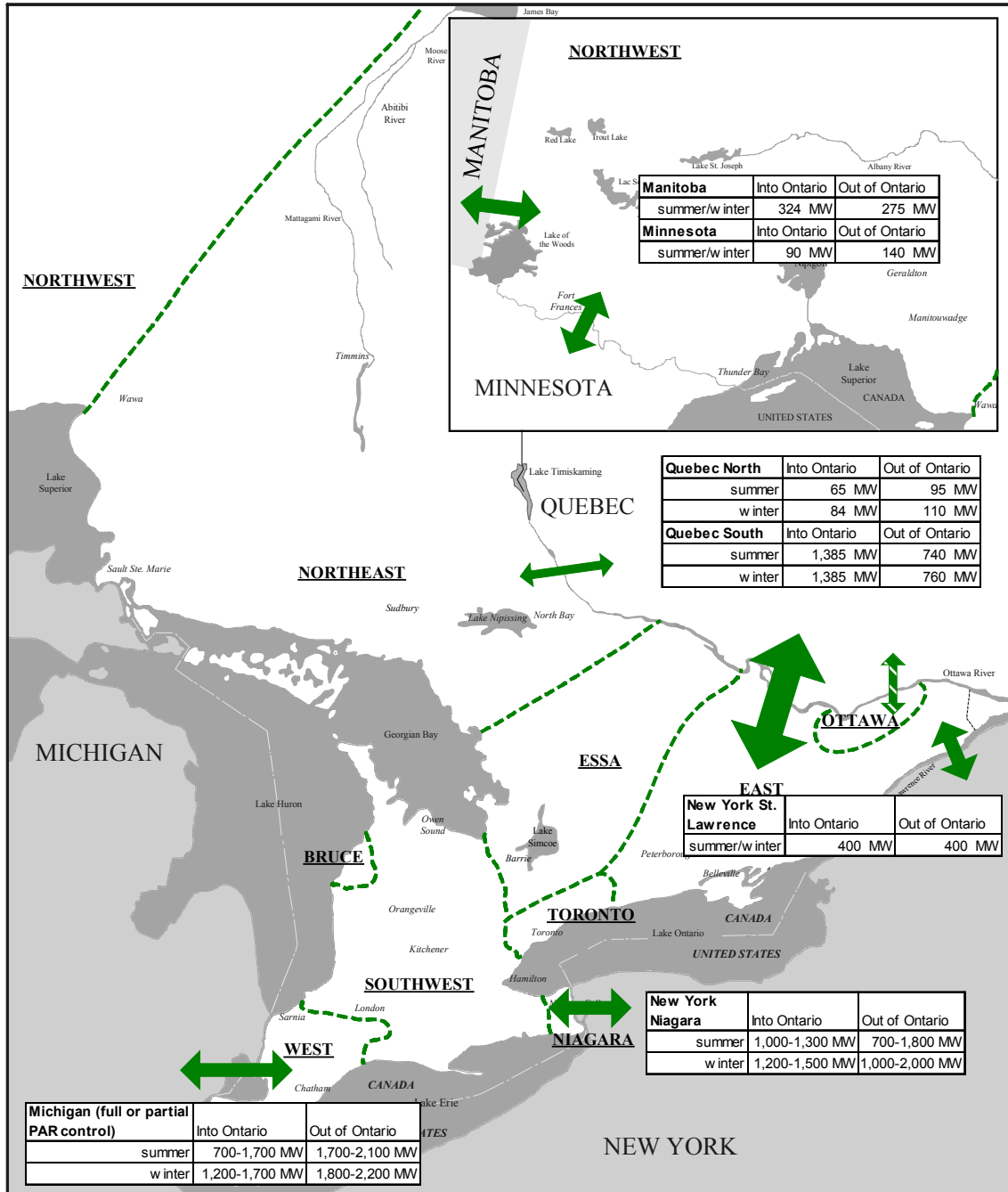
Figures 2.1.1 and 2.1.2 provide a geographic depiction of Ontario's internal transmission zones, major transmission interfaces, and transmission interconnection points with other jurisdictions.

Operating security limits for these interfaces and interconnections are also included in Figures 2.1.1 and 2.1.2. An explanation of the limit values shown in the tables is contained in Sections 3.3 and 5.3. The interconnection and interface limits are used to ensure system stability, acceptable pre-contingency and post-contingency voltage levels and/or acceptable thermal loading levels.

Figure 2.1.3 provides a simplified depiction of Figures 2.1.1 and 2.1.2 and indicates the transmission zones that are described in more detail in Section 4.0.



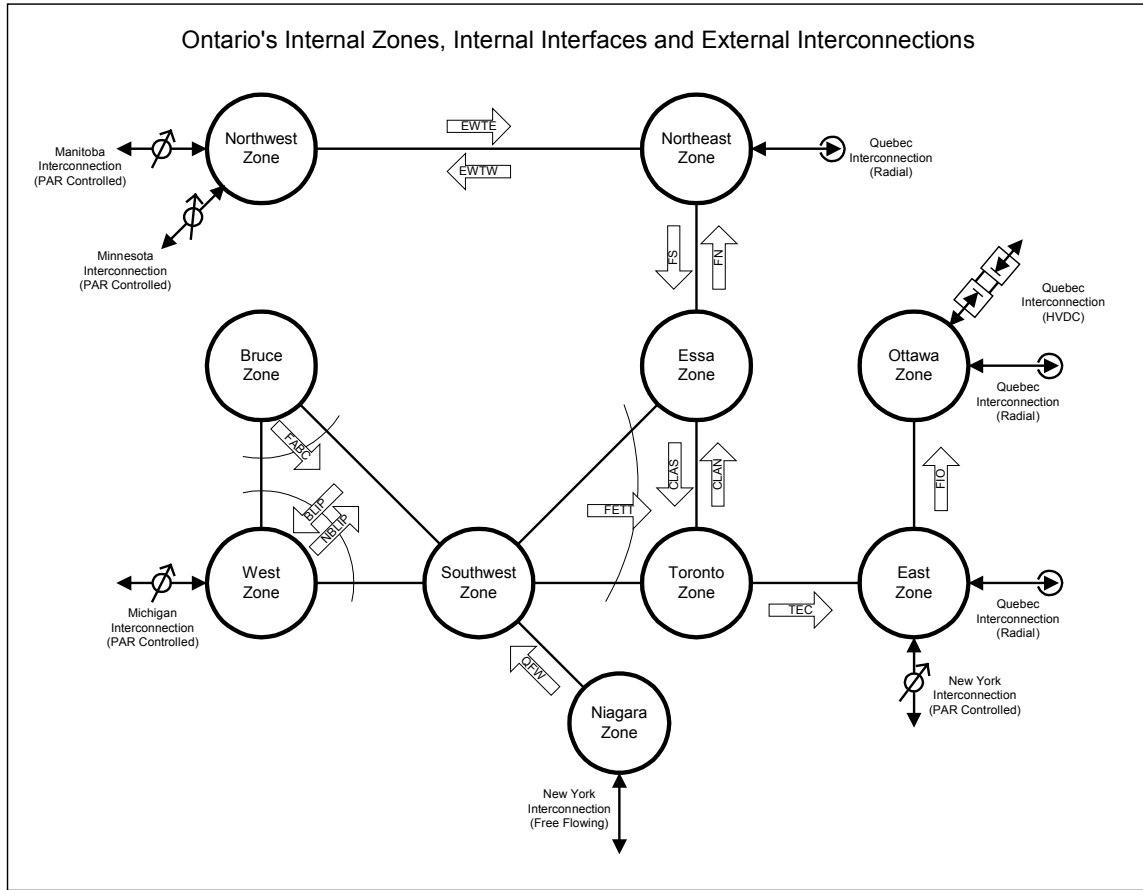
Figure 2.1.2 Ontario's Points of Interconnection with Neighbouring Areas



Notes to Figure 2.1.2:

1. Tables indicate flow limits for each interconnection. Note the Ontario coincident import/export capability is not necessarily the arithmetic sum of the individual flow limits. See Section 5.0 for further details.

Figure 2.1.3 Ontario's Zones, Interfaces and Interconnections



Notes to Figure 2.1.3:

1. See Section 4.0 for further details on the Ontario transmission zones.

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## 3.0 Transmission Interfaces

There are nine major internal interfaces in the Ontario transmission system as illustrated in Figure 2.1.3. Detailed information on interface definitions and limits can be found in IMO System Control Orders (SCOs). These SCOs are available by request via the IMO Help Centre.

### 3.1 Interface Definitions

Interface definitions are formed by grouping one or more lines for the purpose of measuring their combined flow and enforcing a power flow limit or, as it is more commonly, called an interface limit. Interface limits are directional and interfaces may have limits imposed in one or both directions.

### 3.2 Interface Capability Limits

Table 3.2 summarizes the base limits for the major interfaces in Ontario; only normal system (all transmission elements in-service) limits are shown.

Note that some limits are simple constants (e.g. BLIP) whereas others are more complicated and may depend on parameters such as status of specific generator units, other transmission flows, Ontario demand, etc. (e.g. NBLIP, FETT, FABC). In cases where interface limits are based on thermal capability, separate ratings are shown for summer and winter conditions.

**Table 3.2 Interface Base Limits**

Interface	Operating Security Limits (MW)
BLIP	3,500
NBLIP	1,500
QFW	1,750 Summer, 1,950 Winter
FABC	4,050-4,450 with four Bruce B units in-service* 4,440-4,950 with five Bruce units in-service* 4,500-5,300 with six 500 kV Bruce units in-service*
FETT	5,700, 5,500 Summer <sup>(1)</sup> , 5,300 Summer <sup>(2)</sup> , 5,100 Summer <sup>(3)</sup>
CLAN	2,000
CLAS	1,000
FIO	1,900
FN	1,900
FS	1,400
EWTE	325
EWTW	350

Summer Limits apply from May 1 to October 31. Winter Limits apply from November 1 to April 30.

(1) Limit is used if the summer Ontario demand is between 22,001 and 22,600 MW.

(2) Limit is used if the summer Ontario demand is between 22,601 and 25,000 MW.

(3) Limit is used if the summer Ontario demand is between 25,001 and 26,000 MW

(\*) Limit varies according to BLIP flow. Published limit range based on most restrictive contingency.

### 3.3 Interface Characteristics

#### The EWTE/EWTW Interface

The East-West Transfer East (EWTE) and East-West Transfer West (EWTW) flows are functionally related to the power flows between Ontario and Manitoba, and Ontario and Minnesota. In this relationship, the Ontario – Manitoba and Ontario – Minnesota flows can be generally thought of as the independent variables as they are under phase shifter control.

The maximum limits on the East-West tie are 325 MW to the east and 350 MW to the west. The EWTE and EWTW interfaces are constrained by stability limitations. A sample of historical flow distribution on the East West Interface is shown in the Figure 3.3.1.

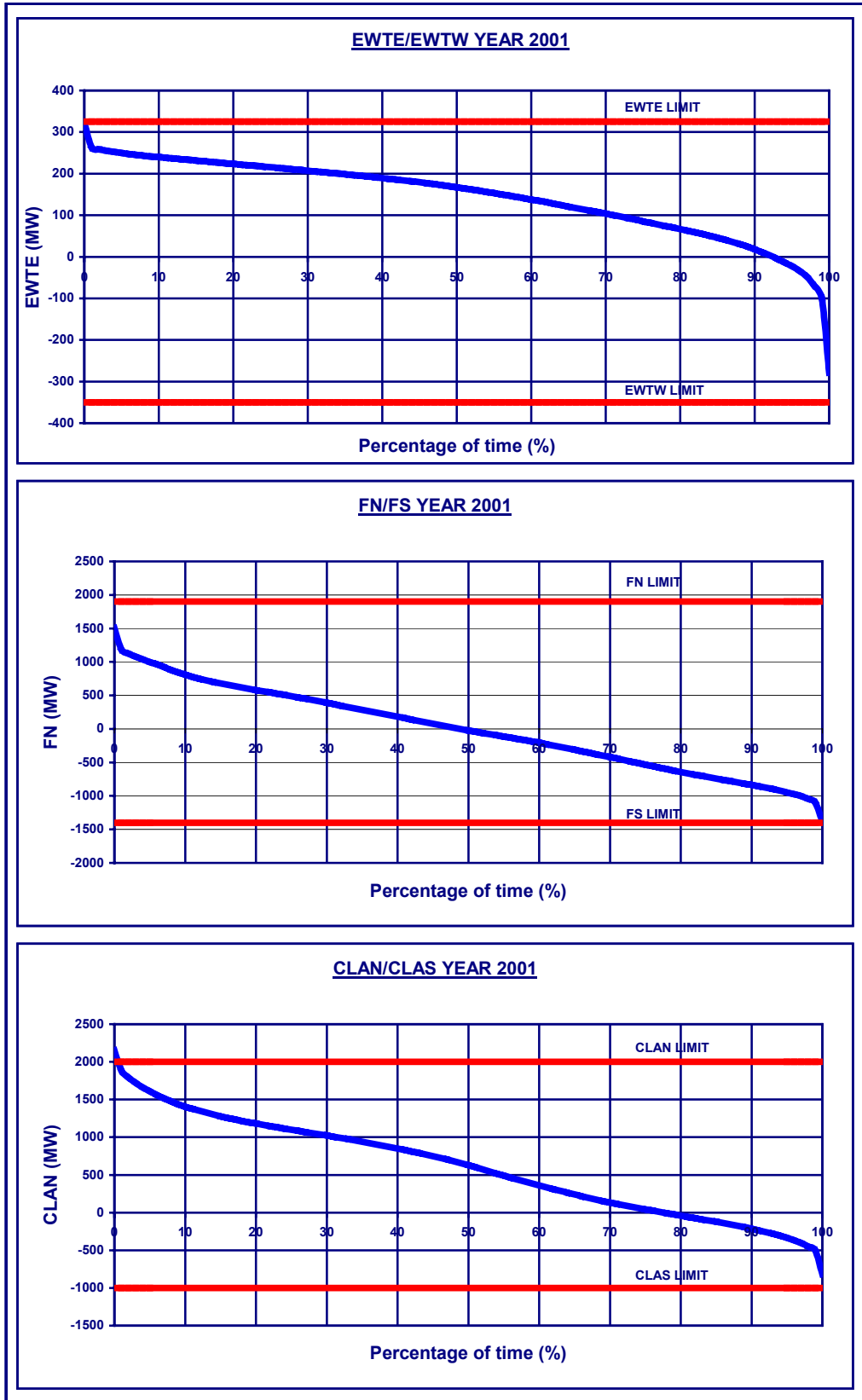
#### The FN/FS Interface

The Flow South (FS) limit is 1,400 MW and the Flow North (FN) limit is 1,900 MW. The Flow North and Flow South interfaces are constrained by voltage and stability limits respectively. A sample of historical flow distribution on the FN/FS interface is shown in the Figure 3.3.1.

#### The CLAN/CLAS Interface

The Claireville North (CLAN) limit is 2,000 MW and the Claireville South (CLAS) limit is 1,000 MW. These limits have been defined to determine the boundary conditions for which the other system limits, in particular FABC and FETT, are valid. A sample of historical flow distribution on the CLAN/CLAS interface is shown in the Figure 3.3.1.

Figure 3.3.1 Historical Flow Distribution – EWTE/EWTW, FN/FS and CLAN/CLAS Interfaces



### The FABC Interface

The Flow Away from Bruce Complex (FABC) limit depends on the number of Bruce units in-service, the BLIP/NBLIP interface flow and a number of other system parameters. The FABC limit is required for preserving system and/or plant stability, and maintaining acceptable post-contingency voltages.

With four Bruce B units and all transmission elements in-service, the FABC interface limit will range from 4,050 MW to 4,450 MW depending on the BLIP/NBLIP interface flow. The impact of other system parameters such as reactive support provided from other generating stations and reactor switching availability would likely result in a lower limit.

With five Bruce units and all transmission elements in-service, the FABC interface limit will range from 4,400 MW to 4,950 MW depending on the BLIP/NBLIP interface flow. With six 500 kV Bruce units and all transmission elements in-service, the FABC interface limit will range from 4,500 MW to 5,300 MW depending on the BLIP/NBLIP interface flow. For both of these cases, the impact of other system conditions would likely result in lower limits.

With four or more Bruce units in-service, the FABC limit can be improved through the use of generation rejection (G/R) of Bruce units. The resulting limit improvements with G/R are not specified in this document, but are described in detail in the appropriate SCO.

### The BLIP/NBLIP Interface

The Buchanan Longwood Input (BLIP) interface is limited to 3,500 MW to the west due to stability limitations. The Negative Buchanan Longwood Input (NBLIP) interface limit is a function of a variety of parameters. Normally the limit is near its high end of about 1,500 MW. The interface is typically constrained by voltage limitations. A sample of historical flow distribution on the BLIP interface is shown in the Figure 3.3.2.

### The QFW Interface

The Queenston Flow West (QFW) interface is limited to 1,950 MW for flows to the west in the winter. In the summer, the limit is 1,750 MW to the west. This interface is constrained by thermal limitations. There is no limit specified for flows to the east, as the level of flows expected in that direction will not cause system concerns. A sample of historical flow distribution on the QFW interface is shown in the Figure 3.3.2.

### The FETT Interface

The Flow East Towards Toronto (FETT) interface limit is a function of a variety of parameters such as Ontario demand and reactive support provided from various generating stations. As a result, the limit of this interface is generally lower than its maximum limit of 5,700 MW. The interface is constrained by a combination of stability and thermal limits. There is no limit specified for flows to the west, as the current level of flows expected in that direction will not cause system concerns. A sample of historical flow distribution on the FETT interface is shown in the Figure 3.3.2.

### The TEC Interface

The Transfer East from Cherrywood (TEC) interface does not have a pre-defined limit for up to any one single element out of service. The TEC interface is included to provide a boundary between the Toronto and East transmission zones. With these zones defined, specific studies can be conducted to consider varying economic conditions and/or varying resource scenarios and to consider these impacts on reliability.



**The FIO Interface**

The Flow into Ottawa (FIO) interface is limited to 1,900 MW to control post-contingency voltage declines in the Ottawa zone. There is no limit specified on this interface for flows to the East zone. The FIO limit can be improved with the use of load rejection in the Ottawa zone. A sample of the historical flow distribution on the FIO interface is shown in Figure 3.3.3.

Figure 3.3.2 Historical Flow Distribution – BLIP/NBLIP, QFW and FETT Interfaces

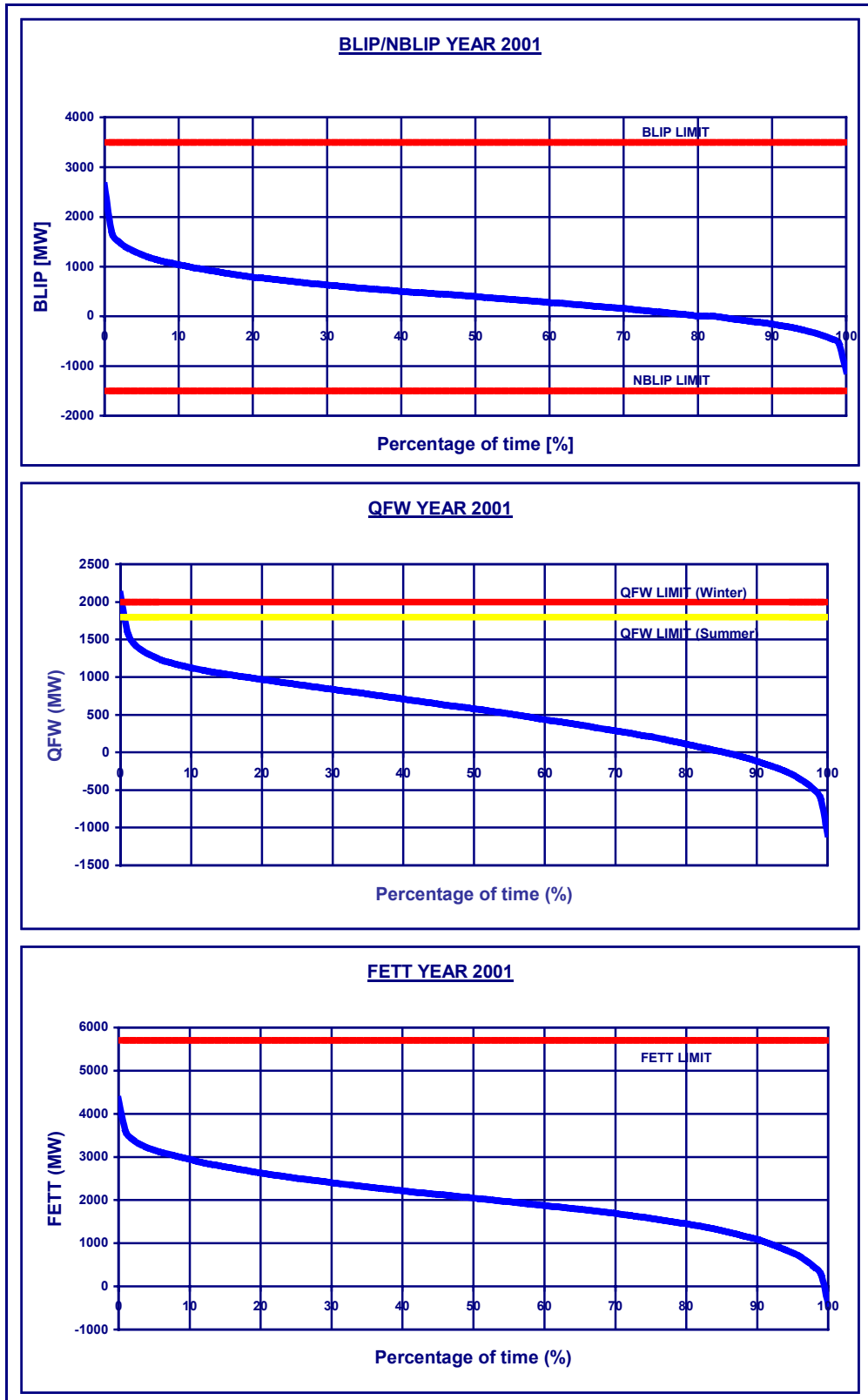
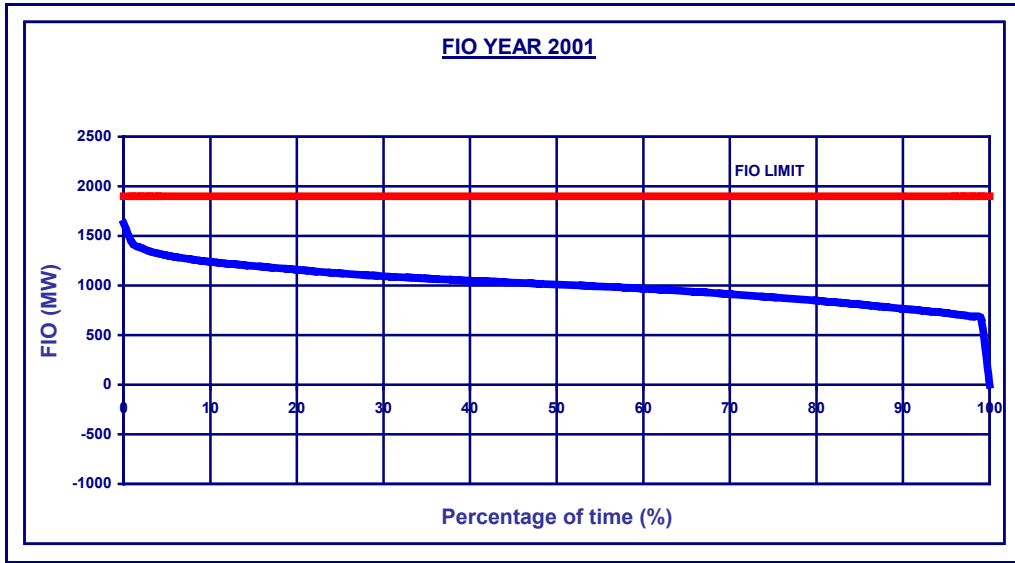


Figure 3.3.3 Historical Flow Distribution – FIO Interface



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## 4.0 Transmission Zones

The Ontario transmission system has been divided into ten zones as illustrated in Figure 2.1.3. Zonal boundaries have been chosen to correspond with the major interfaces described in Section 3.0.

### 4.1 Zone Characteristics

#### Bruce Zone

- The total resources are much greater than the zone peak demand.
- The generation is mostly nuclear.
- There are no external interconnections.

#### East Zone

- The total resources exceed the zone peak demand.
- The generation is a mix of hydroelectric, oil, and gas.
- The zone is externally connected to the Quebec grid.
- The existing interconnection with Quebec is radial.
- The zone is also externally connected to the St. Lawrence interface with New York via phase shifter control.

#### Essa Zone

- The total resources are much less than the zone peak demand.
- The generation is totally hydroelectric.
- For analytical purposes, Des Joachims generation and 115 kV load, which is physically located in the East zone, has been modeled to be part of the Essa zone. The Essa zone is the primary point of receipt of Des Joachims generation.
- There are no external interconnections.

#### Niagara Zone

- The total resources are much higher than the zone peak demand.
- The total load consists of 25 Hz and 60 Hz loads.
- The generation consists of 25 Hz and 60 Hz units, and is predominantly hydroelectric with some cogeneration.
- There is a free-flowing interconnection with New York.

#### Northeast Zone

- The total resources exceed the zone peak demand.
- The generation is mainly hydroelectric with some cogeneration.
- There is some 25 Hz generation radially connected to the 60 Hz electricity system via a frequency changer.

- The zone is externally connected to the Quebec grid.
- The interconnection with Quebec is radial.

**Northwest Zone**

- The total resources generally exceed the zone peak demand.
- The generation is mainly hydroelectric with some coal
- The zone is externally connected to the Manitoba and Minnesota systems.
- The 230 kV Manitoba interconnections are under phase shifter control. The Manitoba 115 kV interconnection is radial. The Minnesota 115 kV interconnection is under phase shifter control.
- To comply with NPCC and MAPP (Mid Continent Area Power Pool) system security criteria, plans have been developed for implementing enhanced security criteria for the operation of this zone. These plans will result in system security criteria that will respect the following contingencies: double circuit faults, 3-phase faults, breaker failure and Manitoba's DC line bipole block. In order to ensure the reliability of the IMO-controlled grid in the Northwest, the enhanced security criteria will be implemented in various stages.

The application of these criteria for the operation of the Northwest zone is expected to impact the operation of the Northeast zone. Therefore, the security criteria for the Northeast will also be reviewed.

**Ottawa Zone**

- The total resources are much less than the zone peak demand.
- The generation is cogeneration.
- The existing interconnection with Quebec is radial.

**Southwest Zone**

- The total resources are generally balanced with the zone peak demand.
- The load consists of 25 Hz and 60 Hz.
- The generation is mostly coal.
- There are no external interconnections.

**Toronto Zone**

- The total resources are slightly higher than the zone peak demand.
- The generation is mostly nuclear and coal.
- There are no external interconnections.

**West Zone**

- The total resources are slightly less than the zone peak demand.
- The generation is mostly coal.
- There is a free-flowing interconnection with Michigan. At some future date, the interconnection will be under phase shifter control.

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## 5.0 Transmission Interconnections

The term interconnection is used to describe interfaces that join Ontario to other jurisdictions (external control areas).

Ontario has interconnections with Manitoba, Minnesota, Quebec, Michigan, and New York.

### 5.1 Interconnection Definitions

Like transmission interfaces, interconnection definitions are formed by grouping one or more lines for the purpose of measuring their combined flow and enforcing a power flow limit. Interconnections limits are defined for flows into Ontario (imports) and out of Ontario (exports).

### 5.2 Interconnection Flow Limits

Table 5.2 summarizes the flow limits for the interconnections; only normal system (all transmission elements in-service) limits are shown.

For Manitoba and Minnesota, the flow limits recognize deadband margins associated with the phase angle regulator taps.

For Michigan and New York, a range of values is given for summer and winter flows into and out of Ontario. The flow limits account for the automatic generation control (AGC) process required to match load and generation within Ontario. A margin of approximately 100 MW has been used for this purpose. Generally, the higher values reflect the amount of power that can be transferred with favourable generation dispatch and weather conditions. With favourable conditions, the flow capabilities of the interconnections will not be affected by internal limitations in the transmission network. The lower values reflect the amount of power that can be transferred with unfavourable dispatch and weather conditions. With unfavourable conditions, the flow capabilities will be affected by internal limitations in the transmission network.

When ambient conditions permit, flow limits over paths restricted by thermal considerations may be increased during real-time operation.

**Table 5.2 Interconnection Limits**

Interconnection	Limit - Flows Out of Ontario MW	Limit - Flows Into Ontario MW
Manitoba	275	324
Minnesota <sup>(3)</sup>	140	90
New York St. Lawrence	400	400
Quebec North – Summer*	95 <sup>(5)</sup>	65
Quebec South (East and Ottawa) - Summer*	740	1,385
New York Niagara (60 Hz and 25 Hz) – Summer <sup>(1)</sup>	700-1,800	1,000-1,300
Michigan – Summer <sup>(2,3)</sup>	1,700-2,100	700-1,700
Quebec North – Winter*	110 <sup>(4)</sup>	84
Quebec South (East and Ottawa) - Winter*	760	1,385
New York Niagara (60 Hz and 25 Hz) – Winter <sup>(1)</sup>	1,000-2,000	1,200-1,500
Michigan – Winter <sup>(2,3)</sup>	1,800-2,200	1,200-1,700

\* Summer Limits apply from May 1 to October 31. Winter Limits apply from November 1 to April 30.

(1) Limits are based on thermal ratings and 75% of pre-load. Summer limits are based on 0-4 km/hr wind speed and 30 Deg.C ambient temperature. Winter limits are based on 0-4 km/hr wind speed and 10 Deg.C ambient temperature.

(2) Limits are based on thermal ratings and 75% of pre-load. Summer limits are based on 0-4 km/hr wind speed and 35 Deg.C ambient temperature. Winter limits are based on 0-4 km/hr wind speed and 10 Deg.C ambient temperature.

(3) For day to day operations of the interconnection, limits are based on ambient conditions such as wind speed, temperature and pre-loads.

(4) Limit based on 0-4 km/hr wind speed\* and 10 Deg.C or less ambient temperature.

(5) Limit based on 0-4 km/hr wind speed and 30 Deg.C or less ambient temperature

### 5.3 Interconnection Characteristics

Most of Ontario's non-radial interconnections are under phase-shifter control, except for New York Niagara and part of Michigan.

#### The Ontario – Manitoba Interconnection

The Ontario-Manitoba Transfer East (OMTE) and Ontario-Manitoba Transfer West (OMTW) limits are both 275 MW in summertime and wintertime, and are constrained by stability and thermal limitations.

The Ontario-Manitoba 115 kV interconnection limits are 49 MW for flows into Ontario in the summertime and wintertime.

#### The Ontario – Minnesota Interconnection

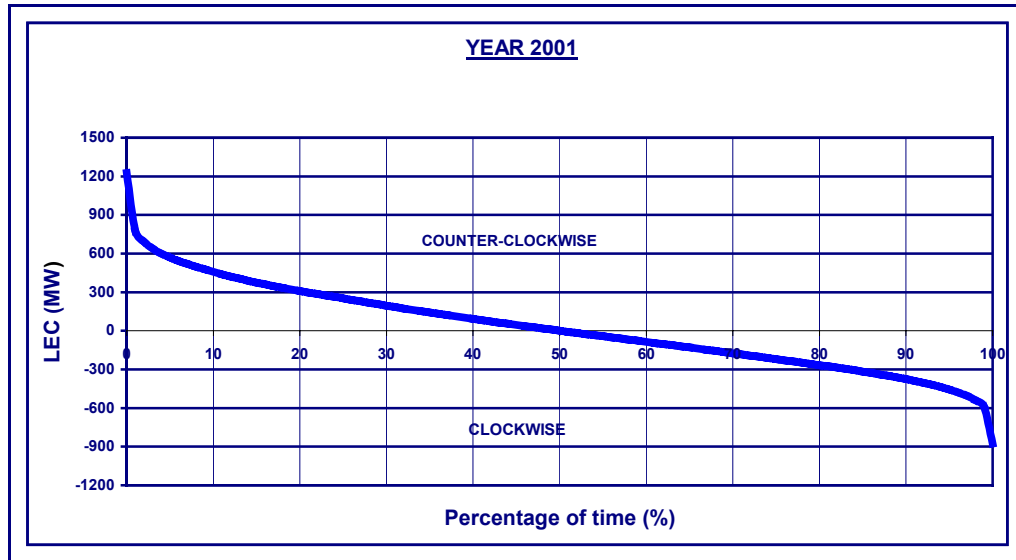
The Minnesota Power Flow North (MPFN) and Minnesota Power Flow South (MPFS) limits are 90 and 140 MW respectively and are constrained by stability and thermal limitations.

### The Ontario – Michigan Interconnection

The Michigan interconnection is constrained by thermal limitations.

At the present time, there is partial phase shifting control of the Ontario – Michigan interconnection. With the expected addition of a new phase angle regulator (PAR) on circuit L4D in mid-May 2003, all four circuits associated with the interconnection will have phase shifting capability. Utilization of the PARs will control a loop flow or a parallel path flow called Lake Erie Circulation (LEC). LEC occurs naturally through a combination of transmission system impedance with interconnection-wide load/generation dispatch; it is measured as an unscheduled flow across the points of interconnection with New York, at Niagara Falls, and with Michigan. The flow can circulate through Ontario in a clockwise direction, in at Michigan and out at New York-Niagara, or in counterclockwise direction, in at New York-Niagara and out at Michigan. LEC flows also appear on and aggravate the BLIP and QFW interfaces as they are in a direct series path. The PARs, with an effective phase angle control range of  $\pm 40$  degrees under full load, are expected to be capable of controlling approximately 600 MW of LEC in either direction. Control of LEC to levels less than 600 MW should allow scheduled power flows to be maintained between Ontario, Michigan and New York, and should also greatly reduce the incidence of constrained operation of QFW interface. A sample of historical flow distribution for LEC is shown in the Figure 5.3.

The flow limits with partial PAR control versus full PAR control will not materially change because of the nature of contingencies under both operating conditions. For the flows out of Ontario, the winter and summer limits can vary from 1,800 to 2,200 MW and from 1,700 to 2,100 MW, respectively. The lower value of each range represents the amount of power that can be transferred when no generation rejection is armed at Lambton. For the flows into Ontario, the winter and summer limits can vary from 1,200 to 1,700 MW and from 700 to 1,700 MW, respectively. The higher value of each range reflects the amount of power that can be transferred as a result of favourable Lambton and TransAlta – Sarnia Regional Cogeneration Project (SRCP) generation dispatch within the West zone and weather conditions. The favourable conditions cause no limitations on the transmission network not directly associated with the interconnection. The lower value of each range reflects the amount of power that can be transferred with the combination of unfavourable generation dispatch (Lambton and TransAlta – SRCP) and hot, windless ambient conditions.

**Figure 5.3 Historical Flow Distribution – Lake Erie Circulation****The Ontario – New York Niagara Interconnection (60 Hz and 25 Hz)**

The New York (NY) Niagara interconnection, in the winter, is limited from 1,200 to 1,500 MW for flows into Ontario and from 1,000 to 2,000 MW for flows out of Ontario. In the summer, the limit is 1,000 to 1,300 MW for flows into Ontario and 700 to 1,800 MW for flows out of Ontario. The interconnection is constrained by thermal limitations in the winter and summer.

The Queenston Flow West (QFW) interface is in series with the NY Niagara interconnection. All flows entering Ontario on the NY Niagara interconnection will also appear on the QFW interface; this includes imports and parallel path flows. Based on past experience and studies, the QFW interface always hits its limit before the limit is reached on the NY Niagara interconnection for flows entering Ontario; as a result, the capability of the NY Niagara interconnection is never fully utilized. The QFW interface is constrained by thermal limitations, which are very dependent on weather conditions.

Typically, when QFW hits its limit of 1,750 MW under summer conditions, the flow across the NY Niagara interconnection is 1,000 MW. Similarly, when QFW hits its limit of 1,950 MW under winter conditions, flow across the NY Niagara interconnection is 1,200 MW. As a result of the QFW interface constraint, the summer and winter flows into Ontario of 1,000 MW and 1,200 MW, respectively, represent the lower value of the limit range shown in Table 5.2. The higher value of the summer and winter flow limits for flows into Ontario represent favourable conditions where the QFW interface is not constraining.

Similarly, at worst, internal constraints in New York can limit flows leaving Ontario to 700 MW and 1,000 MW during the summer and winter periods, respectively. These values represent the lower values of the limit ranges shown in Table 5.2. The higher value of the summer and winter flow limits for flows into New York represent favourable conditions where no New York internal constraints exist.

**The Ontario – New York St. Lawrence Interconnection**

The limit on this interconnection is 400 MW for flows into or out of Ontario. The interconnection is constrained by thermal limitations and is under the control of phase shifters.

**The Ontario – Quebec North Interconnection**

The Quebec North interconnection is thermally limited to 84 MW under winter conditions and 65 MW under summer conditions, for flows into Ontario from radial generation in Quebec. For flows out of Ontario, the limit is 110 MW in the wintertime and 95 MW in the summertime.

**The Ontario (Ottawa and East zones combined) – Quebec South Interconnection**

The Quebec South interconnection is limited to 1,385 MW for flows into Ontario due to stability limitations and available radial generation. For flows out of Ontario the limits, due to stability and thermal limitations, are 740 MW for the summer and 760 MW for the winter.

**Ontario Coincident Import/Export Capability**

The Ontario coincident import/export capability is not the arithmetic sum of the individual interconnection flow limits. With partial phase angle (PAR) control of the Michigan interconnection, the total transfer capability from Ontario to Michigan and New York (St. Lawrence plus Niagara) depends on the distribution of load and generation across the interconnection. At best, the total transfer is the sum of the two flow limits. At worst, the total transfer is the minimum of either the New York (St. Lawrence plus Niagara) or Michigan transfer capability. In the summer, the interconnections can carry coincident exports from 2,350 MW up to 5,550 MW, and coincident imports from 2,964 MW up to 5,264 MW. In the winter, the interconnections can carry coincident exports from 2,685 MW up to 5,885 MW, and coincident imports from 3,483 MW up to 5,483 MW.

When full PAR control is available on the Ontario – Michigan interconnection, the Ontario coincident import/export capability will equal the arithmetic sum of the individual interconnection flow limits for Lake Eric Circulation flow levels up to 600 MW. In the summer, the interconnections will be able to carry coincident exports from 4,050 MW up to 5,550 MW, and coincident imports from 3,964 MW up to 5,264 MW. In the winter, the interconnections will be able to carry coincident exports from 4,485 MW up to 5,885 MW, and coincident imports from 4,683 MW up to 5,483 MW.

The higher values associated the Ontario coincident import ranges represent theoretical levels that could be achieved only with a substantial reduction in generation dispatch in the West and Niagara transmission zones. In practice, the generation dispatch required for these high import levels would rarely, if ever, materialize. Therefore, at best, due to internal constraints in the Ontario transmission network, Ontario has an expected coincident import capability of approximately 4,000 MW.

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