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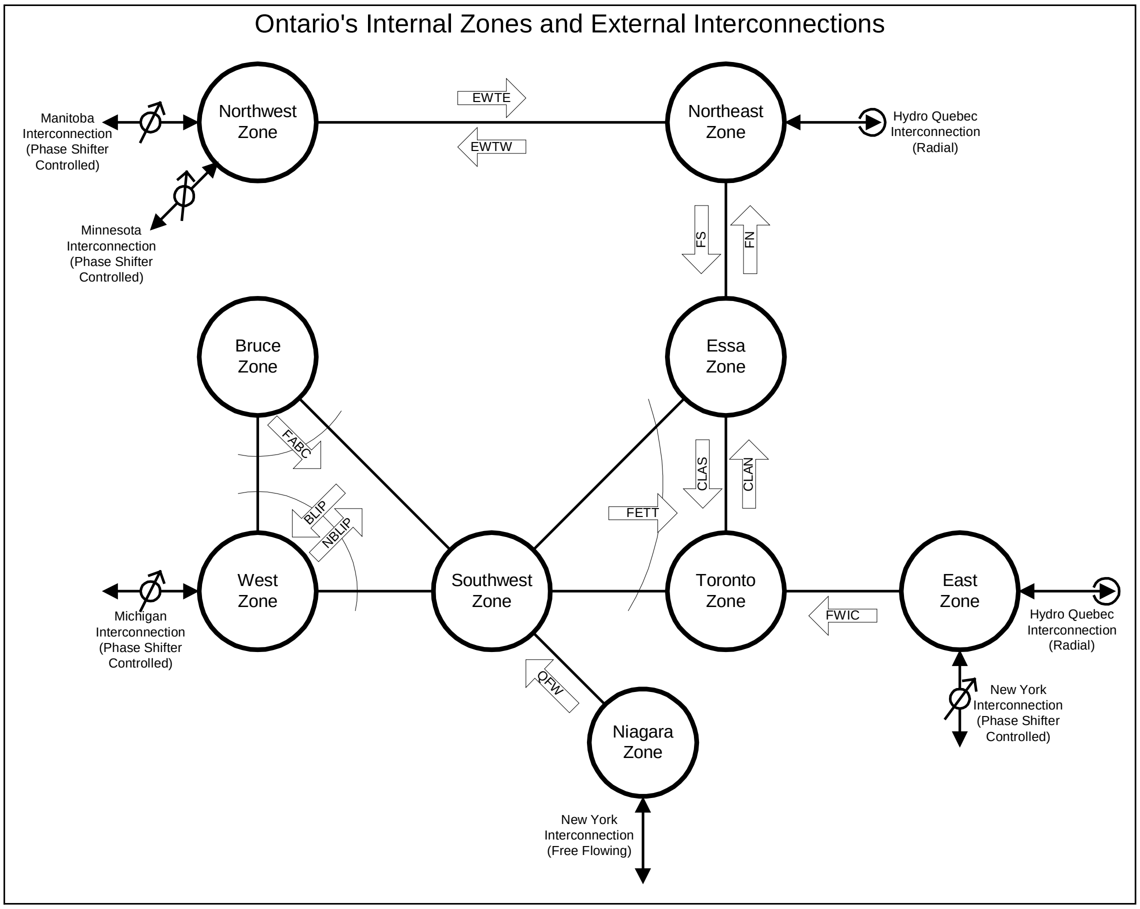
Appendix D1 - Transmission System Interfaces

1.1 Transmission System Interfaces

There are eight major interfaces in the Ontario electricity system, which will be accounted for in this study, as illustrated in Figure D1.1.

Figure D1.1 Ontario's Internal Zones and External Interconnections



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. Appendix D2 shows the major interface definitions used in Ontario. Notice that for each individual transmission element included in an interface definition both the positive direction of power flow and measurement point (e.g. which end of a transmission line the power flow is measured at) are specified.

Interface Capability Limits

Appendix D3 shows the major interface limits that correspond to the definitions in Appendix D2; only normal system (all transmission elements in-service) limits are shown. Notice that some limits are simply constants (e.g. BLIP) and others are more complicated and may depend on parameters such as specific generator unit statuses, other flows, primary demand, etc. (e.g. NBLIP, FETT, FABC). Incases where interface limits are based on thermal capability separate ratings are shown for summer and winter conditions.

1.2 Interface Characteristics

The EWTE/EWTW Interface

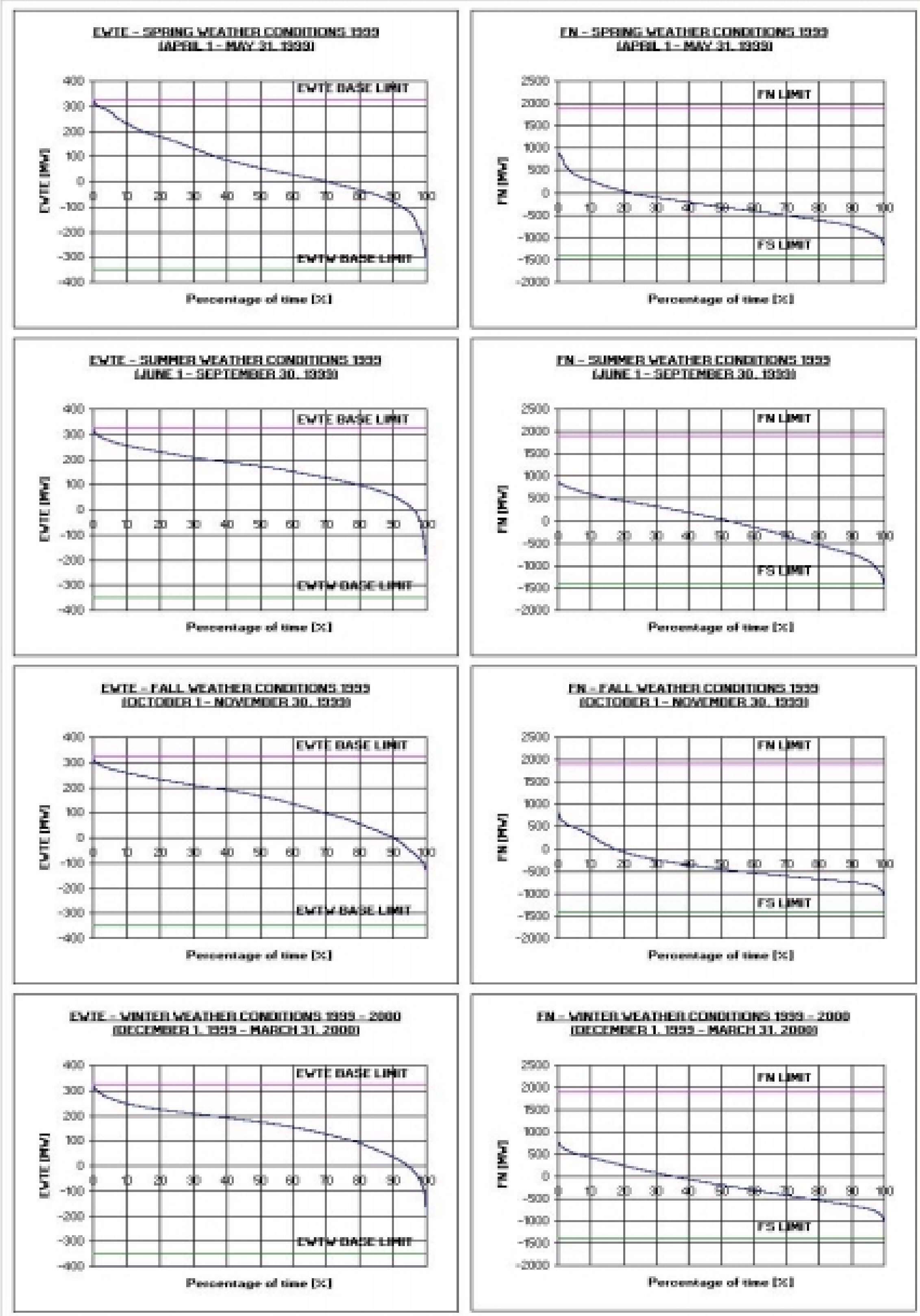
The East-West Transfer East (EWTE) and East-West Transfer West (EWTW) flows are functionally related to the power flows between Ontario and Manitoba (OMTE/OMTW etc.). In this relationship OMTE/OMTW flows can be generally thought of as the independent variables as they are under phase shifter control.

The maximum limits on the East-West tie are 325 MW to the east and 350 MW to the west. During freshet, the EWTE limit causes locked-in generation capacity in the Northwest zone. The EWTE and EWTW interfaces are constrained by stability limitations. A sample of historical flow distribution on the East West Ties is shown in the Figure D1.2.1.

The FN/FS Interface

The Flow South (FS) limit is 1,400 MW and the Flow North (FN) limit is 1,900 MW. During freshet, the Flow South interface is generally limiting the maximum use of lower-cost generating resources in the north. The Flow North and Flow South interfaces are constrained by voltage and stability limits respectively. A sample of historical flow distribution on the Flow North / South interface is shown in the Figure D1.2.1.

Figure D1.2.1 – Historical Flow Distribution – EWTE/EWTW and FN/FS Interfaces



The CLAN/CLAS Interface

The Clairville North (CLAN) limit is 2,000 MW and the Clairville South (CLAS) limit is 1,000 MW.

The FABC Interface

The Flow Away From Bruce Complex (FABC) limit is a functional relationship with a number of other system parameters as shown in Appendix D3. With only a total of four Bruce units available (the other four are on indefinite outage) the FABC limit is high enough that it is never limiting. The FABC limit can also be improved through the use of generation rejection of Bruce units.

The FETT Interface

The FETT (Flow East Towards Toronto) interface limit is a function of a variety of parameters as shown in Appendix D3. Normally the limit is near its high end of about 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 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 D1.2.2.

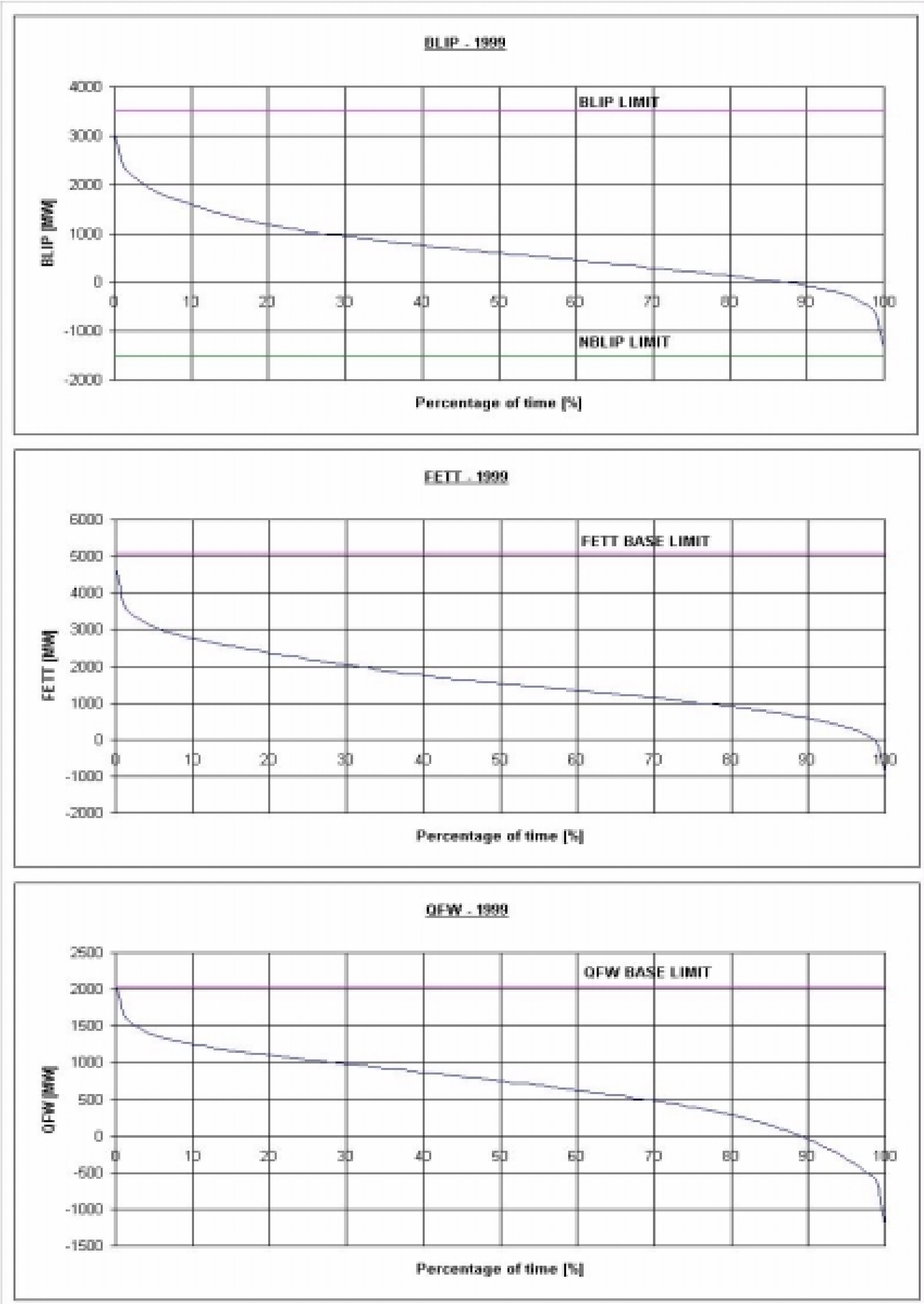
The QFW Interface

The QFW (Queenston Flow West) interface is limited to 2,030 MW for flows to the west in the winter. In the summer, the limit is 1,820 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 D1.2.2.

The BLIP/NBLIP Interface

The BLIP (Buchanan Longwood Input) interface is limited to 3,500 MW to the west due to stability limitations. The NBLIP interface limit is a function of a variety of parameters as shown in Appendix D3. 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 Flow North / South interface is shown in the Figure D1.2.2.

Figure D1.2.2 – Historical Flow Distribution – BLIP/NBLIP, FETT and QFW Interfaces



The FWIC Interface

This interface does not have a pre-defined limit. It is included in this study to provide a boundary for the creation of the East Zone to allow for specific forecasts for this region for such parameters as economic conditions for load growth, total resources, etc.

1.3 Transmission System Zones

The Ontario transmission system has been divided up into nine zones to facilitate the study. Zonal boundaries have been chosen to correspond with the interface definitions in Appendix D2.

Northwest Zone Characteristics

- The total resources generally exceed the peak primary demand.
- The generation is mainly hydroelectric with some coal
- Is externally connected to the Manitoba and Minnesota systems.
- The both interconnections are under phase shifter control.
- MAPP criteria (similar to NPCC) are observed in Manitoba and Minnesota and there is a plan to move toward MAPP criteria limits in the Northwest zone. For many years Manitoba has accepted Northwest zone limits based on criteria less stringent than MAPP, but recently Manitoba joined the MAPP reliability council and as a result Ontario is compelled accordingly.

Northeast Zone Characteristics

- The total resources generally exceed the peak primary demand.
- The generation is mainly hydroelectric with some cogeneration.
- Is externally connected to the Quebec grid.
- The interconnection with Quebec is radial.

Essa Zone Characteristics

- The total resources are much less than the peak primary demand.
- The generation is totally hydroelectric.
- There are no external interconnections.

East Zone Characteristics

- The total resources exceed the peak primary demand.
- The generation is a mix of nuclear, hydroelectric, oil, and gas.
- Is externally connected to the Quebec grid.
- The interconnection with Quebec is radial.
- It is also externally connected to New York with phase shifter control.

Toronto Zone Characteristics

- The total resources are much less than the peak primary demand.
- The generation is mostly nuclear and coal.

- There are no external interconnections.

Bruce Zone Characteristics

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

Southwest Zone Characteristics

- The total resources are well balanced with the peak primary demand.
- The generation is mostly coal.
- There are no external interconnections.

West Zone Characteristics

- The total resources are slightly less than the peak primary demand.
- The generation is mostly coal.
- The interconnection with Michigan is under phase shifter control.

Niagara Zone Characteristics

- The total resources are much higher than the peak primary demand.
- The generation is mostly hydroelectric.

There is a synchronous interconnection with New York.

1.4 Transmission System Interconnections' Capabilities and External Markets

The term interconnection shall be use to describe interfaces that join Ontario to other (external) control areas.

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

Interconnection Definitions

Interconnection definitions are shown in Appendix D4.

Interconnection Capabilities

Interconnection capabilities are shown in Appendix D5.

Interconnection Characteristics

All of Ontario's non-radial interconnections are synchronous and except for Niagara New York are under phase shifter control.

New phase shifters will be installed on the Ontario – Michigan interconnection by the end of summer 2000. The purpose of the new phase shifters is to control a loop flow or parallel path flow called Lake Erie Circulation (LEC) that enters Ontario at the New York Niagara interconnection and exits Ontario at the Michigan interconnection. Most of the time, power flows associated with this condition are greater than 500 MW; on occasion they exceed 1,000 MW. LEC flows also appear on and aggravate the BLIP and QFW interfaces as they are in a direct series path. With the incorporation of the new phase shifters it is expected that the incidence of constrained operation of QFW will be greatly reduced.

For the period of this assessment, the interconnection capability of the transmission system is:

Out of Ontario 5,930 / 5,880 MW (Winter/Summer)

Into Ontario 5,525 / 5,180 MW (Winter/Summer)

There is a non-committed plan to install a new back-to-back HVDC tie with HQ on December 1, 2002 which would increase Ontario's interconnection capability by 1,250 MW in both directions.

The Ontario - Manitoba Interconnection

OPGI currently has a firm contract to purchase 200 MW from Manitoba; this expires on October 31, 2003. The OMTE and OMTW limits are both 240 MW and are constrained by stability and thermal limitations.

The Ontario - Minnesota Interconnection

The MPFN and MPFS limits are 100 and 150 MW respectively and are constrained by stability and thermal limitations.

The Ontario - Michigan Interconnection

The Michigan interconnection is constrained by thermal limitations and it is under phase shifter control. During winter months, the limits are 1800 MW for flows into Ontario and 2,450 MW for flows out of Ontario. In the summer, the limits are 1,765 MW for flows into Ontario and 2,450 MW for flows out of Ontario.

The Ontario - New York Niagara Interconnection

The New York Niagara interconnection, in the winter, is limited to 1,790 MW for flows into Ontario and 2,100 MW for flows out of Ontario. In the summer, the limit is 1,480 MW for flows into Ontario and 2,070 MW for flows out of Ontario. The interconnection is constrained by thermal limitations in the winter and summer.

The 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 purchases 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.

Typically, when QFW hits its limit of 1,820 MW under summer conditions, the flow across the NY Niagara interconnection is 1,100 MW (its limit is 1,480 MW). Similarly, when QFW hits its limit of 2,030 MW under winter conditions, flow across the NY Niagara interconnection is 1,300 MW (its limit is 1,790 MW).

The Ontario - New York East 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 Northeast - Quebec Interconnection

The Quebec North interconnection is thermally limited to 65 MW for flows into Ontario from radial generation in Quebec. For flows out of Ontario, the limit is 80 MW and this is simply based on the maximum amount of radial load available to be supplied in Quebec.

The Ontario East - Quebec Interconnection

The Quebec South interconnection is limited to 1,130 MW for flows into Ontario due to stability limitations and available radial generation. For flows out of Ontario the limits are 490 and 510 for summer and winter respectively and are due to stability and thermal limitations.

Appendix D2 - Definitions of Ontario's Interfaces

(* signifies the measurement point)

Buchanan Longwood Input (BLIP) Interface consists of the following circuits:

B562L	Bruce A to Longwood* 500 kV
B563L	Bruce B to Longwood* 500 kV
N582L	Nanticoke to Longwood* 500 kV
D4W	Detweiler to Buchanan* 230 kV
D5W	Detweiler to Buchanan* 230 kV
M31W	Middleport to Buchanan* 230 kV
M32W	Middleport to Buchanan* 230 kV
M33W	Middleport to Buchanan* 230 kV

Negative Buchanan Longwood Input (NBLIP) Interface consists of the following circuits:

B562L	Longwood* to Bruce A 500 kV
B563L	Longwood* to Bruce B 500 kV
N582L	Longwood* to Nanticoke 500 kV
D4W	Buchanan* to Detweiler 230 kV
D5W	Buchanan* to Detweiler 230 kV
M31W	Buchanan* to Middleport 230 kV
M32W	Buchanan* to Middleport 230 kV
M33W	Buchanan* to Middleport 230 kV

Queenston Flow West (QFW) Interface consists of the following circuits:

Q23BM	Beck2* to Burlington and Middleport (Neale Junction) 230 kV
Q25BM	Beck2* to Burlington and Middleport (Neale Junction) 230 kV
Q24HM	Beck2* to Hamilton and Middleport (Hannon Junction) 230 kV
Q29HM	Beck2* to Hamilton and Middleport (Hannon Junction) 230 kV
Q30M	Beck 2 (Allanburg Junction*) to Middleport 230 kV

Flow East To Toronto (FETT) Interface consists of the following circuits:

B560V	Bruce A to Claireville* 500 kV
M570V	Milton to Claireville* 500 kV
M571V	Milton to Claireville* 500 kV
V586M	Middleport to Claireville* 500 kV
R14T	Trafalgar* to Richview 230 kV
R17T	Trafalgar* to Richview 230 kV
R19T	Trafalgar* to Richview 230 kV
R21T	Trafalgar* to Richview 230 kV
E8V	Orangeville to Essa* 230 kV
E9V	Orangeville to Essa* 230 kV

Flow North (FN) and Interface consists of the following circuits:

X503E	Essa* to Hamner 500 kV
X504E	Essa* to Hamner 500 kV
D5H	Des Joachims* to Holden 230 kV

Flow South (FS) Interface consists of the following circuits:

X503E	Hamner to Essa* 500 kV
X504E	Hamner to Essa* 500 kV
D5H	Holden to Des Joachims* 230 kV

East-West Transfer West (EWTW) Interface consists of the following circuits:

W21M	Wawa* to Marathon 230 kV
W22M	Wawa* to Marathon 230 kV

East-West Transfer East (EWTE) Interface consists of the following circuits:

W21M	Marathon to Wawa* 230 kV
W22M	Marathon to Wawa* 230 kV

Clairville North (CLAN) Interface consists of the following circuits:

E510V	Clairville* to ESSA 500kV
E511V	Clairville* to ESSA 500kV
B82V	Clairville* to Brown Hill 230kV
B83V	Clairville* to Brown Hill 230kV

Clairville South (CLAS) Interface consists of the following circuits:

E510V	ESSA to Clairville* 500kV
E511V	ESSA to Clairville* 500kV
B82V	Brown Hill to Clairville* 230kV
B83V	Brown Hill to Clairville* 230kV

Flow Away from Bruce Complex (FABC) Interface consists of the following circuits:

B560V	Bruce* to Clairville 500kV
B561M	Bruce* to Milton 500kV
B562L	Bruce* to Longwood 500kV
B563L	Bruce* to Longwood 500kV
B4V	Bruce* to Orangeville 230kV
B5V	Bruce* to Orangeville 230kV
B22D	Bruce* to Detweiler 230kV
B23D	Bruce* to Detweiler 230kV
B27S	Bruce* to Owen Sound 230kV
B28S	Bruce* to Owen Sound 230kV

Flow West Into Cherrywood (FWIC) Interface consists of the following circuits:

B540C	Bowmanville to Cherrywood* 500kV
B541C	Bowmanville to Cherrywood* 500kV
B542C	Bowmanville to Cherrywood* 500kV
B543C	Bowmanville to Cherrywood* 500kV
P15C	Dobbin to Cherrywood* 230kV
C28C	Chat Falls to Cherrywood* 230kV
H24C	Havelock to Cherrywood* 230kV
H26C	Havelock to Cherrywood* 230kV
M29C	Merivale to Cherrywood* 230kV
B23C	Belleville to Cherrywood* 230kV

Appendix D3 - Ontario's Interface Limits For All Transmission Elements In-Service

FABC Interface Limit

Is the minimum of the following 13 equations:

Modules 3 & 4

$F_{FABC} - 0.08\ F_{BLIP} \leq 4325 - 75 \max\{0, 6 - N_{Nant}\} - 50 \max\{0, 2 - N_{Lamb}\} - 100 \max\{0, 2 - N_{Darl}\}$

$F_{FABC} \leq 4540 - 75 \max\{0, 6 - N_{Nant}\} - 50 \max\{0, 2 - N_{Lamb}\} - 100 \max\{0, 2 - N_{Darl}\}$

Module 5

$F_{FABC} + 0.11\ F_{BLIP} \leq 4540 - (D_{PD} - D_{ref})/12 - 100(8 - N_{Nant}) - 50 \max\{0, 2 - N_{Lamb}\} + 50\ (2N_{Pick} + N_{Lx} + N_{Lkv} + 4N_{Darl})]$

$F_{FABC} \leq 4240 - (D_{PD} - D_{ref})/12 - 100(8 - N_{Nant}) - 50 \max\{0, 2 - N_{Lamb}\} + 50\ (2N_{Pick} + N_{Lx} + N_{Lkv} + 4N_{Darl})]$

$F_{FABC} \leq 4600 - 100 \max\{0, 6 - N_{Nant}\} - 50 \max\{0, 2 - N_{Lamb}\} - 100 \max\{0, 2 - N_{Darl}\}$

Modules 7 & 8

$F_{FABC} - 0.1\ F_{BLIP} \leq 4743 - (D_{PD} - D_{ref})/12 - 100(8 - N_{Nant}) - 50 \max\{0, 2 - N_{Lamb}\} + 50\ (2N_{Pick} + N_{Lx} + N_{Lkv} + 4N_{Darl})]$

$F_{FABC} \leq 5000 - (D_{PD} - D_{ref})/12 - 100(8 - N_{Nant}) - 50 \max\{0, 2 - N_{Lamb}\} + 50\ (2N_{Pick} + N_{Lx} + N_{Lkv} + 4N_{Darl})]$

$F_{FABC} - 0.08\ F_{BLIP} \leq 4525 - 75 \max\{0, 6 - N_{Nant}\} - 50 \max\{0, 2 - N_{Lamb}\} - 100 \max\{0, 2 - N_{Darl}\}$

$F_{FABC} \leq 4740 - 75 \max\{0, 6 - N_{Nant}\} - 50 \max\{0, 2 - N_{Lamb}\} - 100 \max\{0, 2 - N_{Darl}\}$

Module 10

$F_{FABC} - 0.19\ F_{BLIP} \leq 4586 - 75(8 - N_{Nant}) - 50 \max\{0, 2 - N_{Lamb}\}$

$F_{FABC} \leq 5100 - 75(8 - N_{Nant}) - 50 \max\{0, 2 - N_{Lamb}\}$

$F_{FABC} - 0.1\ F_{BLIP} \leq 4193 - 70 \max\{0, 6 - N_{Nant}\} - 50 \max\{0, 2 - N_{Lamb}\} - 50 \max\{0, 2 - N_{Darl}\}$

$F_{FABC} \leq 4450 - 70 \max\{0, 6 - N_{Nant}\} - 50 \max\{0, 2 - N_{Lamb}\} - 50 \max\{0, 2 - N_{Darl}\}$

Where:

F_{FABC} = MW Flow on the FABC Interface
F_{BLIP} = MW Flow on the BLIP Interface
N_{Nant} = number of on-line units at Nanticoke
N_{Lamb} = number of on-line units at Lambton
N_{Pick} = number of on-line units at Pickering
N_{Lx} = number of on-line units at Lennox
N_{Lkv} = number of on-line units at Lakeview
N_{Darl} = number of on-line units at Darlington
D_{PD} = Primary Demand
D_{ref} = 22000 for summer and 25000 for winter

FETT Interface Limit

Is the minimum of the following two equations:

$$F_{FETT} \leq 3300 + (D_{ref} - D_{PD})/6 - P_{SLC} - \max\{200(7 - N_{Nant}), 150(8 - N_{Nant})\} - 100 \max\{0, (3 - N_{Pick})\} + 100\,(2N_{Pick} + N_{Lx} + N_{Lkv} + 4N_{Darl})$$

$$F_{FETT} + 1.5\,F_{FS} \leq 4500 + (D_{ref} - D_{PD})/6 - P_{SLC} - \max\{200(7 - N_{Nant}), 150(8 - N_{Nant})\} - 100 \max\{0, (3 - N_{Pick})\} + 100\,(2N_{Pick} + N_{Lx} + N_{Lkv} + 4N_{Darl})$$

$$F_{FETT} \leq 5700$$

Where:

F_{FETT} = MW Flow on the FETT Interface
F_{FS} = MW Flow on the Flow South Interface
N_{Nant} = number of on-line units at Nanticoke
N_{Pick} = number of on-line units at Pickering
N_{Lx} = number of on-line units at Lennox
N_{Lkv} = number of on-line units at Lakeview
N_{Darl} = number of on-line units at Darlington
D_{PD} = primary demand
D_{ref} = 22000 for summer and 25000 for winter
P_{SLC} = penalty due to summer load criteria
= 0 if $D_{PD} \leq 22000$ or when the summer load criteria are not applicable
or = 200 if $22000 < D_{PD} \leq 22600$ and when the summer load criteria are applicable
or = 400 if $22600 < D_{PD} \leq 23200$ and when the summer load criteria are applicable
or = 800 if $23200 < D_{PD}$ and when the summer load criteria are applicable

BLIP Interface Limit

$F_{BLIP} \leq 3500$ where F_{BLIP} = MW Flow on the BLIP Interface

NBLIP Interface Limit

Is the minimum of the following five equations:

$F_{NBLIP} \leq 1500$
$F_{NBLIP} \leq 500\ N_{Lamb} + 250\ I_{Lamb\text{-}I/S=0}\ I_{Bru\text{-}I/S\geq 2}$
$F_{NBLIP} \leq 250\ N_{Nant} + 250\ I_{Nant\text{-}I/S\geq 4} + 250$
$F_{NBLIP} \leq 250\ N_{Nant} + 1500\ I_{Bru\text{-}I/S\geq 2}$
$F_{NBLIP} \leq \max\{0, 250\ (N_{Nant} - 1)\} + 1500\ I_{Lamb\text{-}I/S\geq 2} + 1500\ I_{Bru\text{-}I/S\geq 2}$

Where:
F_{NBLIP} = MW Flow on the NBLIP Interface
N_{Nant} = number of on-line units at Nanticoke
N_{Lamb} = number of on-line units at Lambton
$I_{Lamb\text{-}I/S=0}$ = 1 or 0 ("1" if no Lambton units on-line, otherwise "0")
$I_{Lamb\text{-}I/S\geq 2}$ = 1 or 0 ("1" if two or more on-line units at Lambton, otherwise "0")
$I_{Bru\text{-}I/S\geq 2}$ = 1 or 0 ("1" if two or more on-line units at Bruce, otherwise "0")
$I_{Nant\text{-}I/S\geq 4}$ = 1 or 0 ("1" if four or more on-line units at Nanticoke, otherwise "0")

(Note that since Bruce A is out of service, F_{NBLIP} is only valid for up to 4 units at Bruce in-service.)

CLAN Interface Limit

$F_{CLAN} \leq 2000$ where F_{CLAN} = MW Flow on the CLAN Interface

CLAS Interface Limit

$F_{CLAS} \leq 1000$ where F_{CLAS} = MW Flow on the CLAS Interface

FN Interface Limit

FN ≤ 1900 where FN = MW Flow on the FN Interface

FS Interface Limit

FS ≤ 1400 where FS = MW Flow on the FS Interface

QFW Interface Limit

QFW ≤ 1820 for Summer Conditions
QFW ≤ 2030 for Winter Conditions
where QFW = MW Flow on the QFW Interface

FWIC Interface Limit

There is no pre-defined limit on this interface. The interface definitions exist to provide a boundary point for the East Zone.

EWTE Interface Limit

Is the minimum of the following six equations:
EWTE ≤ 325
EWTE ≤ 875 - 2.5*OMTW - 2.5*MPFS
EWTE ≤ 875 - 2.5*OMTW
EWTE ≤ 425 - 0.55*OMTW - MPFS
EWTE ≤ 325 - 0.55*OMTW
EWTE ≤ 425 - MPFS

Where:
EWTE = MW Flow on the EWTE Interface
OMTW = MW Flow on the OMTW Interface
MPFS = MW Flow on the MPFS Interface

EWTW Interface Limit

Is the minimum of the following four equations:
EWTW <= 350
EWTW <= 902.5 - 2.5*OMTE - 2.5*MPFN
EWTW <= 840 - 2.5*OMTE
EWTW <= 400 - MPFN

Where:
EWTE = MW Flow on the EWTE Interface
OMTE = MW Flow on the OMTE Interface
MPFN = MW Flow on the MPFN Interface

In the equations for EWTE and EWTW the parameters OMTE,OMTW,MPFS, and MPFN are generally thought of as the independent variables as they are under phase shifter control.

Appendix D4 - Definitions of Ontario's Interconnections

The Ontario – Manitoba Interconnection

K21W	Kenora 230 kV to Whiteshell 115 kV including combination voltage regulator and phase shifting transformer bank T7 at Whiteshell,
K22W	Kenora 230 kV to Whiteshell 115 kV including combination voltage regulator and phase shifting transformer bank T8 at Whiteshell,
SK1	Rabbit Lake 115 kV to Seven Sisters 115 kV including an in-line voltage regulating transformer at Seven Sisters (radial operation only).

Ontario Manitoba Transfer West (OMTW) consists of the following circuits:

K21W	Kenora* 230 kV to Whiteshell 230 kV
K22W	Kenora* 230 kV to Whiteshell 230 kV

Ontario Manitoba Transfer East (OMTE) consists of the following circuits:

K21W	Whiteshell 230 kV to Kenora* 230 kV
K22W	Whiteshell 230 kV to Kenora* 230 kV

The Ontario – Minnesota interconnection

F3M Fort Frances 115 kV to International Falls 115 kV including two phase shifting transformers operated in series, T10 and T11, located at International Falls.

Minnesota Power Flow North (MPFN) consists of the following circuit:

F3M International Falls 115 kV to Fort Frances* 115 kV

Minnesota Power Flow South (MPFS) consists of the following circuit:

F3M Fort Frances* 115 kV to International Falls 115 kV

The Ontario – Quebec North interconnection consists of the following circuits:

D4Z	Dymond to Rapide Des Iles 115 kV,
H4Z	Holden to Kipawa 115 kV,

The Ontario – Quebec South interconnection consists of the following circuits:

X2Y	Chenaux to Bryson 115 kV,
Q4C	Chats Falls to Quoyon 230 kV,
P33C	Chats Falls to Paugan 230 kV,
H9A	Hawthorne to Maclaren 115 kV,
H2AR	Hawthorne to Maclaren 115 kV,
B5D	St. Isidore to Beauharnois 230 kV,
B31L	St. Lawrence to Beauharnois 230 kV.

The Ontario – Michigan Interconnection consists of the following circuits:

B3N Scott 230 kV to Bunce Creek 120 kV, including in-line autotransformer and phase shifter.
L4D Lambton 230 kV to St. Clair 345 kV, including in-line autotransformer and phase shifter.
L51D Lambton 230 kV to St. Clair 345 kV, including in-line autotransformer and phase shifter.
J5D Keith 230 kV to Waterman 230 kV, including in-line combination voltage regulator and phase shifter SR5.

The Ontario – New York Interconnection at Niagara consists of the following 60 Hz circuits to the New York Power Authority (NYPA), and Niagara Mohawk (NiaMo):

BP76 Beck2 230 kV to Packard 230 kV (NiaMo), including in-line voltage regulating transformer R76,
PA27 Beck2 230 kV to Niagara Moses230 kV (NYPA), including in-line voltage regulating transformer R27,
PA301 Beck2 230 kV to Niagara Moses 345 kV (NYPA), including in-line 230 to 345 kV autotransformers T310 and T302,
PA302 Beck2 230 kV to Niagara Moses 345 kV (NYPA), including in-line 230 to 345 kV autotransformers T310 and T302,
BL104 Beck1 115 kV to Lockport 115 kV (NiaMo),

and the following two 25 Hz circuits

BSC105 Beck1 115 kV to Harper 69 kV (NiaMo), including an in-line 115 to 69 kV transformer at Parks TS,
BSH106 Beck G7 to Harper 69 kV (NiaMo).

The Ontario – New York Interconnection at St. Lawrence consists of the following 60 Hz circuits to the New York Power Authority (NYPA):

L33P St. Lawrence 230 kV to FDR Moses 230 kV (NYPA) including in-line voltage regulating transformer R33 and in-line phase shifting transformer PS33,
L34P St. Lawrence 230 kV to FDR Moses 230 kV (NYPA) including in-line combination voltage regulator and phase shifting transformer PSR34.

Appendix D5 - Ontario's Interconnection Limits For All Transmission Elements In-Service

The following interconnection limits are not constant numbers, they are functionally related with each other and also with EWTE and EWTW as shown in Appendix D4

OMTW Interconnection Limit – Ontario to Manitoba

Is the minimum of the following two equations:
OMTW <= 240
OMTW <= 375 – MPFS

Where:
MPFS = MW Flow on the MPFS Interface
OMTE Interconnection Limit – Manitoba to Ontario

Is the minimum of the following two equations:
OMTE <= 240
OMTE <= 325 - MPFN

Where:
MPFN = MW Flow on the MPFN Interface

MPFS Interconnection Limit – Ontario to Minnesota

Is the minimum of the following two equations:
MPFS <= 150
MPFS <= 375 - OMTW

Where:
OMTW = MW Flow on the OMTW Interface

MPFN Interconnection Limit – Minnesota to Ontario

Is the minimum of the following two equations:
MPFN <= 100
MPFN <= 325 - OMTE

Where:
OMTE = MW Flow on the OMTE Interface

Table D5.1 – Ontario's Interconnection Limits

Interconnection	Limit (MW) Flows Out of Ontario MW	Limit (MW) Flows Into Ontario
Quebec North	80	65
Quebec South – Winter*	510	1,130
Quebec South – Summer*	490	1,130
New York East	400	400
New York Niagara – Winter*	2,100	1,790
New York Niagara – Summer*	2,070	1,480
Michigan - Winter*	2,450	1,800
Michigan - Summer*	2,450	1,765

*Seasonal Limits are based on thermal ratings and 75% of pre-load. Summer Limits apply from May 1 to October 31 and are based on 0-4 km/hr wind speed and 30 Deg.C ambient temperature (except on ties with Michigan, which are based on 35 Deg.C). Winter Limits apply from November 1 to April 30 and are based on 0-4 km/hr wind speed and 10 Deg.C ambient temperature.

Appendix D6 – Plans – Hydro One

Table 6.1 Committed Plans - Hydro One

Committed Plans	Purpose	Description	Projected In-service
Establish connection to Maclaren Industries	Increase interconnection capacity to Hydro Quebec	Provide 230 kV interconnection via D5A	June 2000
Install generation rejection scheme in the West System	Mitigate some of the impact of full compliance to NPCC, MAPP and NERC (this project deals with respecting loss of double circuit as single contingency).	Reject Atikokan GS for the loss of A21L/A22L or M23L/M24L. (Improve TEM and LE limits)	July 2000
Install phase-shifters on the interconnection to Michigan	Control Lake Erie Circulation and increase import capability	845 MVA unit on L51D and L4D; Reconnect T7 auto to L4D for parallel operation with T8	July 2000
Install shunt capacitor bank at Chatham SS	Increase load meeting capability for the Windsor area	230 kV Capacitor: 225 MVAR @ 249.4 kV	June 2001
Refurbish Chatham SS	Replace end of life facilities	Replace 230 kV circuit breakers and associated equipment	July 2001
Refurbish St Lawrence TS	Replace end of life facilities	Replace 230 kV circuit breakers and associated equipment	July 2001
Refurbish L1S 115 kV line section	Transmission line refurbishment	Refurbish Crystal Falls GS x Warren DS	Dec. 2000

Appendix D7 - Load Flow Study

1. Purpose

The purpose of the load flow study was to assess the Transmission Power System behavior during extreme load demand conditions (extreme cold weather in the wintertime and extreme hot weather in the summertime).

2. Assumptions

Nine cases were studied, as outlined in the Tables D7.1 and D7.2. In seven of the cases there were no sales or purchases for the Ontario Power System. In one of the cases, Ontario was selling 2000 MW (1000 MW to Michigan and 1000 MW to New York) and, in the last case, Ontario was purchasing 2000 MW (1000 MW from Michigan and 1000 MW from New York).

The following major assumptions were implemented in the studied cases:

- The load level was set according to the primary demand forecasted values as winter/summer "weekly 20 minutes peaks" (mean values) plus two times their "standard deviation" (see Table 2.1 in Section 2).
- The only case where one "standard deviation" was used is the one with 2000MW sales. This assumption is reasonable, because under such extreme weather conditions high sales are unlikely.
- The generation level was set accordingly, considering the available resources (see Table 3.1 to 3.5 in Section 3)
- The Operating Security Limits for the Ontario Transmission Power System were assumed to be the same for all the studied years, since there are no significant changes in the System configuration which will impact on the Operating Security Limits.

3. Results - Comments

After solving the load flows, all the Operating Security Limits were checked. The study results are summarized in tables D7.1 (Ontario net interchange = 0) and D7.2 (Ontario net interchange = +/-2000).

- In all cases there is sufficient generation available inside Ontario to supply the demand.
- In all winter cases there are no violations of the Operating Security Limits.
- In the summer case where the net interchange = +2000 (Ontario is selling 2000MW), given the moderate Mx demand (the primary demand is the "weekly 20 minutes peak" (mean value) plus only one "standard deviation"), there are no violations of the Operating Security Limits.
- In all summer cases where the net interchange is zero, the steady state voltage at Milton 500kV bus drops below 520kV. All the Operating Security Limits in Southern Ontario area are valid for a voltage at Milton TS greater or equal than 520kV. Therefore pre-contingency voltages lower than this value at Milton TS are considered unacceptable.
- All other parameters for the summer cases are within the Operating Security Limits.
- However, even in the cases where the Milton 500kV bus voltage is above the lower limit, yet the voltages at Milton and Middleport 500kV buses are quite low. This reveals the need of the Milton 500kV area enforcement from the voltage control point of view.
- In order to find the best solution to the "Milton 500kV bus voltage problem", in depth studies are proposed by the IMO. Joint studies, involving Hydro One and Ontario Power Generation Inc., will be also proposed.

Table D7.1 – Net interchange = 0 MW

Load Flow Case	Net Interchange MW	Primary Demand as Per the Forecast (Winter/ Summer 20min Peak Plus 2SD) MW	Milton 500kV Minimum Voltage kV	Observations
Winter 2001	0	24617	520.16	Even without Var support from Pickering A the voltage at Milton TS is above the lower limit
Summer 2001	0	24255	513.8	The high Mx demand and the lack of Var support from Pickering A results in voltage problems at Milton TS
Winter 2003	0	24912	525.2	Because of the relatively low Mx demand the Milton voltage is above the lower limit
Summer 2003	0	24848	517.02	The high Mx demand, even with Var support from Pickering A, results in voltage drop below the lower limit at Milton
Winter 2005	0	25246	524.24	Because of the relatively low Mx demand the Milton voltage is above the lower limit
Summer 2005	0	25396	516.15	The high Mx demand results in voltage drop below the lower limit at Milton
Summer 2010	0	27037	510.08	The high Mx demand results in voltage drop below the lower limit at Milton

Table D7.2 – Net interchange = +/-2000 MW

Load Flow Case	Net Interchange MW	Primary Demand as Per the Forecast (Summer/Winter 20min Peak Plus 1SD/2SD) MW	Milton 500kV Minimum Voltage kV	Observations
Summer 2003	+2000	23581	521.29	Even though the voltage at Milton TS is quite low, it is yet above the 520 kV limit
Winter 2005	-2000	25246	520.44	Even though the voltage at Milton TS is quite low, it is yet above the 520 kV limit