Transfer Capability Assessment Methodology

For transmission planning studies

MAN-2, VERSION 4.1

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1. Introduction

The purpose of this document is to describe the methodology that the Independent Electricity System Operator (IESO) utilizes for performing assessments of Transfer Capability of the Ontario Bulk Electric System (BES) for transmission planning studies. In particular, the described methodology is utilized to perform the annual assessment of Transfer Capability in the Near-Term Transmission Planning Horizon, in accordance with the North American Electric Reliability Corporation (NERC) standard FAC-013-2. The IESO may also utilize this methodology for other planning studies and outlooks.

This document contains the following sections described below:

Section 2 discusses the study parameters and criteria used to determine the Transfer Capability of the IESO-Controlled Grid for transmission planning studies, including those for compliance with NERC FAC-013-2.

Section 3 discusses the electrical zones of the IESO-Controlled Grid. The primary characteristics of each zone are summarized.

Section 4 discusses the major internal transmission interfaces of the IESO-Controlled Grid.

Section 5 discusses the transmission interconnections of the IESO-Controlled Grid with neighbouring jurisdictions.

Section 6 describes the procedure for conducting the assessment of Transfer Capability of the IESO-Controlled Grid for transmission planning studies, including for compliance with NERC FAC-013-2.

Section 7 describes the publishing, maintaining and distribution of the Transfer Capability Methodology document and the annual assessment of Transfer Capability in the Near-Term Transmission Planning Horizon document for compliance with the NERC FAC-013-2 standard.

To provide comments and/or suggestions on this document, please contact the IESO at:

- Toll Free: 1-888-448-7777 or 905-403-6900
- E-mail: customer.relations@ieso.ca

2. Transmission Study Parameters and Criteria

The study parameters, assumptions and criteria used by the IESO to perform the Transfer Capability assessment shall be consistent with the IESO's planning practices, as described in this document and in the Ontario Resource and Transmission Assessment Criteria (ORTAC) document. The parameters and criteria used in the assessment of Transfer Capability shall respect known System Operating Limits.

The IESO-Controlled Grid is divided into ten electrical zones (the IESO's "Transmission Zones" or "IESO Zones"). The groups of transmission circuits which connect between the IESO Zones are the "major internal transmission interfaces". The groups of transmission circuits which connect between the IESO-Controlled Grid and neighbouring systems are the "transmission interconnections". The major internal transmission interfaces and transmission interconnections determine the transfers that are selected for assessment. Transfer scenarios are developed to increase the power flow in a given direction through the major internal transmission interfaces and the transmission interconnections with neighbouring systems.

The next few sections provide an overview of the major internal transmission interfaces and the transmission interconnections, as well as the transfers used to stress those interfaces.

3. IESO Transmission Zones

The IESO-Controlled Grid is mainly comprised of a 500 kV transmission network, a 230 kV transmission network, and several 115 kV transmission networks. It is divided into the ten IESO Zones with characteristics that are described in Section 3.1. The boundaries of the IESO Zones correspond with the major internal transmission interfaces described in Section 4. Figure 3-1 illustrates the IESO Zones.

3.1 IESO Zone Characteristics

Bruce Zone

- The total generation supply is much greater than the zone peak demand.
- The generation is mostly nuclear with some wind.

East Zone

- The total generation supply exceeds the zone peak demand.
- The generation is a mix of hydroelectric, oil, natural gas, some wind, and some solar.
- The zone is connected to Québec via interconnection points that are used to switch radially into either system.
- The zone is also connected to New York via the St. Lawrence interconnection points, which are equipped with phase angle regulator (PAR) control.

Essa Zone

- The total generation supply is much less than the zone peak demand.
- The generation is mostly hydroelectric with some natural gas.
- Des Joachims generation and load is geographically located in the East Zone, but is electrically part of the Essa Zone.

Niagara Zone

- The total generation supply is much greater than the zone peak demand.
- The generation is mostly hydroelectric with some natural gas and wind.

- The zone is connected to New York via the Niagara interconnection points, which are free-flowing.

Northeast Zone

- The total generation supply exceeds the zone peak demand.
- The generation is mainly hydroelectric with some cogeneration, some wind, some solar, and some biofuel.
- The zone is connected radially to Québec via two 115 kV interconnection points.

Northwest Zone

- The total generation supply generally exceeds the zone peak demand.
- The generation is mainly hydroelectric and biofuel with some wind and some natural gas.
- The zone is interconnected to the Manitoba and Minnesota systems.
- The 230 kV Manitoba interconnection points and the Minnesota 115 kV interconnection point are controlled by PARs. The Manitoba 115 kV interconnection point is radial.

Ottawa Zone

- The total generation supply is much less than the zone peak demand.
- The generation is cogeneration and hydroelectric.
- The zone is connected to Québec via bidirectional back-to-back HVDC converters located at Outaouais in Québec. Additional interconnection points with Québec are used to switch radially into either system.

Southwest Zone

- The total generation supply is generally balanced with the zone peak demand.
- The generation is mostly wind and natural gas with some solar.

Toronto Zone

- The total generation supply is less than the zone peak demand.
- The generation is mostly nuclear with some natural gas.

West Zone

- The total generation supply generally exceeds the zone peak demand.

- The generation is mostly natural gas and wind with some solar.
- The zone is connected to Michigan via two 230/345 kV interconnection points, one 230/115 kV interconnection point, and one 230 kV interconnection point. The interconnection is equipped with PAR control.

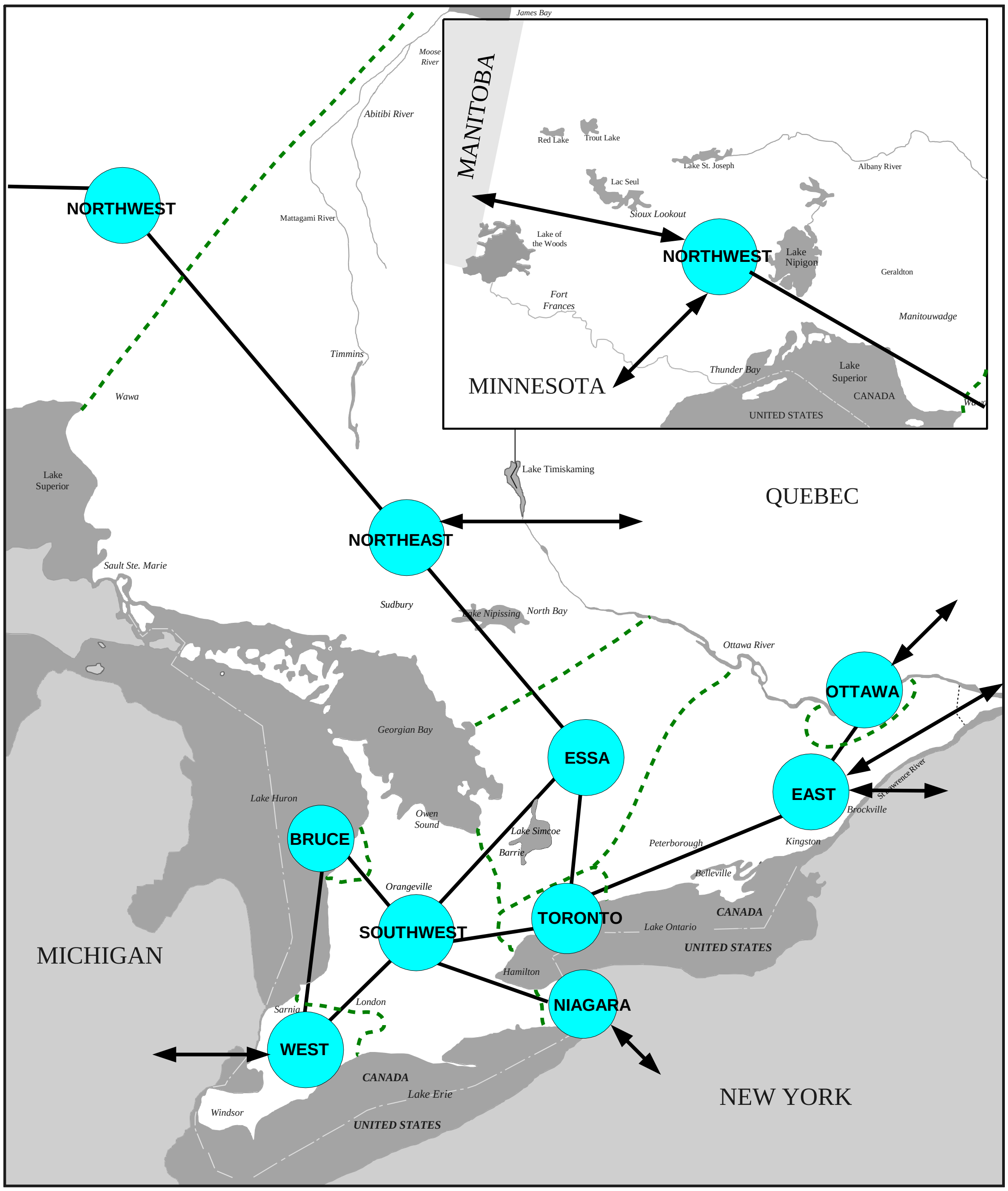

Figure 3-1 | IESO Zones

4. Internal Transmission Interfaces

There are ten major internal interfaces in the Ontario transmission system. Figure 4-1 provides a geographic depiction of the IESO Zones and associated major internal transmission interfaces. The interface limits are used to ensure system stability, acceptable pre-contingency and post-contingency voltage levels, and acceptable thermal loading levels.

The following describes the transfers that are used in the assessment of Transfer Capability to stress these interfaces and, thereby, determine their power transfer capability:

4.1 Buchanan Longwood Input (BLIP) Transfer

The BLIP interface is comprised of the circuits that connect between the West Zone and the Southwest Zone. This includes the three 500 kV circuits into Longwood TS, and the five 230 kV circuits into Buchanan TS.

This transfer stresses the BLIP interface in the flow West direction. The source and sink for this transfer are as follows:

- Source – Scale up generation East of BLIP
- Sink – Scale down generation West of BLIP in the following order:
  - Generation in the West Zone
  - Generation in Eastern Michigan

4.2 Negative Buchanan Longwood Input (NBLIP) Transfer

The NBLIP interface is defined identical as the BLIP interface, but the transfers are measured in the reverse direction.

This transfer stresses the NBLIP interface in the flow East direction. The source and sink for this transfer are as follows:

- Source – Scale up generation West of BLIP in the following order:
  - Generation in the West Zone

- Generation in Eastern Michigan

- Sink – Scale down generation East of BLIP.

4.3 Flow Away from Bruce Complex & Wind (FABCW) Transfer

The FABCW interface is the sum of all power flows away from the Bruce 230 kV and Bruce 500 kV stations (six circuits each) plus wind generation in the area.

This transfer stresses FABCW by transferring power from the generation in the Bruce Zone to the Southwest and Toronto Zones. The source and sink for this transfer are as follows:

- Source – Scale up generation in the Bruce Zone and wind generation upstream of the FABCW interface.
- Sink – Scale down generation in the following order:
  - Scale down generation the Toronto Zone and East Zone.
  - Scale down generation in remaining southern Ontario zones, excluding FABCW source generation.

4.4 Flow East Towards Toronto (FETT) Transfer

The FETT interface is defined by four 500kV circuits into Claireville TS, two 230 kV circuits out of Orangeville TS (measured east of Everett TS) and four 230kV circuits out of Trafalgar TS.

This transfer stresses the FETT interface of the power system by transferring power from the Southwest, Bruce, Niagara and West Zones to the Toronto Zone. The source and sink for this transfer are as follows:

- Source – Scale up generation West of FETT
- Sink – Scale down generation East of FETT.

4.5 Queenston Flow West (QFW) Transfer

The QFW interface is defined by four 230 kV circuits out of Beck 2 TS and three 230 kV circuits into Middleport TS.

The source and sink to stress the QFW interface are as follows:

- Source – Scale up generation in the Niagara Zone and Western New York
- Sink – Scale down generation in the Bruce Zone and Toronto Zone.

4.6 Transfer East of Cherrywoood (TEC) Transfer

The TEC interface is defined by four 500 kV circuits out of Bowmanville SS, one 230 kV circuit (four total) into each of Dobbin TS, Almonte TS, Belleville TS, Havelock TS and two 230 kV circuits into Chats Falls GS.

This transfer stresses the power system in eastern Toronto. The source and sink for this transfer are as follows:

- Source – Scale up generation West of TEC
- Sink – Scale down generation East of TEC.

4.7 Flow into Ottawa (FIO) Transfer

The FIO interface is defined by two 500 kV circuits out of Lennox TGS, one 230 kV circuit coming into St. Isidore TS, one 230 kV circuit out of St. Lawrence TS, one 230 kV circuit coming out of Chats Falls TS and one 230 kV circuit into Merivale TS. This transfer stresses the power system in Ottawa by transferring power from generation outside of the Ottawa Zone through to Québec via the HVDC at Hawthorne. The source and sink for this transfer are as follows:

- Source – Scale up Ontario generation outside of the Ottawa Zone
- Sink – Scale generation in the following order:
    - Scale down generation inside Ottawa Zone.
    - Increase exports to Québec over the HVDC connected at the Hawthorne 230 kV bus.

4.8 Flow North (FN) Transfer

The FN interface is defined by two 500 kV circuits out of Essa TS and one 230 kV circuit into Otto Holden TS.

This transfer stresses the power system connecting Northern and Southern Ontario in the south to north direction. The source and sink for this transfer are as follows:

- Source – Scale up generation in Southern Ontario.
- Sink – Scale generation and load in the following order:
    - Scale down Northern Ontario generation.
    - Scale up load in the Northeast Zone.

4.9 Flow South (FS) Transfer

The FS interface is defined identical as FN, but the transfers are measured in the reverse direction.

This transfer stresses the power system connecting Northern and Southern Ontario in the north to south direction. The source and sink for this transfer are as follows:

- Source – Scale up Northern Ontario generation.
- Sink – Scale down generation in Southern Ontario.

4.10 East-West Transfer East (EWTE) Transfer

The EWTE interface is defined by two 230 kV circuits into Wawa TS.

This transfer stresses the power system in the Northwest Zone by transferring power from West of Marathon to East of Wawa in the flow East direction.

- Source – Scale up generation in the Northwest Zone.
- Sink – Scale down generation East of Wawa.

4.11 East-West Transfer West (EWTW) Transfer

The EWTW interface is defined identical as EWTE, but the transfers are measured in the reverse direction. This transfer stresses the power system in the Northwest Zone by transferring power from East of Wawa to West of Marathon in the flow West direction.

- Source – Scale up generation East of Wawa.
- Sink – Scale down generation in the Northwest Zone.

4.12 Claireville North (CLAN) Transfer

The CLAN interface delineates the Toronto Zone and Essa Zone.

This transfer stresses the power system by transferring power from southern Ontario into the Essa and Northeast Zones. It is a non-binding interface and is not studied for Transfer Capability Assessments in the Near-Term and Long-Term Transmission Planning horizons.

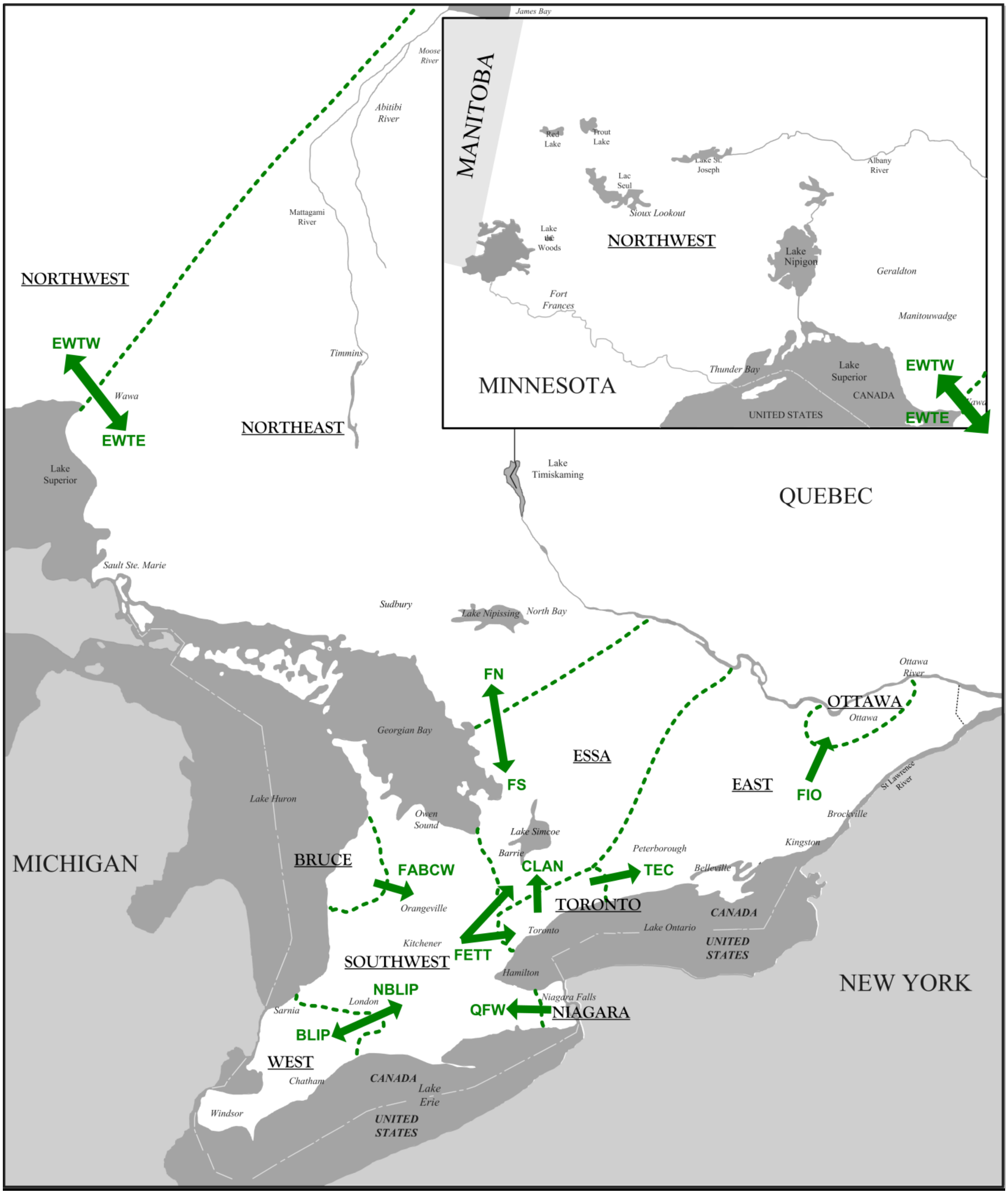

Figure 4-1 | Ontario's Major Internal Transmission Interfaces

5. Transmission Interconnections

The term interconnection is used to describe interfaces that connect Ontario to neighbouring jurisdictions (external control areas). For Transfer Capability Assessments, interconnections are stressed in both import and export scenarios by adjusting the generation nearest to the interconnection points on either side as required, with one side acting as the source and the other side as the sink, to determine their transfer limits.

Ontario has interconnections with Manitoba, Minnesota, Québec, Michigan, and New York. Figure 5-1 provides a geographic depiction of the IESO Zones and transmission interconnection points with these jurisdictions. Figure 5-2 summarizes the relationship between IESO Zones, major internal transmission interfaces and interconnections in a single diagram.

5.1 The Ontario – Manitoba Interconnection

The Ontario – Manitoba interconnection consists of two 230 kV circuits and one 115 kV circuit. The transfers on the 230 kV interconnection points are under the control of PARs and defined as Ontario – Manitoba Transfer East (OMTE) and Ontario – Manitoba Transfer West (OMTW). Ontario and Manitoba are synchronously connected at 230 kV, while the 115 kV interconnection is operated normally open.

5.2 The Ontario – Minnesota Interconnection

The Ontario – Minnesota interconnection consists of one 115 kV interconnection point. The transfers on this interconnection are the Minnesota Power Flow North (MPFN) and the Minnesota Power Flow South (MPFS). The interconnection is under the control of a PAR. Ontario and Minnesota are synchronously connected.

5.3 The Ontario – Michigan Interconnection

The Ontario – Michigan interconnection consists of two 230/345 kV interconnection points, one 230/115 kV interconnection point, and one 230 kV interconnection point. The interconnection is under the control of PARs. Ontario and Michigan are synchronously connected.

5.4 The Ontario – New York Niagara Interconnection

The Ontario – New York Niagara interconnection consists of two 230/345 kV interconnection points and two 230 kV interconnection points.

The Queenston Flow West (QFW) interface is in series with the New York Niagara interconnection. All flows entering Ontario on the New York Niagara interconnection will impact flows on the QFW interface; this includes imports and parallel path flows. Ontario and New York Niagara are synchronously connected.

5.5 The Ontario – New York St. Lawrence Interconnection

The Ontario – New York St. Lawrence interconnection consists of two 230 kV circuits. The interconnection is under the control of PARs. Ontario and New York are synchronously connected at St. Lawrence.

5.6 The Ontario – Québec Interconnection

The Northeast Zone contains two radial 115 kV interconnection points with Québec. The East Zone consists of four 230 kV & one 115 kV radial interconnection points with Québec. In the Ottawa Zone there are two HVDC interconnections as well as one 230 kV & one 115 kV radial interconnection points.

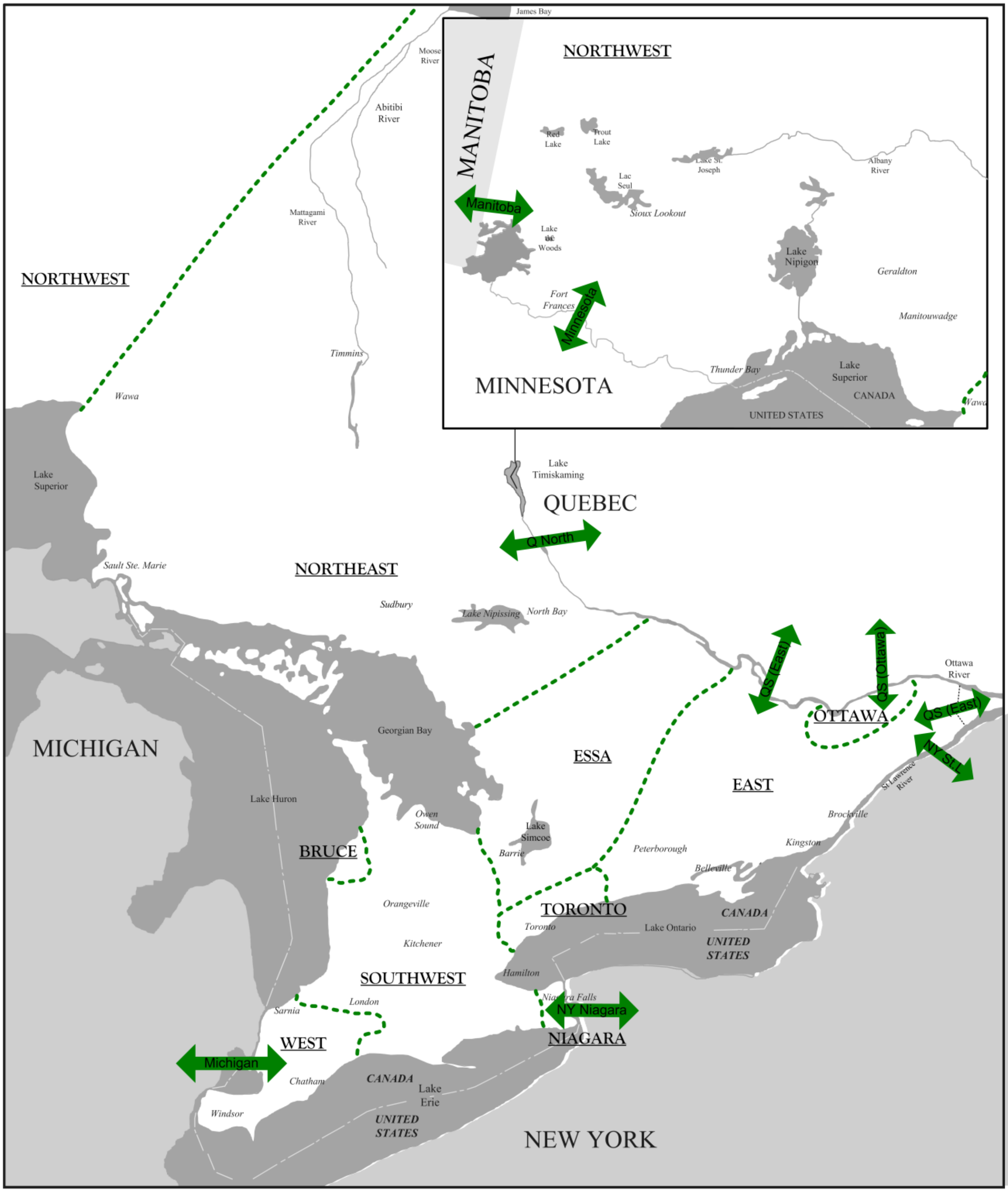

Figure 5-1 | Ontario's Points of Interconnection with Neighbouring Areas

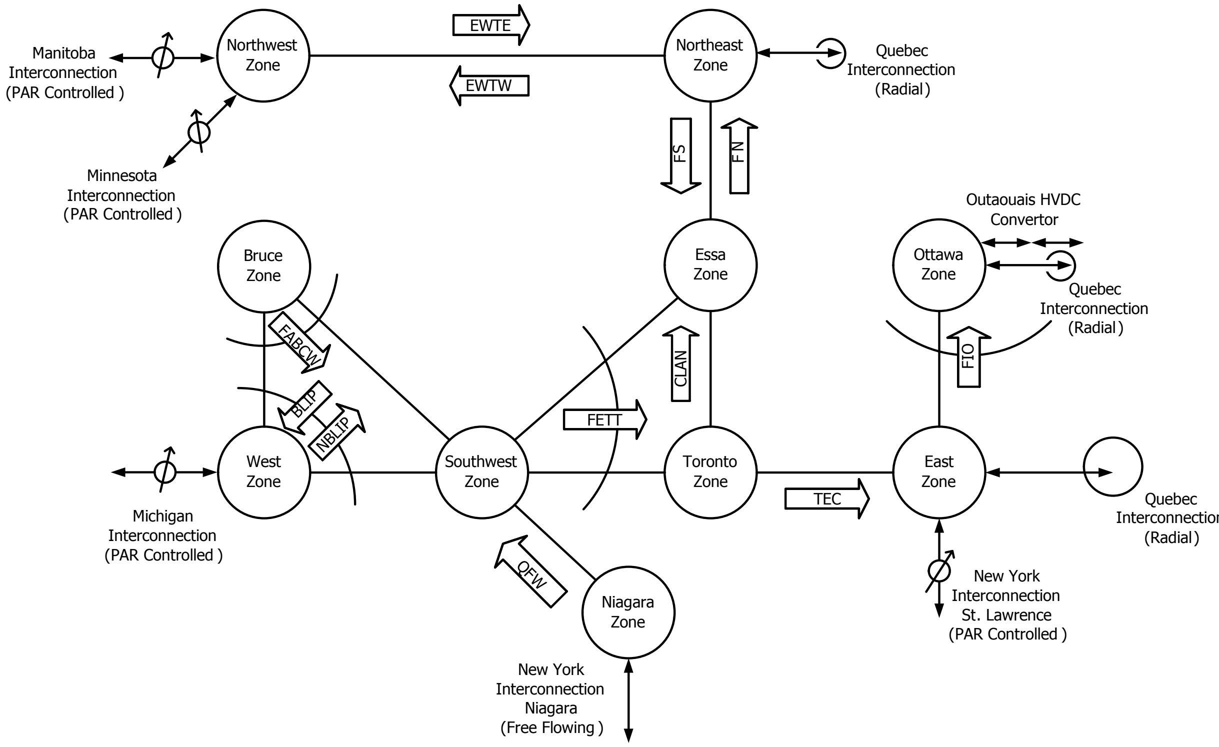

Figure 5-2 | IESO Zones, Interfaces and Interconnections

6. Study Methodology

The methodology below is carried out after the scope of the Transfer Capability assessment has been established.

The study methodology described in this section provides the IESO's basic approach to performing assessments of Transfer Capability for transmission planning studies. It is not intended to be an in-depth instructional guide for performing power system studies, and as such, certain details have been omitted.

6.1 Base Case Selection and Adjustment

The most appropriate and up to date base case for the transmission study period is initially selected. The base case is adjusted to reflect the generation, transmission, and demand conditions, among other things, for the study period and as detailed in sections 6.1.1 to 6.1.5 below. The criteria for base cases are described in ORTAC, section 2.3.

6.1.1 System Demand

The selected base case is adjusted to reflect the IESO's latest load forecast and load modeling. Details on system demand used in Transfer Capability assessments can be found in ORTAC, section 2.4.

6.1.2 Generation Dispatch

The selected base case is adjusted to reflect generation output in accordance with a reasonable economic dispatch. Base case adjustments account for planned generation outages, generation additions and generation retirements that occur within the study period.

6.1.3 Transmission System Topology

The transmission system topology should be accurately represented in the base case for the planning study period.

Planned transmission outages, additions and retirements shall be implemented in the base case if they span the study period. Transmission changes that occur only for a portion of the study period may be implemented in the base case if their removal, addition or change results in a reasonable worst case scenario. Planned transmission projects scheduled to be in service within the study period will be included in the assessment.

6.1.4 Parallel Path (Loop Flow) Adjustments

Parallel path (loop flow) adjustments are considered for the Transfer Capability assessment. With all transmission elements in service and with full PAR control of the Ontario – Michigan interconnection, parallel path flows do not limit Transfer Capability of the Ontario BES and are therefore not studied in detail. This is because with all transmission elements in service and with full PAR control of the Ontario – Michigan interconnection, parallel path flows of up to 600 MW in either direction are expected to be controlled. When PARs on the Ontario-Michigan interconnection points are out service or other impactful transmission outages exist during the study period, parallel path flows may occur on both Michigan and New York interfaces and the impact on Transfer Capability is studied.

6.1.5 Approved or Projected Transmission Uses

Currently, transmission service is not sold in Ontario; transactions at the interconnections are scheduled based on economic merit. Access to transmission is via the energy market. Resources that clear the market are allowed to flow.

6.2 Stressed Transfer Cases

Transfers across the major internal interfaces and interconnections in the base case are stressed as described in Section 4 and Section 5, respectively.

6.3 Contingencies

A list of contingencies is developed based on planning practice, engineering judgement and past studies. The criteria for the development and use of contingencies are detailed in ORTAC, section 2.

Selected steady-state contingencies may include, but are not limited to, the following:

- Loss of a single circuit,
- Loss of a single generating unit,
- Loss of a single transformer,
- Loss of a single shunt device,
- Loss of two adjacent circuits on a multi-circuit tower, and

- Loss of elements resulting from a breaker failure event.

Selected transient events may include, but are not limited to, the following:

- Three-phase fault on a single element with normal clearing,
- Single-phase fault with delayed clearing due to a stuck breaker, and
- Line-line-ground fault on two phases of adjacent circuits on a multi-circuit tower.

6.4 Monitored Facilities

The BES facilities that may limit the transfers considered in the Transfer Capability assessment are monitored. The monitored elements include, but are not limited to, all BES facilities within the zones that define the interface under study. The monitored electrical parameters include, but are not limited to, bus and generator voltages, generator angles, as well as transformer, line, and interface loading.

6.5 Performance Criteria

Performance criteria refers to the measures that determine acceptable pre-contingency and post-contingency system performance. The criteria used in the assessment shall adhere to the requirements detailed in the ORTAC. This includes steady state voltage limits, transient voltage limits, and line loading limits, among other performance criteria.

6.6 Special Protection Systems (SPS)/Remedial Action Schemes (RAS)

The use of SPS/RAS to determine Transfer Capability is allowed in accordance with planning practices and in accordance with ORTAC, section 3.4.

6.7 Conduct Simulations/Perform tests

The stressed transfer cases are assessed with respect to the defined contingencies, and performance of the monitored facilities are compared to performance criteria. Transfers are incrementally increased until a violation of performance criteria is observed.

Violations from the output of the simulations shall be examined. Pre-contingency and post-contingency violations may be addressed by adjusting the base case through generation re-dispatch, load adjustment, bus voltage set point adjustment, and use of available shunt elements. Post-contingency violations may also be solved by use of SPS/RAS, if the SPS/RAS meets the requirements for the study.

The Transfer Capability is defined for the selected major internal interfaces and interconnections as the transfer across the selected interface that marginally meets defined performance criteria.

6.8 Produce Transmission Transfer Capability Study Report

After a study is performed, the study work and findings must be documented. The report must address the items in the scope of the study.

7. Publishing and Maintaining Transmission Transfer Capability Documentation

The IESO will notify and distribute its Transfer Capability Methodology to applicable NERC functional entities in accordance with requirement R2 of NERC standard FAC-013-2.

The IESO will provide the results of the Transfer Capability assessment to applicable NERC functional entities in accordance with requirement R5 of NERC standard FAC-013-2. The IESO will provide applicable data requested, subject to the conditions specified in requirement R6 of NERC standard FAC-013-2.

All written requests can be made to orcp@ieso.ca

8. References

IESO, Ontario Resource and Transmission Assessment Criteria (ORTAC), Issue 5.0, August 22, 2007.

NERC, FAC-013-2 Assessment of Transfer Capability for the Near-Term Transmission Planning Horizon, November 21, 2013.

NERC, TPL-001-4 Transmission System Planning Performance Requirements, November 26, 2014.

NPCC, "NPCC Regional Reliability Reference Directory #1, Design and Operation of the Bulk Power System", Version 2, dated September 30, 2015

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