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Susan Frank
Vice President and Chief Regulatory Officer
Regulatory Affairs

BY COURIER

May 23, 2014

Ms. Kirsten Walli
Ontario Energy Board
Suite 2700, 2300 Yonge Street
Toronto, ON.
M4P 1E4

Dear Ms. Walli:

EB-2013-0421 – Hydro One Networks' Section 92 – Supply to Essex County Transmission Reinforcement Project – Hydro One Additional Evidence and Updates to Pre-filed Evidence

I am attaching two paper copies of the additional evidence with respect to Hydro One Networks' Application and Pre-filed Evidence that was filed with the Board on January 22, 2014. The draft System Impact Assessment and the draft Customer Impact Assessment have now been filed as Exhibit B, Tab 6, Schedules 3 and 4. Additionally, the following exhibits have been updated:

Exhibit A, Tab 1, Schedule 1	Pages 2 - 4
Exhibit A, Tab 3, Schedule 1	Pages 1, 2, and 4
Exhibit B, Tab 2, Schedule 1	Pages 1 and 3
Exhibit B, Tab 4, Schedule 2	Page 1
Exhibit B, Tab 4, Schedule 3	Pages 1, 4 - 16
Exhibit B, Tab 4, Schedule 5	Pages 6 - 7
Exhibit B, Tab 5, Schedule 2	Page 1
Exhibit B, Tab 6, Schedule 1	Pages 1 - 5

An electronic copy of both the additional evidence and the updated evidence have been filed using the Board's Regulatory Electronic Submission System (RESS) and the confirmation of successful submission slip is provided with this letter.

Sincerely,

ORIGINAL SIGNED BY SUSAN FRANK

Susan Frank

Attach.
cc. EB-2013-0421 Intervenors (electronic only)

APPLICATION

ONTARIO ENERGY BOARD

In the matter of the *Ontario Energy Board Act, 1998*;

And in the matter of an Application by Hydro One Networks Inc. for an Order or Orders granting leave to construct new transmission line facilities ("Supply to Essex County Transmission Reinforcement "**SECTR**" Project") in the Windsor – Essex region in southwestern Ontario.

1. The Applicant is Hydro One Networks Inc. ("**Hydro One**"), a subsidiary of Hydro One Inc. The Applicant is an Ontario corporation with its head office in the City of Toronto. Hydro One carries on the business, among other things, of owning and operating transmission facilities within Ontario.

2. Hydro One hereby applies to the Ontario Energy Board ("**the Board**") pursuant to Section 92 of the *Ontario Energy Board Act, 1998* ("**the Act**") for an Order or Orders granting leave to construct approximately 13 kilometers of transmission line facilities in the Windsor – Essex area. These facilities are required to:
   a) address electricity supply capacity needs in the Windsor – Essex area;
   b) minimize the impact of major transmission outages to customers in the area; and
   c) ensure that Hydro One is compliant with the IESO's Ontario Resource and Transmission Assessment Criteria.

3. The proposed transmission line project, between Leamington Junction (located along the Chatham Switching Station to Keith Transmission Station 230 kV

corridor) and a new transmission station, Leamington TS, in the municipality of Leamington, includes:

- Construction of approximately 13 km of new 230 kV double-circuit line on steel lattice towers on a new ROW;
- Installation of optic ground wire ("**OPGW**") for system telecommunication purposes on top of the new 230 kV towers serving Leamington TS as well as new OPGW on the existing towers near Leamington Junction.

A map showing the general location of the proposed facilities is provided in **Exhibit B, Tab 2, Schedule 2.**

The proposed in-service date is March 2017.

4. The Ontario Power Authority (**"OPA"**) has determined the need for the project and the alternatives that were considered as part of the integrated plan for the Windsor-Essex area. The OPA's evidence on the need for the project is filed at **Exhibit B, Tab 1, Schedule 5**.

5. The total cost of the line facilities for which Hydro One is seeking approval is estimate to be approximately $45 million. The details are provided in **Exhibit B, Tab 4, Schedule 2**. The estimated cost of associated station work with the SECTR Project is $32 million. The project economics as filed in **Exhibit B, Tab 4, Schedule 3** indicate that the project will result in no increase in the Line Connection pool rate and a maximum increase of 0.51% in the Transformation Connection pool rate ($0.01 increase). It is estimated that there is a minimal impact (0.01%) on the overall average Ontario consumer's electricity bill.

6. The OPA has provided an assessment of the appropriate apportionment of the costs associated with the SECTR Project. The analysis concludes that 22.5%

7. should be allocated to transmission ratepayers due to system benefits and the remainder paid for by local load customers due to customer benefits. The OPA cost responsibility evidence is provided in **Exhibit B, Tab 4, Schedule 4.**

8. In regard to the customer benefits and consistent with the OEB's "beneficiary pays" principle, Hydro One has proposed an allocation of costs at the distribution level for the transmission investments associated with the SECTR Project. This methodology ensures fairness in the allocation of upstream transmission costs and avoids cross-subsidization at the distribution level among beneficiaries. Commencement of the SECTR project is contingent upon the Board endorsing the methodology as described in **Exhibit B, Tab 4, Schedule 5.**

9. The SECTR Project is expected to have no significant environmental impacts. A Class EA was completed for the Project under the *Class Environmental Assessment for Minor Transmission Facilities* ("**Class EA**") approved by the Ministry of the Environment ("**MOE**"). The Class EA process is described in **Exhibit B, Tab 6, Schedule 1**.

10. The Independent Electricity System Operator ("**IESO**") has provided a draft System Impact Assessment ("**SIA**") of the proposed facilities to assess the impact of these facilities on the IESO-controlled grid. The Draft SIA is filed as **Exhibit B, Tab 6, Schedule 3**.

11. A Customer Impact Assessment ("**CIA**") in accordance with Hydro One's customer connection procedures, is filed as **Exhibit B, Tab 6, Schedule 4**.

12. Hydro One has consulted stakeholders in the Windsor – Essex area to identify potential concerns associated with the construction of the proposed transmission facilities. The feedback received from stakeholders was considered and

incorporated into the preparation of this Application. The stakeholder consultation process is described in **Exhibit B, Tab 6, Schedule 5.** Municipalities, LDCs, the WindsorEssex Economic Development Corporation, growers and their associations have provided letters of support that can be found in **Exhibit B, Tab 6, Schedule 2**. Hydro One will continue to communicate with stakeholders and the local community to ensure that potential concerns during the construction and commissioning stages of the proposed facilities are addressed.

13. Details on the Hydro One engagement process with neighbouring First Nation and Métis communities is filed in **Exhibit B, Tab 6, Schedule 6**.

14. New permanent land rights on properties from Leamington Junction to Leamington TS will be required to accommodate the proposed transmission facilities. Temporary rights for construction purposes will also be required at specific locations along the corridor. Further information regarding the real estate needs to complete this project are provided in **Exhibit B, Tab 6, Schedule 7.**

15. This Application is supported by written evidence which includes details of the Applicant's proposal for the transmission reinforcement work. The written evidence is prefiled as attached and may be amended from time to time prior to the Board's final decision on this Application. Further, the Applicant may seek meetings with Board Staff and intervenors in an attempt to identify and reach agreements to settle any issues arising out of this Application.

16. Hydro One requests a written hearing for this proceeding.

17. Hydro One requests that a copy of all documents filed with the Board be served on the Applicant and the Applicant's counsel, as follows:

a) The Applicant:

Ms. Erin Henderson
Senior Regulatory Coordinator
Hydro One Networks Inc.

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b) The Applicant's counsel:

Michael Engelberg
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Hydro One Networks Inc.

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SUMMARY OF PREFILED EVIDENCE

Hydro One Networks Inc. (“**Hydro One**”) is applying to the Board for an order granting leave to construct transmission line facilities in the Windsor – Essex area pursuant to Section 92 of the *Ontario Energy Board Act, 1998* (“**the Act**”).

The proposed facilities, to be constructed, owned and operated by Hydro One are as described in **Exhibit B, Tab 2, Schedule 1**. A map showing the location of the proposed transmission facilities is provided in **Exhibit B, Tab 2, Schedule 2**.

The planned in-service date for the Supply to Essex Country Transmission Reinforcement (**“SECTR”**) Project is March 2017. A construction schedule for the project is shown at **Exhibit B, Tab 5, Schedule 2**.

The evidence identifies near-term supply capacity and other reliability needs in the Windsor – Essex region. Specifically, there is a need for additional supply capacity in the Kingsville–Leamington 115 kV subsystems, and a need to minimize the impact of supply interruptions to customers in the J3E-J4E subsystem. Currently the J3E-J4E subsystem does not comply with the IESO’s Ontario Resource and Transmission Assessment Criteria restoration criteria. Further evidence on need is found in **Exhibit B, Tab 1, Schedule 4** and **Exhibit B, Tab 1, Schedule 5**.

The Independent Electricity System Operator (“**IESO**”) has provided a Draft System Impact Assessment (“**SIA**”) for the SECTR Project. It is filed as **Exhibit B, Tab 6, Schedule 3**.

A Customer Impact Assessment ("**CIA**"), in accordance with Hydro One's customer connection procedures, is filed as **Exhibit B, Tab 6, Schedule 4**.

The total cost of the SECTR Line Project is estimated to be $45 million. Coincident with the transmission line facilities that Hydro One is seeking approval for, station work will be undertaken at an estimated cost of $32 million. The proposed new transmission facilities will be included in both the line connection pool and the transformation connection pool revenue requirements as the new facilities will address both system needs and load customer needs. Details of the project economics are filed in **Exhibit B, Tab 4, Schedule 3**.

In conjunction with the Hydro One application to the Board for an order granting leave to construct transmission line facilities, Hydro One also requests that the Board endorse the proposed cost allocation methodology at the distribution level for the customer-related transmission investments associated with the SECTR Project provided in **Exhibit B, Tab 4, Schedule 5**. This methodology, modelled on cost responsibility provisions of the Transmission System Code, ensures fairness in the allocation of upstream transmission costs and avoids cross-subsidization at the distribution level among beneficiaries. In an effort to ensure regulatory certainty for ratepayers (including Hydro One Distribution, embedded local distribution companies and large commercial distributon customers) a decision on a methodology for allocating, at the distribution level, the upstream customer-related investment costs is required in order for Hydro One to proceed with the SECTR Project.

The design of the proposed facilities is in accordance with good utility practice and meets the requirements of the *Transmission System Code* for licensed transmitters in Ontario.

The SECTR Project is subject to the *Class Environmental Assessment for Minor Transmission Facilities* process, in accordance with the Ontario *Environmental Assessment Act*. Agency and public comments received during the draft Environmental Study Report review and comment period were addressed and documented in the final ESR, which was filed with the Ministry of the Environment in July 2010. Prior to construction, Hydro One will obtain all regulatory approvals, licences and permits, as required. Details on the environmental assessment process are filed in **Exhibit B, Tab 6, Schedule 1**.

Hydro One has consulted with affected property owners and stakeholders in the project study area. The purpose of the consultation was to identify potential concerns associated with the construction activities of the proposed transmission facilities. The feedback received from stakeholders was considered and incorporated into the preparation of this Application. Details regarding the consultation process are filed as **Exhibit B, Tab 6, Schedule 5**. Hydro One will continue to work with the local community and landowners and will ensure that potential concerns identified as part of the Environmental Approval process and during the construction phase are addressed.

Hydro One is undertaking an engagement process with neighbouring First Nations communities. In 2008 Hydro One advised the Ontario Ministry of Aboriginal Affairs ("**MAA**") and Indian and Northern Affairs Canada ("**INAC**") of the SECTR project and requested input on First Nation and Métis interests in the area. The MAA advised that the project did not appear to be located in an area where First Nation existing or asserted rights could be impacted by the SECTR Project. INAC determined that Specific Claims have been submitted by Caldwell First Nation, Walpole Island First Nation, Chippewas of Kettle and Stony Point, Chippewas of the Thames First Nation, Oneida Nation of the Thames, Munsee-Delaware Nation, and Moravian of the Thames First Nation. In addition, they recommended that Hydro One apprise Aamjiwnaang First Nation of the

SECTR Project. Further information on Hydro One's engagement process with First Nations and Métis is filed in **Exhibit B, Tab 6, Schedule 6**.

Hydro One requests a written hearing for this proceeding and submits that the evidence supports granting the requested Order based on the following grounds:

- The need for additional supply in the Windsor-Essex area and the need to minimize the impact of supply interruptions has been established;
- There are no adverse system or anticipated customer impacts from the project;
- The project will be fully compliant with the relevant codes, rules and licences;
- There will be a minor customer total bill impact (approximately 0.01%) as a result of the new line facilities.

In order for the proposed project to proceed, it must be considered to be in the "public interest". Subsection 96(2) of the Act specifies that, for section 92 purposes, "the Board shall only consider the interests of consumers with respect to prices and the reliability and quality of electricity service" and "where applicable and in a manner consistent with the policies of the Government of Ontario, the promotion of the use of renewable energy sources." Hydro One submits that the proposed facilities are in the public interest because:

- The existing capability of the transmission system in the Windsor - Essex area is not sufficient to serve the anticipated future electricity demand resulting from population growth and economic activity;
- The SECTR Project is a cost-effective solution to achieving this objective;
- The need for the SECTR Project has been determined by the OPA and the Project is supported by multiple parties in the Windsor - Essex area. The support of these parties is documented in 9 letters of endorsement provided in **Exhibit B, Tab 6, Schedule 2**;

- There will be no material impact on the price of electricity; and
- The cost responsibility methodology proposed is consistent with the Transmission System Code and the Ontario Energy Board's "beneficiary pays" principles

For the reasons provided above, Hydro One respectfully submits that the proposed transmission line facilities should be approved under section 92 of the Act. Accordingly, Hydro One requests an Order from the Board pursuant to section 92 of the Act granting leave to construct the proposed transmission line facilities. In addition, Hydro One requests that the Board endorse the methodology for allocation of upstream costs at the distribution level as set out in this Application.

DESCRIPTION OF THE PROPOSED FACILITIES

1.0 PROPOSED FACILITIES

The Hydro One proposed Supply to Essex County Transmission Reinforcement ("**SECTR**") Project will contribute to meeting the capacity needs of the Windsor – Essex region as well as minimize the impact of supply interruptions to customers in the region.

Four 230 kV transmission circuits C21J, C22J, C23Z and C24Z are currently in this corridor. The SECTR Project proposes to build a new double-circuit 230 kV transmission line that will originate from the Hydro One transmission corridor between Chatham SS and Sandwich Junction. Two new circuits will tap into circuits C21J and C22J approximately 20 km east of Sandwich Junction and extend south 13 km, along a new transmission corridor, to the Municipality of Leamington where a new transformer station (Leamington TS) will be located.

A map indicating the geographic location and a schematic diagram of the proposed facilities are provided in **Exhibit B, Tab 2, Schedule 2** and **Exhibit B, Tab 2, Schedule 3,** respectively. Illustrations of the transmission towers along this corridor are provided in **Exhibit B, Tab 2, Schedule 4**. The IESO's Draft System Impact Assessment ("**SIA**") is filed as **Exhibit B, Tab 6, Schedule 3,** and the Customer Impact Assessment ("**CIA**"), is filed as **Exhibit B, Tab 6, Schedule 4**.

The proposed project is consistent with the transmission solution recommended by the OPA for addressing the needs in the Windsor – Essex region. The need for the proposed facilities is described in **Exhibit B, Tab 1, Schedules 4 and 5**.

This application is seeking OEB approval to allow for the reinforcement of Hydro One's transmission line facilities, with the following work:

- Construct approximately 13 km of new 230 kV double-circuit line on a new ROW between the new Leamington TS and new taps on 230 kV circuits C21J and C22J between Chatham TS and Sandwich Junction at a location approximately 20 km from Sandwich Junction;
- Installation of Optic Ground Wire ("**OPGW**") on new and existing towers.

The proposed facilities are subject to section 92 approval.

In conjunction with this line work, Hydro One will also complete the following station work:

- Build a new 230/27.6 kV Leamington TS in the Municipality of Leamington.

The new transmission line facilities and station work will address the near- and medium-term needs of the Windsor-Essex area, and are a major element in addressing longer-term needs in the region.

2.0 DETAILS OF THE PROPOSED FACILITIES

The proposed facilities will be owned and operated by Hydro One. The following is the specific work and facilities required as part of the proposed project:

Line Work

- Build approximately 13 km of new 230 kV double-circuit line on a new ROW between the new Leamington TS and new taps on 230 kV circuits C21J and C22J between Chatham TS and Sandwich Junction at a location approximately 20 km from Sandwich Junction. The new circuits will tap from existing tower 225 on circuit

C21J and new tower 465b on circuit C22J. This tapping location will be known as Leamington Junction.

- Install OPGW on top of the new 230 kV towers serving Leamington TS as well as new OPGW on the existing C21J/C23Z towers (near Leamington Junction) to be used for tapping into the existing OPGW splice box.

Station Work

- Build a new Leamington TS near the NW corner of Hwy 77 and Mersea Road 6 in the Municipality of Leamington. The new station will consist of two 230/27.6 – 27.6 kV 75/100/125 MVA step-down transformers and associated 27.6 kV switchgear and feeder positions.

The planned in-service date for the proposed facilities is March 2017.

Upon completion of this project, some load will be transferred from Kingsville TS to Leamington TS. The transfer of sufficient demand supplied from the 115 kV system in the Kingsville-Leamington subsystem to the 230 kV system in the Kingsville-Leamington area will address the reliability needs of the Windsor – Essex region as identified in **Exhibit B, Tab 1, Schedule 5**. As a result of this load transfer only one of the three end-of-life 115/27.6 kV 25/33/42 MVA transformers at Kingsville TS will be replaced using Hydro One’s Sustainment program. The other two will be decommissioned and not replaced.

PROJECT COSTS

The estimated capital cost of the Supply to Essex County Transmission Reinforcement ("**SECTR**") Project, including overheads and capitalized interest is shown below:

Table 1
Cost of Line Work

	Estimated Cost ($000's)
Planning & Estimating	$1,500
Line Protection Facilities	0
Property [1]	11,709
Project Management	630
Engineering	966
Procurement	9,736
Construction	9,724
Removals	2,268
Contingencies[2]	2,078
Costs before Overhead and AFUDC	**$38,611**
Overhead [3]	5,390
Capitalized Interest [4]	1,286
Total Line Work	**$45,287**

[1] Property includes costs for temporary rights along the ROW.

[2] Contingencies also include contingency on removal costs of $181K

[3] Overhead costs allocated to the project are for asset management and corporate services costs. These costs are charged to capital projects through a standard overhead capitalization rate. As such they are considered "Indirect Overheads". Hydro One does not allocate any project activity to "Direct Overheads" but rather charges all other costs directly to the project.

[4] Capitalized interest is calculated using the Board's approved interest rate methodology (EB-2006-0117) to the projects' forecast monthly cash flow and carry-forward closing balance from the preceding month.

The cost of the line work provided above allows for the schedule of approval, design and construction activities provided in **Exhibit B, Tab 5, Schedule 2**.

The estimated cost of the new Leamington TS associated station work is $32.1 million (please refer to **Exhibit B, Tab 2, Schedule 1** for a description of work).

1.0 RISKS AND CONTINGENCIES

As with most projects, there is some risk associated with estimating costs. Hydro One's cost estimate includes an allowance for contingencies in recognition of these risks.

Based on past experience, the estimate for this project work includes allowances in the contingencies to cover the following potential risks:

- Cancellation or delays in obtaining required power and telecommunications system outages (needed for the line upgrade work and commissioning activities);
- Construction equipment failures;
- Material delivery delay due to procurement or vendor issues;
- Activities or materials of a minor nature, not included in the estimate preparation;
- Labour hours deviating from the estimate.

Cost contingencies that have not been included, due to the unlikelihood or uncertainty of occurrence, include:

- Mitigation costs due to addressing any issues associated with having a Union Gas pipeline parallel to the new ROW;
- Labour disputes;
- Delays in obtaining regulatory approvals, permits and licences;
- Delays in property rights acquisitions;
- Safety or environmental incidents;

- Unexpected First Nations/Métis interests;
- Significant changes in costs of materials since the estimate preparation;

2.0 COSTS OF COMPARABLE PROJECTS

The OEB Filing Requirements for Electricity Transmission and Distribution Applications (EB-2006-0170), Chapter 4, requires the applicant to provide a cost comparable project constructed by the applicant. Table 2 below shows the cost, construction and technical comparison of the SECTR Project to the Hurontario Station and Transmission Line Reinforcement ("**HSTLR**") Project (EB-2006-0215).

For the purpose of context, Hydro One recently (2010) placed in-service a new double-circuit 230 kV transmission line from Hurontario SS to Cardiff TS as part of the HSTLR Project. The HSTLR Project was chosen as a good "apples-to-apples" comparison to the SECTR Project because of its similar construction conditions and design. Both projects have a double-circuit 230 kV transmission line supplying a transmission station. Key project information on the two projects is provided in Table 2 below.

The total cost per km is based on the comparable costs of the two projects. The main drivers of the variance in comparable costs are:

- The Leamington Junction to Leamington TS ROW corridor is situated adjacent to a Union Gas pipeline which introduces some risk whereas the HSTLR project was already located on land designated for utility use with no pipeline adjacent to it. This results in higher construction costs for SECTR;
- The HSTLR Project costs were incurred over the 2007 to 2010 period as compared to SECTR Project costs which reflect costs for the period 2014 to 2016. Significant increases in material and equipment prices occurred over the intervening period;

- The SECTR Project includes as a contingency a cost of relocating 6.8 km of distribution lines located in the ROW deemed as interference for the 230kV transmission lines.

Note that the HSTRL Project did not require any acquisition of additional land or land rights.

Table 2
Costs of Comparable Projects

Project	**Supply To Essex Transmission Reinforcement Project (estimate)**	**Hurontario Stn. And Transmission Line Reinforcement Project (actual)**
Technical	230 kV double circuits on single structures Generally install steel lattice tower structures	230 kV double circuits on single structures Generally install steel lattice tower structures
Length (km)	13 km	4.2 km
Project Surroundings	Mostly urban agricultural, residential & commercial	Mostly rural & urban residential & commercial
Environmental Issues	None	None
In-Service Date	2016-05-31	2010-03-30
Total Project Cost	$47,555k	$10,002K
Less: Non-Comparable Costs		
Property[1,2]	$13,752k	$0k
Planning & Estimating[1]	$1,500k	$0k
Total Comparable Project Costs	$32,303k	$10,002k
Total Cost/km	$2.5M/km	$2.4M/km

[1] Associated contingency, overhead & capitalized interest are included

[2] SECTR requires acquisition of property rights whereas no property was purchased for HSTLR as it was located on land designated for utility use already

PROJECT ECONOMICS

1.0 ECONOMIC FEASIBILITY

The proposed transmission work for the Supply to Essex County Transmission Reinforcement ("**SECTR**") Project comprises line assets and related station assets. The transformation assets, which include establishing a new Leamington TS will be included in the Transformation Connection Pool for rate-making purposes. The line assets, which include a new 230 kV double-circuit line between the new Leamington TS and new taps on 230 kV circuits between Chatham TS and Sandwich Junction, will be included in the Line Connection Pool. More details concerning the assignment of costs is provided in section 2.0 below.

See **Exhibit B, Tab 2, Schedule 1**, for detailed information on the proposed work. A Discounted Cash Flow ("**DCF**") calculation has been completed for each pool consistent with the economic evaluation requirements of the Transmission System Code to determine whether a capital contribution is required. For the Line Connection Pool capital contributions totaling $31.7 million, plus HST, are required and for the Transformation Connection Pool capital contributions totaling $8.7 million, plus HST, are required.

Capital Contribution Required *in $ millions, excluding HST*	Line Pool	Transformation Pool	Total
Hydro One Distribution	31.7	8.7	40.4
Total	**31.7**	**8.7**	**40.4**

As the sole transmission-connected customer in the project area, Hydro One Distribution is responsible for the capital contribution related to the project, as noted in the table above. In order to help recover the capital contribution from other project beneficiaries within Hydro One's distribution system (i.e., embedded LDCs and commercial customers), Hydro One is proposing a methodology for the allocation of project costs among them, See **Exhibit B, Tab 4, Schedule 5** for the proposed methodology for allocation of customer-related project costs among distribution-system beneficiaries.

2.0 COST RESPONSIBILITY

Line Connection

The line cost of the SECTR Project is $45.3M. This includes the cost of building approximately 13 km of new 230 kV double-circuit line on a new right-of-way, installation of optic ground wire, providing connections to the new circuits and right-of-way acquisition.

Transformation Connection

The transformation cost of the SECTR Project is $32.1M. This includes the cost of establishing a new Leamington TS, providing the station with two 230/27.6 – 27.6 kV 75/100/125 MVA step-down transformers, associated 27.6 kV switchgear and feeder positions and property acquisition.

Cost Allocation

The OPA has determined that the SECTR Project will address both system needs and load customer needs. In accordance with the beneficiary pays principle, the OPA has recommended that load customers pay 77.5% of the SECTR cost (see **Exhibit B, Tab 4, Schedule 4** for more details). Since the realization of the system benefit is due to both the line connection and transformation components of the SECTR Project it is recommended that 77.5% of the line connection cost of the project (77.5% of $45.3M) and 77.5% of the transformation cost of the project (77.5% of $32.1M) be assigned to the customer.

With the establishment of Leamington TS sufficient load will be transferred from Kingsville TS to Leamington TS. This will reduce the need for the current four transformers at Kingsville TS to two transformers. Three of the transformers at Kingsville TS are at end-of-life with planned replacement in 2015 (under Hydro One Transmission's Sustainment program). With the planned load transfer to Leamington TS, only one of these three transformers will need to be replaced. The estimated cost to replace three transformers is $18M, while the estimated cost to replace one transformer and reconfigure the station to a two-transformer station is $12M. This represents a $6M reduction in cost due to the SECTR Project. Given that 77.5% of the cost of SECTR is assigned to the customer, this same percentage of the savings due to SECTR is to be credited to the customer for economic evaluation purposes. Since the cost reduction is at the transformation level, the credit is to be given to the customer at the transformation pool. There would also be a net saving of OM&A costs from maintaining a two-transformer station rather a four-transformer station at Kingsville TS.

The table below indicates the cost responsibility for the elements of work to be done on the project.

Cost Responsibility *in $ million, excluding HST*	Cost of Work (per B-4-2)	Cost Responsibility		Capital Contribution
		Customers	Pool	
Transmission Line Facilities	45.3[1]	35.1	10.2	31.7
Station Facilities	32.1	20.2[2]	11.9	8.7
Total	**77.4**	**55.3**	**22.1**	**40.4**

2.1 Line Connection Pool

A 25-year discounted cash flow analysis for the Line Connection facilities is provided in Table 1 below. The results indicate that the forecast incremental revenues are expected to be insufficient to pay for the incremental capital and operating costs and therefore a capital contribution will be required. The capital contribution is estimated to be $31.7 million for Hydro One Distribution, the sole transmission connected customer.

2.2 Transformation Connection Pool

A 25-year discounted cash flow analysis for the Transformation Connection facilities is provided in Table 2 below. The results indicate that the forecast incremental revenues are expected to be insufficient to pay for the incremental capital and operating costs and therefore a capital contribution will be required. The capital contribution is estimated to be $8.7 million for Hydro One Distribution.

[1] Line costs of $45.3 million include $43.0 million of up front capital costs plus $2.3 million removal costs
[2] $20.2 million = ($32.1 million station facilities costs less $6 million Kingsville cost reduction) x 77.5%

3.0 RATE IMPACT ASSESSMENT

The analysis of the Line Connection Pool and Transformation Connection Pool rate impacts has been carried out on the basis of Hydro One's transmission revenue requirement for the year 2014, and the most recently approved Ontario Transmission Rate Schedules. As none of the costs are Network-pool-related, based on the criteria used to allocate transmission costs to the three pools as approved by the Board in its RP-1999-0044 decision, the Network Pool revenue requirement would be unaffected by the new facilities.

Line Connection Pool

Based on the Line Connection Pool incremental cash flows associated with the net capital cost of the project, $11.3 million ($43.0 million gross cost less $31.7 million capital contribution), there will be a change in the Line Connection pool revenue requirement once the project's impacts are reflected in the transmission rate base, net of capital contribution, at the projected March 2017 in-service date. Over a 25-year time horizon, the Line Connection Pool rate will remain flat at the current rate of $0.82/kW/month. The maximum revenue deficiency related to the proposed line facilities will be $0.7 million in the year 2019, which will result in a 0% (after rounding) rate impact in that year. The detailed analysis illustrating the calculation of the incremental line revenue deficiency and rate impact is provided in Table 3 below.

Transformation Connection Pool

Based on the Transformation Connection Pool incremental cash flows associated with the net capital cost of the project, $23.4 million ($32.1 million gross cost less $8.7 million capital contribution), there will be a change in the Transformation Connection Pool revenue requirement once the project's impacts are reflected in the transmission rate base, net of capital contribution, at the projected March 2017 in-service date. Over a 25-

year time horizon, the Transformation Connection Pool rate will initially rise by 1 cent/kw/month, from the current rate of $1.98/kW/month to $1.99/kW/month before falling back to the current rate. The maximum revenue deficiency related to the proposed transformation facilities will be $1.0 million in the year 2019. This will result in a maximum rate impact of 0.51% in that year. The detailed analysis illustrating the calculation of the incremental transformation revenue deficiency and rate impact is provided in Table 4 below.

Impact on Typical Residential Customer

Adding the costs of the new facilities to the respective pools will cause a slight increase in a typical residential customer's rates. The table below shows this result for a typical residential customer who is under the Regulated Price Plan ("**RPP**").

A. Typical monthly bill (Residential R1 in a high density zone at 1,000 kWh per month with winter commodity prices.)	$182.98 per month
B. Transmission component of monthly bill	$14.04 per month
C. Line and Transformation Pool share of Transmission component	$5.83 per month
D. Impact on Line and Transformation Pool Provincial Uniform Rates (Tables 3 and 4. Combined Impact of Line 0.00% and Transformation 0.51%)	0.37%
E. Increase in Transmission costs for typical monthly bill (C x D)	$0.02 per month or $0.26 per year
F. Net increase on typical residential customer bill (E / A)	0.01%

Note: Values rounded to two significant digits.

Table 1 – DCF Analysis, Hydro One Distribution, Line Pool, page 1

Date:	12-May-14
Project #	17503

SUMMARY OF CONTRIBUTION CALCULATIONS
Line Pool - Estimated cost

Facility Name:	Supply to Essex County Transmission Reinforcement
Description:	Line Pool Capital Contribution
Customer:	Hydro One Distribution

			In-Service Date	<-------	Project year ended - annualized from In-Service Date				-------->							
		Month	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	
		Year	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	
			0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	
Revenue & Expense Forecast														
Load Forecast (MW)				37.3	38.2	39.2	40.1	41.0	42.0	42.9	43.9	44.8	45.8	46.8	47.7	
Tariff Applied ($/kW/Month)				0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Incremental Revenue - $M				0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	
Removal Costs - $M			(1.8)													
On-going OM&A Costs - $M			0.0	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	
Municipal Tax - $M				(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	
Net Revenue/(Costs) before taxes - $M			(1.8)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	
Income Taxes			0.5	0.2	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	
Operating Cash Flow (after taxes) - $M			(1.3)	0.4	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	
		Cumulative PV @ 5.84%														
PV Operating Cash Flow (after taxes) - $M	**(A)**	**4.8**	**(1.3)**	**0.4**	**0.6**	**0.5**	**0.5**	**0.4**	**0.4**	**0.3**	**0.3**	**0.3**	**0.3**	**0.2**	**0.2**	
Capital Expenditures - $M																
Upfront - capital cost before overheads & AFUDC			(29.6)													
- Overheads			(2.7)													
- AFUDC			(1.0)													
Total upfront capital expenditures			**(33.3)**													
On-going capital expenditures				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
PV On-going capital expenditures			0.0													
Total capital expenditures - $M			**(33.3)**													
Capital Expenditures - $M																
PV CCA Residual Tax Shield - $M			**0.1**													
PV Working Capital - $M			**(0.0)**													
PV Capital (after taxes) - $M	**(B)**	**(33.2)**	**(33.2)**													
Cumulative PV Cash Flow (after taxes) - $M	**(A) + (B)**	**(28.4)**	**(34.5)**	**(34.1)**	**(33.6)**	**(33.1)**	**(32.6)**	**(32.2)**	**(31.8)**	**(31.5)**	**(31.2)**	**(30.9)**	**(30.6)**	**(30.4)**	**(30.2)**	

Discounted Cash Flow Summary

Economic Study Horizon - Years: **25**

Discount Rate - % **5.84%**

		Before Cont $M		**After Cont** $M	**Impact** $M
PV Incremental Revenue		6.0		6.0	
PV OM&A Costs		(2.0)		(2.0)	
PV Municipal Tax		(2.1)		(2.1)	
PV Income Taxes		(0.5)		(0.5)	0.0
PV CCA Tax Shield		3.5		0.2	(3.4)
PV Capital - Upfront	(33.3)		(33.3)		
Add: PV **Capital Contribution**	**0.0**	(33.3)	**31.7**	(1.6)	31.7
PV Capital - On-going		0.0		0.0	
PV Working Capital		(0.0)		(0.0)	
PV Surplus / (Shortfall)		(28.4)		(0.0)	28.4
Profitability Index*		**0.1**		**1.0**	

Notes:
*PV of total cash flow, excluding net capital expenditure & on-going capital & proceeds on disposal / PV of net capital expenditure & on-going capital & proceeds on disposal

Table 1 – DCF Analysis, Hydro One Distribution, Line Pool, page 2

Date:	12-May-14
Project #	17503

SUMMARY OF CONTRIBUTION CALCULATIONS
Line Pool - Estimated cost

Facility Name:	Supply to Essex County Transmission Reinforcement
Description:	Line Pool Capital Contribution
Customer:	Hydro One Distribution

<------- Project year ended - annualized from In-Service Date -------->

		Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31
	Month / Year	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**
		13	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
Revenue & Expense Forecast														
Load Forecast (MW)		48.7	49.7	50.6	51.6	52.6	53.7	54.6	55.5	56.5	57.6	58.6	59.6	60.7
Tariff Applied ($/kW/Month)		0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Incremental Revenue - $M		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6
Removal Costs - $M														
On-going OM&A Costs - $M		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Municipal Tax - $M		(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Net Revenue/(Costs) before taxes - $M		0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Income Taxes		0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Operating Cash Flow (after taxes) - $M		0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
PV Operating Cash Flow (after taxes) - $M	**(A)**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Capital Expenditures - $M														
Upfront - capital cost before overheads & AFUDC														
- Overheads														
- AFUDC														
Total upfront capital expenditures														
On-going capital expenditures		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PV On-going capital expenditures														
Total capital expenditures - $M														
Capital Expenditures - $M														
PV CCA Residual Tax Shield - $M														
PV Working Capital - $M														
PV Capital (after taxes) - $M	**(B)**													
Cumulative PV Cash Flow (after taxes) - $M	**(A) + (B)**	**(30.0)**	**(29.8)**	**(29.6)**	**(29.5)**	**(29.3)**	**(29.2)**	**(29.0)**	**(28.9)**	**(28.8)**	**(28.7)**	**(28.6)**	**(28.5)**	**(28.4)**

Table 2 – DCF Analysis, Hydro One Distribution, Transformation Pool, page 1

Date:	13-May-14
Project #	17503

SUMMARY OF CONTRIBUTION CALCULATIONS
Transformation Pool - Estimated cost

Facility Name:	Supply to Essex County Transmission Reinforcement
Description:	Transformation Pool Capital Contribution
Customer:	Hydro One Distribution

			In-Service Date	<-------	Project year ended - annualized from In-Service Date				-------->						
		Month	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31
		Year	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**
			0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Revenue & Expense Forecast															
Load Forecast (MW)				37.3	38.2	39.2	40.1	41.0	42.0	42.9	43.9	44.8	45.8	46.8	47.7
Tariff Applied ($/kW/Month)				1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98
Incremental Revenue - $M				0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1
Removal Costs - $M			0.0												
On-going OM&A Costs - $M			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Municipal Tax - $M				(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Net Revenue/(Costs) before taxes - $M			0.0	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0
Income Taxes			0.0	(0.0)	0.2	0.1	0.1	0.1	0.0	0.0	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)
Operating Cash Flow (after taxes) - $M			0.0	0.8	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9
		Cumulative PV @ 5.84%													
PV Operating Cash Flow (after taxes) - $M	**(A)**	**12.7**	**0.0**	**0.8**	**0.9**	**0.9**	**0.8**	**0.7**	**0.7**	**0.7**	**0.6**	**0.6**	**0.5**	**0.5**	**0.5**
Capital Expenditures - $M															
Upfront - capital cost before overheads & AFUDC			(17.2)												
- Overheads			(2.4)												
- AFUDC			(0.7)												
Total upfront capital expenditures			**(20.2)**												
On-going capital expenditures				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PV On-going capital expenditures			0.0												
Total capital expenditures - $M			**(20.2)**												
Capital Expenditures - $M															
PV CCA Residual Tax Shield - $M			**0.1**												
PV Working Capital - $M			**0.0**												
PV Capital (after taxes) - $M	**(B)**	**(20.1)**	**(20.1)**												
Cumulative PV Cash Flow (after taxes) - $M	**(A) + (B)**	**(7.4)**	**(20.1)**	**(19.3)**	**(18.4)**	**(17.6)**	**(16.8)**	**(16.0)**	**(15.4)**	**(14.7)**	**(14.1)**	**(13.5)**	**(13.0)**	**(12.4)**	**(12.0)**

Discounted Cash Flow Summary

Economic Study Horizon - Years: **25**

Discount Rate - % **5.84%**

		Before Cont $M		After Cont $M	Impact $M
PV Incremental Revenue		14.6		14.6	
PV OM&A Costs		0.0		0.0	
PV Municipal Tax		(1.3)		(1.3)	
PV Income Taxes		(3.5)		(3.5)	(0.0)
PV CCA Tax Shield		3.0		1.7	(1.3)
PV Capital - Upfront	(20.2)		(20.2)		
Add: PV **Capital Contribution**	**0.0**	(20.2)	**8.7**	(11.5)	8.7
PV Capital - On-going		0.0		0.0	
PV Working Capital		0.0		0.0	
PV Surplus / (Shortfall)		(7.4)		(0.0)	7.4
Profitability Index*		**0.6**		**1.0**	

Notes:

*PV of total cash flow, excluding net capital expenditure & on-going capital & proceeds on disposal / PV of net capital expenditure & on-going capital & proceeds on disposal

1 **Table 2 – DCF Analysis, Hydro One Distribution, Transformation Pool, page 2**

Date:	13-May-14
Project #	17503

SUMMARY OF CONTRIBUTION CALCULATIONS
Transformation Pool - Estimated cost

Facility Name:	Supply to Essex County Transmission Reinforcement
Description:	Transformation Pool Capital Contribution
Customer:	Hydro One Distribution

			<-------		Project year ended - annualized from In-Service Date		-------->							
		Month	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31	Mar-31
		Year	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**
			13	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
Revenue & Expense Forecast															
Load Forecast (MW)			48.7	49.7	50.6	51.6	52.6	53.7	54.6	55.5	56.5	57.6	58.6	59.6	60.7
Tariff Applied ($/kW/Month)			1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98
Incremental Revenue - $M			1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4
Removal Costs - $M															
On-going OM&A Costs - $M			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Municipal Tax - $M			(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Net Revenue/(Costs) before taxes - $M			1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3
Income Taxes			(0.1)	(0.1)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.3)	(0.3)	(0.3)	(0.3)
Operating Cash Flow (after taxes) - $M			0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PV Operating Cash Flow (after taxes) - $M	**(A)**		**0.5**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**
Capital Expenditures - $M															
Upfront - capital cost before overheads & AFUDC															
- Overheads															
- AFUDC															
Total upfront capital expenditures															
On-going capital expenditures			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PV On-going capital expenditures															
Total capital expenditures - $M															
Capital Expenditures - $M															
PV CCA Residual Tax Shield - $M															
PV Working Capital - $M															
PV Capital (after taxes) - $M	**(B)**														
Cumulative PV Cash Flow (after taxes) - $M	**(A) + (B)**		**(11.5)**	**(11.1)**	**(10.6)**	**(10.2)**	**(9.9)**	**(9.5)**	**(9.2)**	**(8.8)**	**(8.5)**	**(8.2)**	**(7.9)**	**(7.7)**	**(7.4)**

2

Table 3 – Revenue Requirement and Line Pool Rate Impact, page 1

Supply to Essex County Transmission Reinforcement		**Project YE 31-Mar 2018**	**31-Mar 2019**	**31-Mar 2020**	**31-Mar 2021**	**31-Mar 2022**	**31-Mar 2023**	**31-Mar 2024**	**31-Mar 2025**	**31-Mar 2026**	**31-Mar 2027**	**31-Mar 2028**	**31-Mar 2029**
Calculation of Incremental Revenue Requirement ($ millions)		1	2	3	4	5	6	7	8	9	10	11	12
In-service date	31-Mar-17												
Capital Cost	43.0												
Less: Capital Contribution Required	(31.7)												
Net Project Capital Cost	11.3												
Average Rate Base		5.6	11.0	10.9	10.7	10.6	10.4	10.3	10.1	9.9	9.8	9.6	9.5
Incremental OM&A Costs		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grants in Lieu of Municipal tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Depreciation		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Interest and Return on Rate Base		0.4	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6
Income Tax Provision		0.0	(0.0)	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
REVENUE REQUIREMENT PRE-TAX		**0.8**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**
Incremental Revenue		0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5
SUFFICIENCY/(DEFICIENCY)		**(0.4)**	**(0.7)**	**(0.7)**	**(0.7)**	**(0.7)**	**(0.7)**	**(0.7)**	**(0.7)**	**(0.7)**	**(0.7)**	**(0.6)**	**(0.6)**
	Base Year												
Line Pool Revenue Requirement including sufficiency/(deficiency)	189	190	190	190	190	190	190	190	190	190	190	190	190
Line MW	231	232	232	232	232	232	232	232	232	232	232	232	232
Line Pool Rate ($/kw/month)	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Increase/(Decrease) in Line Pool Rate ($/kw/month), relative to base year		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RATE IMPACT relative to base year		**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**

Assumptions

Incremental OM&A		$1.5 k per new km of line each year.
Grants in Lieu of Municipal tax	0.47%	Transmission system average
Depreciation	2.00%	Reflects 50 year average service life for towers, conductors and station equipment, excluding land
Interest and Return on Rate Base	6.59%	Includes OEB-approved ROE of 9.36%, 2.11% on ST debt, and 4.94% on LT debt. 40/4/56 equity/ST debt/ LT debt split
Income Tax Provision	26.50%	2014 federal and provincial corporate income tax rate
Capital Cost Allowance	8.00%	100% Class 47 assets except for Land

Table 3 – Revenue Requirement and Line Pool Rate Impact, page 2

Supply to Essex County Transmission Reinforcement		**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**
		2030	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**
Calculation of Incremental Revenue Requirement ($ millions)		13	14	15	16	17	18	19	20	21	22	23	24	25
In-service date	31-Mar-17													
Capital Cost	43.0													
Less: Capital Contribution Required	(31.7)													
Net Project Capital Cost	11.3													
Average Rate Base		9.3	9.2	9.0	8.9	8.7	8.6	8.4	8.2	8.1	7.9	7.8	7.6	7.5
Incremental OM&A Costs		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grants in Lieu of Municipal tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Depreciation		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Interest and Return on Rate Base		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
Income Tax Provision		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
REVENUE REQUIREMENT PRE-TAX		**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
Incremental Revenue		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6
SUFFICIENCY/(DEFICIENCY)		**(0.6)**	**(0.6)**	**(0.6)**	**(0.6)**	**(0.5)**	**(0.5)**	**(0.5)**	**(0.5)**	**(0.5)**	**(0.5)**	**(0.4)**	**(0.4)**	**(0.4)**
	Base Year													
Line Pool Revenue Requirement including sufficiency/(deficiency)	189	190	190	190	190	190	190	190	190	190	190	190	190	190
Line MW	231	232	232	232	232	232	232	232	232	232	232	232	232	232
Line Pool Rate ($/kw/month)	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Increase/(Decrease) in Line Pool Rate ($/kw/month), relative to base year		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RATE IMPACT relative to base year		**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**

Table 4 – Revenue Requirement and Transformation Pool Rate Impact, page 1

		Project YE											
Supply to Essex County Transmission Reinforcement		**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**	**31-Mar**
		2018	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**
Calculation of Incremental Revenue Requirement ($ millions)		1	2	3	4	5	6	7	8	9	10	11	12
In-service date	31-Mar-17												
Capital Cost	32.1												
Less: Capital Contribution Required	(8.7)												
Net Project Capital Cost	23.4												
Average Rate Base		11.5	22.7	22.2	21.8	21.3	20.9	20.4	20.0	19.5	19.0	18.6	18.1
Incremental OM&A Costs		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grants in Lieu of Municipal tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Depreciation		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Interest and Return on Rate Base		0.8	1.5	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.2	1.2
Income Tax Provision		(0.0)	(0.2)	(0.1)	(0.1)	(0.0)	(0.0)	0.0	0.1	0.1	0.1	0.1	0.1
REVENUE REQUIREMENT PRE-TAX		**1.4**	**1.9**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**1.9**
Incremental Revenue		0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1
SUFFICIENCY/(DEFICIENCY)		**(0.5)**	**(1.0)**	**(1.0)**	**(1.0)**	**(1.0)**	**(1.0)**	**(1.0)**	**(0.9)**	**(0.9)**	**(0.9)**	**(0.8)**	**(0.8)**
	Base Year												
Transformation Pool Revenue Requirement including sufficiency/(deficiency)	393	394	394	395	395	395	395	395	395	395	395	394	394
Transformation MW	198	198	198	198	198	198	198	199	199	199	199	199	199
Transformation Pool Rate ($/kw/month)	1.98	1.98	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99
Increase/(Decrease) in Transformation Pool Rate ($/kw/month), relative to base year		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RATE IMPACT relative to base year		**0.00%**	**0.51%**	**0.51%**	**0.51%**	**0.51%**	**0.51%**	**0.51%**	**0.51%**	**0.51%**	**0.51%**	**0.51%**	**0.51%**

Assumptions		
Incremental OM&A		Nil
Grants in Lieu of Municipal tax	0.47%	Transmission system average
Depreciation	2.00%	Reflects 50 year average service life for towers, conductors and station equipment, excluding land
Interest and Return on Rate Base	6.59%	Includes OEB-approved ROE of 9.36%, 2.11% on ST debt, and 4.94% on LT debt. 40/4/56 equity/ST debt/ LT debt split
Income Tax Provision	26.50%	2014 federal and provincial corporate income tax rate
Capital Cost Allowance	8.00%	100% Class 47 assets except for Land

Table 4 – Revenue Requirement and Transformation Pool Rate Impact, page 2

Supply to Essex County Transmission Reinforcement		31-Mar 2030	31-Mar 2031	31-Mar 2032	31-Mar 2033	31-Mar 2034	31-Mar 2035	31-Mar 2036	31-Mar 2037	31-Mar 2038	31-Mar 2039	31-Mar 2040	31-Mar 2041	31-Mar 2042
Calculation of Incremental Revenue Requirement ($ millions)		13	14	15	16	17	18	19	20	21	22	23	24	25
In-service date	31-Mar-17													
Capital Cost	32.1													
Less: Capital Contribution Required	(8.7)													
Net Project Capital Cost	23.4													
Average Rate Base		17.7	17.2	16.8	16.3	15.8	15.4	14.9	14.5	14.0	13.5	13.1	12.6	12.2
Incremental OM&A Costs		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grants in Lieu of Municipal tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Depreciation		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Interest and Return on Rate Base		1.2	1.1	1.1	1.1	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.8
Income Tax Provision		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
REVENUE REQUIREMENT PRE-TAX		**1.9**	**1.9**	**1.9**	**1.9**	**1.9**	**1.8**	**1.8**	**1.8**	**1.8**	**1.7**	**1.7**	**1.7**	**1.6**
Incremental Revenue		1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4
SUFFICIENCY/(DEFICIENCY)		**(0.8)**	**(0.7)**	**(0.7)**	**(0.6)**	**(0.6)**	**(0.6)**	**(0.5)**	**(0.5)**	**(0.4)**	**(0.4)**	**(0.3)**	**(0.3)**	**(0.2)**
	Base Year													
Transformation Pool Revenue Requirement including sufficiency/(deficiency)	393	394	394	394	394	394	394	394	394	394	394	394	394	394
Transformation MW	198	199	199	199	199	199	199	199	199	199	199	199	199	199
Transformation Pool Rate ($/kw/month)	1.98	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.98	1.98	1.98	1.98	1.98	1.98
Increase/(Decrease) in Transformation Pool Rate ($/kw/month), relative to base year		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RATE IMPACT relative to base year		**0.51%**	**0.51%**	**0.51%**	**0.51%**	**0.51%**	**0.51%**	**0.51%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**

1
Table 5 – Derivation of Load used in DCF, page 1

Relevant SECTR Loads		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
		Annual Non-Coincident Peak Load Forecast for SECTR Project												
Kingsville TS (with 2 transformers)	MW	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0
Leamington TS	MW	115.3	116.5	117.7	118.9	120.2	121.4	122.7	123.9	125.2	126.5	127.8	129.1	130.4
Load sub-total	MW	169.3	170.5	171.7	172.9	174.2	175.4	176.7	177.9	179.2	180.5	181.8	183.1	184.4
Current Capacity (Kingsville TS with 4 transformers)	MW	120	120	120	120	120	120	120	120	120	120	120	120	120
Load in excess of capacity, calendar-year basis	MW	49.3	50.5	51.7	52.9	54.2	55.4	56.7	57.9	59.2	60.5	61.8	63.1	64.4
PLI-adjustment		*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*
PLI-adjusted load in excess of capacity	MW	37.1	38.0	38.9	39.9	40.8	41.7	42.7	43.6	44.6	45.5	46.5	47.5	48.5

Adjusted for in-service month:													
Project Year*		***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***
		March 31, 2017 to March 30, 2018	March 31, 2018 to March 30, 2019	March 31, 2019 to March 30, 2020	March 31, 2020 to March 30, 2021	March 31, 2021 to March 30, 2022	March 31, 2022 to March 30, 2023	March 31, 2023 to March 30, 2024	March 31, 2024 to March 30, 2025	March 31, 2025 to March 30, 2026	March 31, 2026 to March 30, 2027	March 31, 2027 to March 30, 2028	March 31, 2028 to March 30, 2029
Load in excess of capacity, project-year basis	**MW**	**37.3**	**38.2**	**39.2**	**40.1**	**41.0**	**42.0**	**42.9**	**43.9**	**44.8**	**45.8**	**46.8**	**47.7**

Note:
2 * Project-year load = 3/12 of current year load + 9/12 of previous calendar-year load, based on March 31, 2017 in-service date

Table 5 – Derivation of Load used in DCF, page 2

		Annual Non-Coincident Peak Load Forecast for SECTR Project												
Relevant SECTR Loads		**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**
Kingsville TS (with 2 transformers)	MW	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0
Leamington TS	MW	131.7	132.9	134.2	135.6	136.9	138.3	139.4	140.7	142.1	143.5	144.9	146.3	146.3
Load sub-total	MW	185.7	186.9	188.2	189.6	190.9	192.3	193.4	194.7	196.1	197.5	198.9	200.3	201.7
Current Capacity (Kingsville TS with 4 transformers)	MW	120	120	120	120	120	120	120	120	120	120	120	120	120
Load in excess of capacity, calendar-year basis	MW	65.7	66.9	68.2	69.6	70.9	72.3	73.4	74.7	76.1	77.5	78.9	80.3	81.7
PLI-adjustment		*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*	*75%*
PLI-adjusted load in excess of capacity	MW	49.5	50.4	51.4	52.4	53.4	54.4	55.2	56.3	57.3	58.3	59.4	60.4	61.5
Adjusted for in-service month:														
Project Year*		***13***	***14***	***15***	***16***	***17***	***18***	***19***	***20***	***21***	***22***	***23***	***24***	***25***
		March 31, 2029 to March 30, 2030	March 31, 2030 to March 30, 2031	March 31, 2031 to March 30, 2032	March 31, 2032 to March 30, 2033	March 31, 2033 to March 30, 2034	March 31, 2034 to March 30, 2035	March 31, 2035 to March 30, 2036	March 31, 2036 to March 30, 2037	March 31, 2037 to March 30, 2038	March 31, 2038 to March 30, 2039	March 31, 2039 to March 30, 2040	March 31, 2040 to March 30, 2041	March 31, 2041 to March 30, 2042
Load in excess of capacity, project-year basis	**MW**	**48.7**	**49.7**	**50.6**	**51.6**	**52.6**	**53.7**	**54.6**	**55.5**	**56.5**	**57.6**	**58.6**	**59.6**	**60.7**

Note:
* Project-year load = 3/12 of current year load + 9/12 of previous calendar-year load, based on March 31, 2017 in-service date

Table 6 – DCF Assumptions

Hydro One Networks -- Transmission Connection Economic Evaluation Model
2014 Parameters and Assumptions

Transmission rates are based on current OEB-approved uniform provincial transmission rates.

Monthly Rate ($ per kW)	
Transformation	**1.98**
Line	**0.82**

Grants in lieu of Municipal tax (% of up-front capital expenditure, a proxy for property value):		**0.47%**	Based on Transmission system average
Income taxes:			
Basic Federal Tax Rate - % of taxable income:	2014	**15.00%**	Current rate
Ontario corporation income tax - % of taxable income:	2014	**11.50%**	Current rate
Capital Cost Allowance Rate: Class 47 costs	2014	**8%**	Current rate
After-tax Discount rate:		**5.84%**	Based on OEB-approved ROE of 9.36% on common equity and 2.11% on short-term debt, 4.94% forecast cost of long-term debt and 40/60 equity/debt split, and current enacted income tax rate of 26.5%

Other Assumptions:

Estimated Incremental OM&A: Project specific ($ k):

Overhead Line	**$1.5**	per new km of line each year

PROPOSED COST ALLOCATION METHODOLOGY AT THE DISTRIBUTION LEVEL FOR UPSTREAM TRANSMISSION INVESTMENTS

1.0 INTRODUCTION

The construction of the new transformer station and associated transmission line in the Windsor-Essex area will require capital contributions from benefiting customers, consistent with the Ontario Energy Board's "beneficiary pays" principle. Based on the Ontario Power Authority's ("**OPA**") assessment, provided in **Exhibit B, Tab 4, Schedule 4**, that certain system benefits will result from this investment, only that portion of the total investment cost associated with customer benefits, as opposed to system benefits, will be attributed to connecting customers.[1]

As the sole transmission-connected customer in this case, Hydro One Distribution will be required under the Transmission System Code[2] ("**TSC**") to provide a capital contribution, net of incremental revenues less incremental operating costs, to Hydro One Transmission towards the cost of the new transmission connection facilities. In accordance with section 6.3.1 of the TSC, Hydro One Transmission has determined the required capital contribution by performing an economic evaluation using the methodology set out in Appendix 5 of the TSC (see **Exhibit B, Tab 4, Schedule 3**).

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[1] Certain costs associated with the end-of-life transformer replacement work at Kingsville TS that are avoided as a result of the SECTR project would also qualify as system benefit costs.

[2] The Ontario Energy Board's (the "Board") *Transmission System Code ("TSC")*, dated June 10, 2010, along with Appendix 5 of the TSC, and the Board's *Notice of Amendments to Codes – Amendments to the Transmission System Code and the Distribution System Code*, dated August 26, 2013, are attached as Attachment 1.

2.0 UPSTREAM TRANSMISSION COST ALLOCATION

The capital contribution required to be paid to Hydro One Transmission represents an upstream transmission cost to the project beneficiaries at the distribution level. To ensure a fair allocation of this upstream cost, Hydro One Distribution takes guidance from the relevant provisions of the TSC. Hydro One Distribution will perform economic evaluations based on the methodology set out in Appendix 5 of the TSC to allocate, at the distribution level, portions of this capital contribution to all distributors operating in Hydro One Distribution's service area (including Hydro One Distribution itself) that benefit from the project, based on each distributor's load forecast.

For purposes of these economic evaluations, Hydro One Distribution will attribute a portion of the project cost to each distributor in proportion to that distributor's non-coincident incremental peak load requirements, consistent with section 6.3.15 of the TSC. The results of these economic evaluations, which take into consideration the expected transmission revenues that will be generated according to each distributor's load forecast, will form the basis for the apportionment.

In turn, each distributor will need to further apportion its share of the capital contribution within its own service area. Each distributor will perform an economic evaluation for each of its customers in the General Service, Sub-Transmission or equivalent rate class that requests a new or expanded connection ("**new large customer**"). The distributor will also perform an additional economic evaluation for its ratepayers generally. The results of these economic evaluations, performed based on the methodology set out in Appendix 5 of the TSC, will determine the proportion of the capital contribution that each new large customer and ratepayers of that distributor will be required to pay.

2.1 Benefiting Customers

The following distributors will benefit from the Supply to Essex County Transmission Reinforcement ("**SECTR**") project, as proposed in **Exhibit B, Tab 2, Schedule 1,** and are expected to make a capital contribution towards the transmission investment, subject to an economic evaluation:

- Hydro One Distribution
- Essex Powerlines Corporation
- E.L.K. Energy Inc.
- Entegrus Powerlines Inc.

The distributors listed above who are customers of Hydro One Distribution will be required to provide a 25-year load forecast and a security deposit to Hydro One Distribution, and to also execute a Capital Cost Recovery Agreement with Hydro One Distribution prior to the commencement of construction of the new transmission connection facilities.

The new large customers[3] of each of the four distributors listed above will also be required to make a capital contribution towards the transmission investment through their respective distributors. These customers will also be required to provide a 25-year load forecast and a security deposit, and to execute a Capital Cost Recovery Agreement with their respective distributors prior to the commencement of construction of the new transmission connection facilities.

[3] For clarity, 'new large customers' include members of the *Ontario Greenhouse Vegetable Growers Association*.

2.2 Economic Evaluation True-ups

Hydro One Distribution will perform true-ups on all capital contributions collected from distributors in relation to this project, based on the approach set out in sections 6.5.3–6.5.11 of the TSC. These true-ups will apply the same methodology as was used to carry out the initial economic evaluation (discussed in section 2.0 above), and the same inputs except for load, which will be based on the actual load up to the true-up point and on an updated load forecast for the remainder of the economic evaluation period.

For consistency with the treatment of the overall capital contribution payable by Hydro One Distribution to Hydro One Transmission, an economic horizon of 25 years will be used, with true-up points (consistent with TSC provisions) at the end of each of the fifth and tenth years of operation, and at the end of the fifteenth year of operation if actual load is twenty percent higher or lower than the intial load forecast at the end of the tenth year of operation. Where the true-up shows that the distributor's actual load and updated load forecast is lower than the load in the initial load forecast, the distributor will be required to make a payment to make up the shortfall, adjusted appropriately to reflect the time value of money. Where the true-up shows that the actual load and updated load forecast is higher than the load in the initial load forecast, the excess revenue will be posted as a credit to the distributor in a notional account. Any credit balance remaining in the notional account after the last true-up will be rebated to the distributor, adjusted to reflect the time value of money.

Each distributor (including Hydro One Distribution) will, in turn, perform true-ups on all capital contributions collected from new large customers and ratepayers in similar fashion.

2.3 Unforecasted Capacity Assignments

Hydro One Distribution will provide a refund on a capital contribution collected at the distribution level from a distributor in relation to this project in situations where capacity from the new transmission connection facilities is assigned to another distributor with a previously unforecasted capacity requirement. The refund methodology will be based on the approach set out in sections 6.3.17 and 6.3.17A of the TSC. The approach involves providing a refund to a customer where excess capacity on a new facility is assigned to another customer within fifteen years after the date on which the facility comes into service. Hydro One Distribution will collect a capital contribution from the subsequent customer to cover the amount of the refund. Hydro One Distribution will determine the amount of the refund to the initial customer by calculating a revised capital contribution amount using the economic evaluation methodology set out in Appendix 5 of the TSC.

Distributors (including Hydro One Distribution) will provide refunds on capital contributions collected from new large customers and ratepayers in similar fashion.

2.4 Load vs. Generation

As noted in the OPA's assessment of need for this area in **Exhibit B, Tab 1, Schedule 5**, the greenhouse growers in the region have indicated strong interest in developing distributed generation through investments in combined heat and power generation. The SECTR Project is therefore expected to serve a mix of load and generation customers. It is Hydro One's assumption that the net incremental coincident peak flow triggering the need for the new facilities is caused by incremental *load*, as opposed to generation. Hydro One has therefore based its cost allocation approach on load customer cost responsibility provisions, consistent with the guidance in section 6.3.16 of the TSC.

3.0 SUMMARY OF COST ALLOCATION APPROACH

The approach to allocating the costs and required capital contributions in this project is a five-step process:

1. Hydro One Transmission invests in new transmission connection facilities in the amount of the project cost.
2. The project cost is allocated between system benefit (no capital contribution required) and customer benefit (capital contribution required).
3. At the transmission level, Hydro One Distribution, as the sole transmission-connected customer for the proposed facilities, pays a capital contribution to Hydro One Transmission, in accordance with an economic evaluation performed on the customer benefit portion of the project cost.
4. At the distribution level, Hydro One Distribution performs economic evaluations to allocate the capital contribution among all benefiting distributors (including Hydro One Distribution itself).
5. Benefiting distributors (including Hydro One Distribution), in turn, perform economic evaluations to further apportion each distributor's share of the capital contribution among its own new large customers and ratepayers.

Hydro One will also allocate the associated project facility costs, such as distribution feeders, to the Project's beneficiaries.

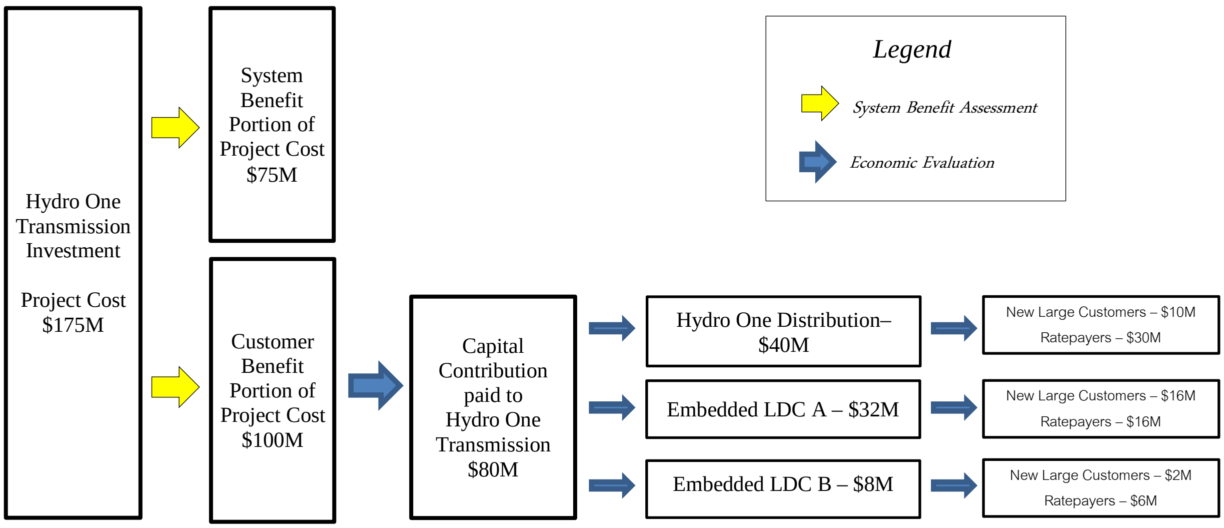
4.0 ILLUSTRATIVE EXAMPLE

For additional clarity, the following example illustrates the proposed approach to allocate the upstream transmission cost of a hypothetical capital investment by Hydro One Transmission of $175 million—$75 million of which is assessed to be for system benefit—to meet the capacity needs of three distributors (one of which is Hydro One

Distribution and the other two are embedded customers of Hydro One Distribution), totaling 200 megawatts of non-coincident incremental peak load. Economic evaluations, which take into consideration projected revenues associated with customers' load forecasts, are performed to determine the total capital contribution payable at the transmission level, and the allocation at the distribution level of that total capital contribution among the three distributors and their respective distribution customers.

In this example, the total capital contribution payable at the transmission level, as determined through an economic evaluation performed by Hydro One Transmission, is $80 million. At the distribution level, economic evaluations performed by Hydro One Distribution allocate this total capital contribution among the three distributors (including Hydro One Distribution itself). The economic evaluations in this example are assumed to result in allocations of 50%, 40% and 10% for Hydro One Distribution, Embedded Distributor A, and Embedded Distributor B, respectively. To allocate each distributor's capital contribution among that distributor's own customers, an economic evaluation is performed by the particular distributor for each of its new large customers, as well as an additional economic evaluation for its ratepayers generally. In this example, the results of these economic evaluations are assumed to yield the capital contribution allocations shown in the diagram and table below. Although not shown in the diagram and table below, capital contribution allocations are calculated separately for each new large customer. Capital contribution allocations for ratepayers are absorbed into the respective distributors' revenue requirements and recovered through rates.

Flow of Costs Diagram (Illustrative Only)



Cost Responsibility Table (Illustrative Only)

<table>
<tr><th>Distributor</th><th>Non-Coincident Incremental Peak Load (MW)</th><th>Attributed Project Cost (Input to Economic Evaluation) ($M)</th><th>Capital Contribution Allocation Percentage based on Economic Evaluation</th><th colspan="3">Capital Contribution ($M)</th></tr>
<tr><td rowspan="2">Hydro One Distribution</td><td rowspan="2">90</td><td rowspan="2">45</td><td rowspan="2">50%</td><td rowspan="2">40</td><td>New Large Customers</td><td>10</td></tr>
<tr><td>Ratepayers</td><td>30</td></tr>
<tr><td rowspan="2">Embedded LDC A</td><td rowspan="2">80</td><td rowspan="2">40</td><td rowspan="2">40%</td><td rowspan="2">32</td><td>New Large Customers</td><td>16</td></tr>
<tr><td>Ratepayers</td><td>16</td></tr>
<tr><td rowspan="2">Embedded LDC B</td><td rowspan="2">30</td><td rowspan="2">15</td><td rowspan="2">10%</td><td rowspan="2">8</td><td>New Large Customers</td><td>2</td></tr>
<tr><td>Ratepayers</td><td>6</td></tr>
<tr><td>TOTAL</td><td>200</td><td>100</td><td>100%</td><td>80</td><td colspan="2"></td></tr>
</table>

TABLE SHOWING PROPOSED CONSTRUCTION AND IN-SERVICE SCHEDULE

TASK	START	FINISH
Submit Section 92		January 2014
Projected Section 92 Approval	January 2014	June 2014
Prepare and Sign CCRA	June 2014	May 2015
Detailed Engineering	May 2015	March 2016
Property Rights Acquisition	February 2015	September 2015
Tender & Award Major Long Lead Materials	June 2015	February 2016
Receive Major Long Lead Materials	February 2016	July 2016
Construction	September 2015	February 2017
Commissioning	November 2016	March 2017
In Service		**March 2017**

OTHER MATTERS / AGREEMENTS / APPROVALS

1.0 SYSTEM IMPACT ASSESSMENT ("SIA")

Under the Market Rules, any party planning to construct a new or modified connection to the IESO-controlled grid must request an IESO SIA of these facilities. The IESO draft SIA for the SECTR Project is filed as **Exhibit B, Tab 6, Schedule 3**. The assessment concludes that the proposed connection of the project is expected to have no material adverse impact on the reliability of the integrated power system and that the Project improves the supply capacity needs of the Windsor area.

The IESO assessment addresses the impact of the proposed facilities on system operating voltage, system operating flexibility, and on the ability of other connections to deliver or withdraw power supply from the IESO-controlled grid.

2.0 CUSTOMER IMPACT ASSESSMENT ("CIA")

The Hydro One CIA, in accordance with its customer connection procedures, is filed as **Exhibit B, Tab 6, Schedule 4**. The CIA indicates that this transmission reinforcement will not materially affect short-circuit levels at customer transmission connection points and it will have no material adverse reliability impact on existing customers in the area.

3.0 STAKEHOLDER AND COMMUNITY CONSULTATION

Hydro One conducted stakeholder and community consultation to provide information about the project and give people opportunities to ask questions and provide feedback. The government ministries, agencies, municipal staff and elected officials, and residents in a defined study area were consulted through personal contact, e-mail or direct mailing, newspaper notices, the establishment of a project website (http://www.HydroOne.com/Projects/SupplyEssex/Pages/EssexCounty.aspx) and Public Information Centres ("**PICs**"). The feedback received through the consultation process regarding potential construction effects on the natural environment, agriculture, and the neighbouring property owners was considered and incorporated as appropriate. The details of Hydro One's stakeholder consultation process are described in **Exhibit B, Tab 6, Schedule 5**.

Hydro One carried out a parallel engagement process with neighbouring First Nations and Métis communities as described in **Exhibit B, Tab 6, Schedule 6**.

4.0 ENVIRONMENTAL ASSESSMENT

The proposed Supply to Essex County Transmission Reinforcement ("**SECTR**") Project falls within the definition of the projects covered under the Hydro One (1992) "*Class Environmental Assessment for Minor Transmission Facilities*" ("**Class EA**"), which is approved under the *Environmental Assessment Act* ("**EA Act**") by the Ministry of the Environment ("**MOE**").

The Class EA process that was completed for this Project included:

- Collection of environmental and socio-economic features within the study area;
- Identification of any environmental effects of the proposed transmission facilities and the corresponding mitigation measures;
- Consultation with the public and stakeholders (e.g. federal and provincial ministries, municipal officials and property owners) to further identify issues and concerns with the project and to address those concerns through mitigation; and
- Engagement with First Nations communities.

Between the official Notice of Commencement of the project in 2008 and the Notice of Completion of the draft ESR in 2010, Hydro One conducted comprehensive public and government agency consultation to inform stakeholders about the SECTR Project as well as identify and resolve potential concerns (see **Exhibit B, Tab 6, Schedule 5** for further information on Stakeholder and Community Consultation). Engagement with First Nations communities to respond to and consider their issues and concerns was also undertaken during this time and as mentioned earlier is further discussed at **Exhibit B, Tab 6, Schedule 6**.

A draft Environmental Study Report (**"ESR"**) was made available for public review and comment for approximately 30 calendar days starting February 11 and ending March 12, 2010.

Agency and public comment letters received during this period were addressed and documented in the final ESR as required by the Class EA process. Two Part II Order requests for a higher level of assessment, i.e. Individual Environmental Assessment were received. Both requests were based on the assumption that the Project would contribute to or service future developments of industrial wind farms in Essex County or anywhere within the Great Lakes Basin and its watershed. In letters dated May 18, 2010, the Minister of the Environment responded to the individuals stating that the purpose of the Project is to satisfy the increasing electricity demand and facilitate the connection of new customers who use electricity in the vicinity. He noted that electrical generation projects, including industrial wind farms, are planned and developed by third party companies and are not within the scope of this Class EA and that a separate approval process exists for these projects.

Comments and issues raised during the review period along with the requests for an Individual EA were documented in the final ESR which was filed with the MOE on July 22, 2010. Through filing the final ESR, Hydro One has complied with the *EA Act* for the

SECTR Project. There is no expiration for the Class EA although there is an amendment process that may include public participation if there is a change in the project. Prior to construction, Hydro One will seek all regulatory approvals, licences and permits as required.

5.0 COMPLIANCE WITH INDUSTRY STANDARDS AND CODES

The proposed facilities will be constructed, owned and operated by Hydro One. The design and maintenance of these facilities will be in accordance with good utility practice, as established in the *Transmission System Code*.

6.0 LAND MATTERS

The proposed line will connect the future Leamington Transformer Station ("**TS**") and tower structure 225 (Leamington Junction) to the Chatham Switching Station and Keith TS corridor. Details on land requirements, existing and required land rights, and the process for acquiring the required land rights is provided in **Exhibit B, Tab 6, Schedule 7.**

7.0 OTHER APPROVAL REQUIREMENTS

Hydro One will address all federal, provincial and municipal requirements of the construction process, including:

- Environmental Compliance Approval for noise from the Ministry of Environment under the *Environmental Protection Act;*
- Environmental Compliance Approval for drainage from the Ministry of Environment under the *Environmental Protection Act;*
- Agreements for pipeline crossings from Union Gas;
- Fisheries Act and Endangered Species Act requirements;

- A building permit from the Municipality of Leamington;
- Stage 2 Archaeological Assessment for the station site and the line; and
- Entrance permits from the Municipality of Leamington and Township of Lakeshore.

Hydro One will also voluntarily comply with Municipal Site Development Plan requirements and municipal noise bylaws.

IESO'S SYSTEM IMPACT ASSESSMENT

REPORT

Power to Ontario.
On Demand.

System Impact Assessment Report

CONNECTION ASSESSMENT & APPROVAL PROCESS

Second Draft

CAA ID: **2013-507**

Project: **Leamington TS - Supply to Essex County Transmission Reinforcement Project**

Applicant: **Hydro One Networks Inc.**

Market Facilitation Department
Independent Electricity System Operator

Date: May 9, 2014

Document Name	System Impact Assessment Report
Issue	Second Draft
Reason for Issue	Draft
Effective Date	May 9, 2014

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System Impact Assessment Report

Acknowledgement

The IESO wishes to acknowledge the assistance of Hydro One in completing this assessment.

Disclaimers

IESO

This report has been prepared solely for the purpose of assessing whether the connection applicant's proposed connection with the IESO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether the IESO should issue a notice of conditional approval or disapproval of the proposed connection under Chapter 4, section 6 of the Market Rules.

Conditional approval of the proposed connection is based on information provided to the IESO by the connection applicant and Hydro One at the time the assessment was carried out. The IESO assumes no responsibility for the accuracy or completeness of such information, including the results of studies carried out by Hydro One at the request of the IESO. Furthermore, the conditional approval is subject to further consideration due to changes to this information, or to additional information that may become available after the conditional approval has been granted.

If the connection applicant has engaged a consultant to perform connection assessment studies, the connection applicant acknowledges that the IESO will be relying on such studies in conducting its assessment and that the IESO assumes no responsibility for the accuracy or completeness of such studies including, without limitation, any changes to IESO base case models made by the consultant. The IESO reserves the right to repeat any or all connection studies performed by the consultant if necessary to meet IESO requirements.

Conditional approval of the proposed connection means that there are no significant reliability issues or concerns that would prevent connection of the proposed project to the IESO-controlled grid. However, the conditional approval does not ensure that a project will meet all connection requirements. In addition, further issues or concerns may be identified by the transmitter(s) during the detailed design phase that may require changes to equipment characteristics and/or configuration to ensure compliance with physical or equipment limitations, or with the Transmission System Code, before connection can be made.

This report has not been prepared for any other purpose and should not be used or relied upon by any person for another purpose. This report has been prepared solely for use by the connection applicant and the IESO in accordance with Chapter 4, section 6 of the Market Rules. The IESO assumes no responsibility to any third party for any use, which it makes of this report. Any liability which the IESO may have to the connection applicant in respect of this report is governed by Chapter 1, section 13 of the Market Rules. In the event that the IESO provides a draft of this report to the connection applicant, the connection applicant must be aware that the IESO may revise drafts of this report at any time in its sole discretion without notice to the connection applicant. Although the IESO will use its best efforts to advise you of any such changes, it is the responsibility of the connection applicant to ensure that the most recent version of this report is being used.

Hydro One

The results reported in this report are based on the information available to Hydro One, at the time of the study, suitable for a System Impact Assessment of this connection proposal.

The short circuit and thermal loading levels have been computed based on the information available at the time of the study. These levels may be higher or lower if the connection information changes as a result of, but not limited to, subsequent design modifications or when more accurate test measurement data is available.

This study does not assess the short circuit or thermal loading impact of the proposed facilities on load and generation customers.

In this report, short circuit adequacy is assessed only for Hydro One circuit breakers. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One circuit breakers and identifying upgrades required to incorporate the proposed facilities. These results should not be used in the design and engineering of any new or existing facilities. The necessary data will be provided by Hydro One and discussed with any connection applicant upon request.

The ampacity ratings of Hydro One facilities are established based on assumptions used in Hydro One for power system planning studies. The actual ampacity ratings during operations may be determined in real-time and are based on actual system conditions, including ambient temperature, wind speed and project loading, and may be higher or lower than those stated in this study.

The additional facilities or upgrades which are required to incorporate the proposed facilities have been identified to the extent permitted by a System Impact Assessment under the current IESO Connection Assessment and Approval process. Additional project studies may be necessary to confirm constructability and the time required for construction. Further studies at more advanced stages of the project development may identify additional facilities that need to be provided or that require upgrading.

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Executive Summary

Conditional Approval for Connection

Hydro One Networks Inc. (the "connection applicant") has proposed to develop Leamington TS – Supply to Essex County Transmission Reinforcement Project (the "project"), in Leamington, Ontario. The project will consist of two 75/100/125 MVA, 215.5/27.6/27.6 kV transformers connecting to 230 kV circuits C21J and C22J via a 13 km 230 kV double circuit overhead tap line. Some of the load at Kingsville TS, which is connected to 115 kV circuits K2Z and K6Z, will be transferred to the project. Hydro One is considering the following two load transfer options:

A. Retain four transformers with 124 MW of load at Kingsville TS and transfer the remaining Kingsville load to the project.
B. Retain two transformers with 54 MW of load at Kingsville TS and transfer the remaining Kingsville load to the project.

The planned in-service date of the project is May 2016.

This assessment concludes that the proposed project, subject to the requirements specified in this report, is expected to have no material adverse impact on the reliability of the integrated power system. Therefore, the IESO recommends that a Notification of Conditional Approval for Connection be issued for Leamington TS – Supply to Essex County Transmission Reinforcement Project subject to the implementation of the requirements outlined in this report.

Findings and Recommendations

Findings

The Project:

1. The project improves the supply capacity needs of the Windsor area.
2. The proposed connection arrangement and equipment for the project are acceptable to the IESO. The proposed 230 kV connection equipment meet the requirements and standards in the Market Rules and Transmission System Code (TSC).
3. Under certain outage conditions, there is a potential for reverse power flow on the project's transformers. This is not a concern for the IESO. See recommendation 2 for Hydro One.

Kingsville Load Transfer Options:

The two load transfer options, A & B, from Kingsville TS to the project were compared for their impact on the Windsor 230 kV and 115 kV systems under 2026 summer peak load conditions. The following findings were identified based on the study results:

4. With option B for loss of K2Z, post-contingency loading on circuit K6Z and 115 kV voltages at Kingsville TS are within the *Ontario Resource and Transmission Assessment Criteria (ORTAC)* without the need of any control action.

With option A for loss of K2Z, post-contingency loading above the short term emergency rating (STE) on circuit K6Z and low 115 kV voltages at Kingsville TS will occur. Arming the Lauzon load rejection (L/R) scheme as part of the Windsor Area Special Protection Scheme (SPS) to reject load at Kingsville will mitigate these issues. However, this control action is a violation of the *ORTAC* criteria. Hence, option B is better than option A.

With two transformers retained at Kingsville in option B, for loss of one transformer, post-contingency loading above the 10-day long term rating (LTR) will occur on the remaining transformer with the more limiting rating. Should option B be retained, Hydro One has indicated that they have plans to replace this transformer with a new transformer that has a higher 10-day LTR.

5. With option A or B and high flows east or west between Keith TS and Chatham SS, which represent past historical maximum transfers, post-contingency thermal loadings and voltages in the Windsor 230 and 115 kV systems remain within applicable *ORTAC* criteria with the utilization of appropriate control actions. With option B, the post-contingency loadings are lower and less control actions are required. Hence, option B is better than option A.
6. With option A or B and high flows east or west between Keith TS and Chatham SS, the incorporation of the project is not expected to have adverse impact on import/export capability via circuit J5D.
7. With option A or B, the load restoration capability of the Windsor 115 kV system is improved following the simultaneous loss of double circuits C23Z and C24Z. Option B is better, as it allows all forecasted load that is lost following this contingency to be restored.
8. With option B, the simultaneous loss of double circuits C21J and C22J will interrupt load at Malden TS and the project of up to 237 MW for the 2016-2026 period which is within the *ORTAC* criteria.

Findings 9 and 10 below were observed when respecting the North American Electric Reliability Corporation (NERC) TPL-001-04 Bulk Electric System (BES) Planning Performance Events based on NERC's new definition of the BES effective in Ontario July 1, 2014.

9. With options A or B, high flows east from Keith TS to Chatham SS and all elements in-service, for a Lauzon T1L7 breaker failure, multiple control actions are needed to mitigate post-contingency thermal loadings in the Windsor 115 kV system, as this contingency is not included in the Lauzon L/R scheme which is part of the Windsor Area SPS.
10. With options A or B, high flows east or west between Keith TS and Chatham SS and all elements in-service, for the loss of double circuit Z1E and Z7E, control actions were taken to mitigate post-contingency over-voltages on the Lauzon 115 kV system. With option A, the Lauzon L/R scheme as part of the Windsor Area SPS was armed to switch out the Kingsville capacitors. However, switching out the Lauzon capacitor post-contingency would be a better control action. With option B, the Lauzon capacitor was switched out-service pre-contingency as there were no control actions available post-contingency. This resulted in lower voltages on the Lauzon 230 kV and 115 kV systems compared to option A.

Recommendations

1. It is recommended that Hydro One choose Kingsville load transfer option B rather than option A. Option A is however, an improvement compared to keeping all of the load at Kingsville.
2. It is recommended that Hydro One assess the reverse power flow on the project's transformers and confirm that there is no unacceptable tripping or loading concern on the transformers.

Recommendations 3 and 4 below are required for respecting the NERC TPL-001-04 BES Planning Performance Events based on NERC's new definition of the BES effective in Ontario July 1, 2014.

3. It is recommended that Hydro One consider expanding the Lauzon L/R scheme as part of the Windsor Area SPS to include the Lauzon T1L7 breaker failure which is a NERC TPL-001-04 BES Planning Performance Event so that load rejection (L/R) can be armed for this contingency. This would provide greater operating flexibility.
4. It is recommended that Hydro One consider adding the selection of the Lauzon capacitor to be tripped for the Z1E+Z7E contingency which is a contingency that is already included in the Lauzon L/R scheme as part of the Windsor Area SPS. This would provide greater operating flexibility.

IESO's Requirements for Connection

<u>Connection Applicant Requirements</u>

Project Specific Requirements: The following *specific* requirements are applicable for the incorporation of the project. Specific requirements pertain to the level of reactive compensation needed, operation restrictions, special protection system, upgrading of equipment and any project specific items not covered in the *general* requirements.

(1) Hydro One is required to review the relay settings of the 230 kV circuits C21J and C22J. Any modifications made to protections after this SIA is finalized must be submitted to the IESO at least six (6) months before any modifications are to be implemented on the existing protection systems.

(2) The simultaneous loss of double circuits C21J and C22J will interrupt load at Malden TS and the project of up to 237 MW for the 2016 to 2026 period which is within the *ORTAC* criteria. Hydro One and the affected Local Distribution Companies (LDCs) are expected to work together to ensure that up to 87 MW of load can be restored within approximately 4 hours and up to 237 MW of load can be restored within approximately 8 hours as per the *ORTAC* criteria.

General Requirements: The connection applicant shall satisfy all applicable requirements and standards specified in the Market Rules and the TSC. The following requirements summarize some of the general requirements that are applicable to the project, and are presented in detail in section 2 of this report.

1. As currently assessed the project does not fall within the Northeast Power Coordinating Council's (NPCC) definition of Bulk Power System (BPS). As such, the project will not have any elements classified as BPS and will not have to meet any NPCC reliability obligations.
2. NERC's new definition of the BES will be effective in Ontario July 1, 2014. As currently assessed, based on this new definition, the project will not have any elements classified as BES and will not have to meet any NERC reliability obligations.
3. The project is required to meet obligations and requirements of the Market Rules.
4. The connection applicant shall ensure that the project's 230 kV connection equipment is capable of continuously operating between 220 kV and 250 kV, as specified in Appendix 4.1 of the Market Rules. Any protective relay settings must be set to ensure that equipment remains in-service for voltages up to 5% above the maximum continuous value.
5. The connection applicant shall ensure that the project's 230 kV connection equipment is designed to be fully operational in all reasonably foreseeable ambient temperature conditions. The connection equipment must also be designed so that the adverse effects of its failure on the IESO-controlled grid are mitigated.

6. The connection applicant shall ensure that the project's 230 kV connection equipment is designed to withstand the fault levels in the local area. If any future system changes result in an increased fault level higher than the equipment's capability, the connection applicant is required to replace the equipment with higher rated equipment capable of withstanding the increased fault level, up to maximum fault level specified in Appendix 2 of the TSC.
7. The connection applicant shall install and maintain facilities and equipment at the project to provide 3% and 5% voltage reduction within five minutes of receipt of direction from the IESO.
8. The connection applicant shall have the capability to maintain the power factor at the defined meter point of the project within the range of 0.9 lagging and 0.9 leading.
9. The connection applicant is required to install under frequency load shedding (UFLS) facilities at the project to allow for the detection of under-frequency conditions and the selection and tripping of load via circuit breakers.

   The connection applicant is required to ensure that the UFLS targets specified in Section 10.4.6 of Chapter 5 of the Market Rules and Section 4.5 of Market Manual 7.4 are met after the addition of the proposed project. During the IESO Market Entry/Facility Registration process, the connection applicant is required to submit a revised schedule of under-frequency tripping selections and their related load amounts for each applicable shedding stage that will satisfy the UFLS targets.
10. The connection applicant shall ensure that the telemetry requirements for the project are satisfied as per the applicable Market Rules requirements. The determination of telemetry quantities and telemetry testing will be conducted during the IESO Market Entry/Facility Registration process.
11. If revenue metering equipment is being installed as part of this project, the connection applicant should be aware that revenue metering installations must comply with Chapter 6 of the IESO Market Rules. For more details the connection applicant is encouraged to seek advice from their Metering Service Provider (MSP) or from the IESO metering group.
12. The connection applicant shall ensure that the project's protection systems are designed to satisfy all the requirements of the TSC.

    As currently assessed by the IESO, the project is not considered essential to the power system and therefore does not require redundant protection systems in accordance with section 8.2.1a of the TSC.

    The project's protection systems must also only trip the appropriate equipment required to isolate the fault. The project shall have the capability to ride through routine switching events and design criteria contingencies in the grid that do not disconnect the project by configuration.

    The connection applicant shall have adequate provision in the project's design of protections and controls to allow for future installation of Special Protection Scheme (SPS) equipment. Should a new SPS be installed or an existing SPS be expanded to improve the transfer capability into the area or to accommodate transmission reinforcement projects, the facility may be required to participate in the SPS system and to install the necessary protection and control facilities to affect the required actions. These SPS facilities must comply with the NPCC Reliability Reference Directory #7 for Type 1 SPS.
13. The connection applicant is currently a restoration participant. The connection applicant is required to update its restoration participant attachment to include details regarding the project. For more details please refer to the Market Manual 7.8. Details regarding restoration participant requirements will be finalized in the IESO Market Entry/Facility Registration process.
14. The connection applicant must initiate and complete the IESO Market Entry/Facility Registration process for this project in a timely manner before IESO final approval for connection is granted.

    Equipment data must be provided to the IESO at least seven months before energization to the IESO-controlled grid. The IESO will confirm that the data for the equipment installed meets the Market Rules requirements and matches or exceeds the performance predicted in this assessment.

If the submitted data differs materially from the ones used in this assessment, then further analysis of the project will need to be done by the IESO.

At the sole discretion of the IESO, performance tests may be required at transmission facilities. The objectives of these tests are to demonstrate that equipment performance meets the IESO requirements, and to confirm models and data are suitable for IESO purposes.

– End of Section –

1. Project Description

Hydro One Networks Inc. (the “connection applicant”) has proposed to develop Leamington TS – Supply to Essex County Transmission Reinforcement Project (the “project”), in Leamington, Ontario. This new transformer station will connect to 230 kV circuits C21J and C22J at about 49.1 km from Chatham SS via a 13 km double circuit 230 kV overhead tap line. Some of the load at Kingsville TS, connected to 115 kV circuits K2Z and K6Z, will be transferred to the project. Hydro One is considering the following two load transfer options:

A. Retain four transformers with 124 MW of load at Kingsville TS and transfer the remaining Kingsville load to the project.
B. Retain two transformers with 54 MW of load at Kingsville TS and transfer the remaining Kingsville load to the project.

Figure 1 shows the single-line diagram of the proposed project. The station will consist of two 75/100/125 MVA, 215.5/27.6/27.6 kV transformers each with a 230 kV disconnect switch on the high voltage side of the transformer. The 27.6 kV buses will be separated by a normally open bus-tie breaker and a shunt capacitor bank rated at 21.6 Mvar@28.8 kV will be installed on one of the 27.6 kV buses. The load will be fed from a total of six feeders. The planned in-service date is May 31, 2016.

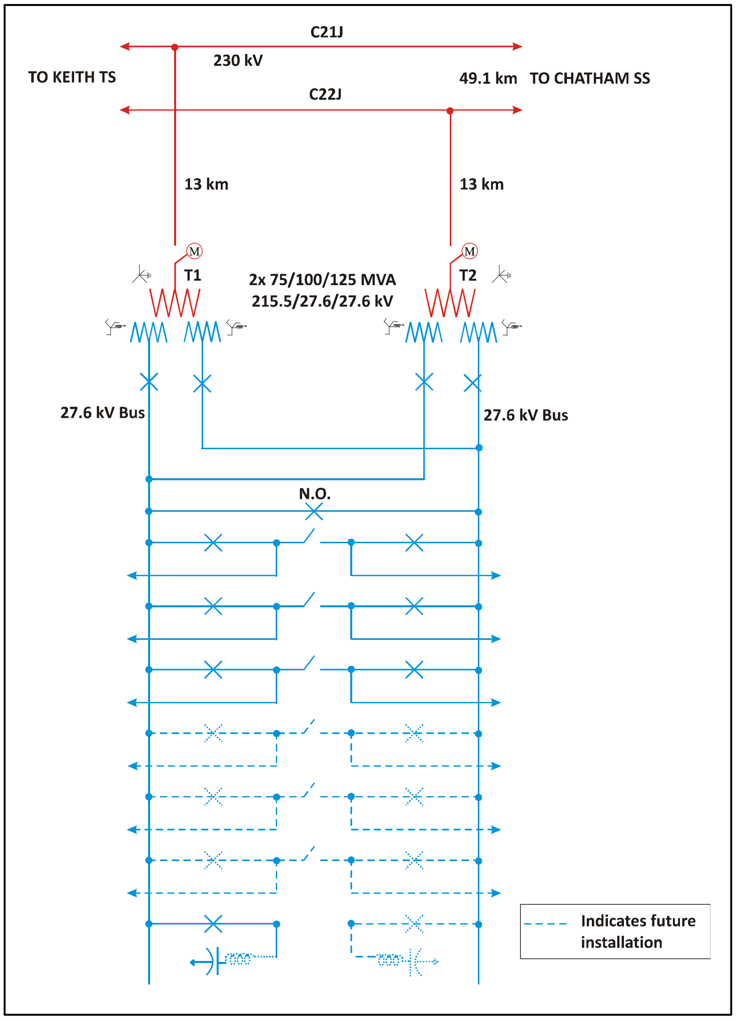

Figure 1: Single Line Diagram of Leamington TS

– End of Section –

2. General Requirements

The connection applicant shall satisfy all applicable requirements and standards specified in the Market Rules and the TSC. The following sections highlight some of the general requirements that are applicable to the project.

2.1 Reliability Standards

As currently assessed the project does not fall within the NPCC definition of BPS. As such, the project will not have any elements classified as BPS and will not have to meet any NPCC reliability obligations.

NERC‘s new definition of the BES will be effective in Ontario July 1, 2014. As currently assessed, based on this new definition, the project will not have any elements classified as BES and will not have to meet any NERC reliability obligations.

The project is required to meet obligations and requirements of the Market Rules. The project’s BPS and BES classifications will be re-evaluated by the IESO as the electrical system evolves.

2.2 Voltage Requirements

Appendix 4.1 of the Market Rules states that under normal operating conditions, the voltages in the 230 kV system in IESO-controlled grid are maintained within the range of 220 kV to 250 kV. Thus, the project’s 230 kV connection equipment must have a maximum continuous voltage rating of at least 250 kV.

Any protective relay settings must be set to ensure that connection equipment remains in-service for voltages up to 5% above the maximum continuous value specified in Appendix 4.1 of the Market Rules, to allow the power system to recover from transient disturbances.

2.3 Connection Equipment Design

The connection applicant shall ensure that the project’s 230 kV connection equipment is designed to be fully operational in all reasonably foreseeable ambient temperature conditions. The connection equipment must also be designed so that the adverse effects of its failure on the IESO-controlled grid are mitigated.

2.4 Fault Levels

The TSC requires connection equipment connecting to the transmission system be designed to withstand the fault levels in the area where the equipment is installed. Thus, the connection applicant shall ensure that the project’s connection equipment is designed to withstand the fault levels in the area. If any future system changes result in an increased fault level higher than the equipment’s capability, the connection applicant is required to replace the equipment with higher rated equipment capable of withstanding the increased fault level, up to maximum fault level specified in the TSC. Appendix 2 of the TSC establishes the maximum fault levels for the transmission system.

For the 230 kV system, the maximum 3 phase symmetrical fault level is 63 kA and the maximum single line to ground symmetrical fault level is 80 kA (usually limited to 63 kA).

2.5 Voltage Reduction Facilities

Appendix 4.3 of the Market Rules requires that distributors connected to the IESO-controlled grid with directly connected load facilities of aggregated rating of 20 MVA or more and with the capability to regulate distribution voltage under load, shall install and maintain facilities and equipment to provide voltage reduction capability. Voltage reduction capability represents the capability of reducing demand by lowering the customer voltage by 3% and 5% within five minutes of receipt of direction from the IESO. This is required to achieve load reduction during periods when supply resources are limited. The voltage reduction capability can be achieved by installing under-load tap changers (ULTC) at the project.

2.6 Power Factor

Appendix 4.3 of the Market Rules requires connected wholesale customers and distributors connected to the IESO-controlled grid to have the capability to maintain the power factor within the range of 0.9 lagging and 0.9 leading as measured at the defined meter point of the project.

2.7 Under Frequency Load Shedding Facilities

The connection applicant has an aggregate peak load at all its owned facilities, including the proposed project that is greater than 25 MW. Thus, the connection applicant is required to participate in the UFLS program according to Section 4.5 of the Market Manual Part 7.4.

The connection applicant is required to install UFLS facilities at the proposed project to allow for the detection of under-frequency conditions and the selection and tripping of load via circuit breakers.

The connection applicant must select 35% of aggregate peak load among its owned facilities for under-frequency tripping, based on a date and time specified by the IESO that approximates system peak, according to section 10.4 of Chapter 5 of the Market Rules.

As the connection applicant has a peak load of 100 MW or greater at all its owned facilities, the UFLS relay connected loads shall be set to achieve the amounts to be shed stated in the following table:

UFLS Stage	Frequency Threshold (Hz)	Total Nominal Operating Time (s)	Load Shed at stage as % of Connection Applicant's Load	Cumulative Load Shed at stage as % of Connection Applicant's Load
1	59.5	0.3	7 – 9	7 – 9
2	59.3	0.3	7 – 9	15 – 17
3	59.1	0.3	7 – 9	23 – 25
4	58.9	0.3	7 - 9	32 - 34
Anti-Stall	59.5	10.0	3 – 4	35 - 37

The requirements in the table above are currently under review. The IESO will notify the connection applicant of any impending changes to which the connection applicant will have to comply.

Capacitor banks connected to the same facility as the load should be shed by UFLS relay at 59.5 Hz with a time delay of 3 seconds.

The maximum load that can be connected to any single UFLS relay is 150 MW to ensure that the inadvertent operation of a single under-frequency relay during the transient period following a system disturbance does not lead to further system instability.

2.8 IESO Telemetry Data

In accordance with Section 7.5 of Chapter 4 of the Market Rules, the connection applicant shall provide to the IESO the applicable telemetry data for the project as listed in Appendix 4.17 of the Market Rules on a continual basis. The data shall be provided in accordance with the performance standards set forth in Appendix 4.22, subject to Section 7.6A of Chapter 4 of the Market Rules. The whole telemetry list will be finalized during the IESO Market Entry/Facility Registration process.

The connection applicant must install monitoring equipment that meets the requirements set forth in Appendix 2.2 of Chapter 2 of the Market rules. As part of the IESO Market Entry/Facility Registration process, the connection applicant must also complete end to end testing of all necessary telemetry points with the IESO to ensure that standards are met and that sign conventions are understood. All found anomalies must be corrected before IESO final approval to connect any phase of the project is granted.

2.9 Revenue Metering

If revenue metering equipment is being installed as part of the project, the connection applicant should be aware that revenue metering installations must comply with Chapter 6 of the IESO Market Rules. For more details the connection applicant is encouraged to seek advice from their Metering Service Provider (MSP) or from the IESO metering group.

2.10 Protection Systems

The connection applicant shall ensure that the project's protection systems are designed to satisfy all the requirements of the TSC. New protection systems must be coordinated with the existing protection systems.

As currently assessed by the IESO, the project is not considered essential to the power system and therefore does not require redundant protection systems in accordance with section 8.2.1a of the TSC. In the future, as the electrical system evolves, the project may be designated as essential by the IESO. In that case these redundant protections systems would have to satisfy all requirements of the TSC, and in particular, they could not use common components, common battery banks or common secondary CT or PT windings.

The project's protection systems must only trip the appropriate equipment required to isolate the fault. After the facility begins commercial operation, if an improper trip of the 230 kV circuit(s) C21J and C22J occurs due to events within the facility, the facility may be required to be disconnected from the IESO-controlled grid until the problem is resolved.

The project shall have the capability to ride through routine switching events and design criteria contingencies in the grid that do not disconnect the project by configuration. Standard fault detection, auxiliary relaying, communication, and rated breaker interrupting times are to be assumed.

As currently assessed by the IESO, the project is not required to be part of an SPS. However, the connection applicant is required to have adequate provision in the design of protections and controls at the facility to allow for future installation of Special Protection Scheme (SPS) equipment. Should a future SPS be installed or an existing SPS be expanded to improve the transfer capability in the area or to accommodate transmission reinforcement projects, the facility may be required to participate in the SPS system and to install the necessary protection and control facilities to affect the required actions. These SPS facilities must comply with the NPCC Reliability Reference Directory #7 for Type 1 SPS. In particular, if the SPS is designed to have ‘A’ and ‘B’ protection at a single location for redundancy, they must be on different non-adjacent vertical mounting assemblies or enclosures. Two independent trip coils are required on the breakers selected for L/R.

2.11 Restoration Requirements

The connection applicant is currently a restoration participant. The connection applicant is required to update its restoration participant attachment to include details regarding the project. For more details please refer to the Market Manual 7.8. Details regarding restoration participant requirements will be finalized in the IESO Market Entry/Facility Registration process.

As currently assessed by the IESO, this facility is not classified as a Key Facility that is required to establish a Basic Minimum Power System following a system blackout. Key Facility and Basic Minimum Power System are terms defined in the NPCC Glossary of Terms.

2.12 IESO Market Entry/Facility Registration

The connection applicant must initiate and complete the IESO Market Entry/Facility Registration process for the project in a timely manner before IESO final approval for connection is granted.

Equipment data must be provided to the IESO at least seven months before energization to the IESO-controlled grid, to allow the IESO to incorporate this project into IESO work systems and to perform any additional reliability studies. The data may be shared with other reliability entities in North America as needed to fulfill the IESO’s obligations under the Market Rules, NPCC and NERC rules.

The IESO will confirm that the data for the equipment installed meets the Market Rules requirements and matches or exceeds the performance predicted in this assessment. If the submitted data differs materially from the ones used in this assessment, then further analysis of the project will need to be done by the IESO.

At the sole discretion of the IESO, performance tests may be required at transmission facilities. The objectives of these tests are to demonstrate that equipment performance meets the IESO requirements, and to confirm models and data are suitable for IESO purposes

– End of Section –

3. Data Verification

3.1 Connection Arrangement

The connection arrangement of the project, as shown in Figure 1, will not reduce the level of reliability of the integrated power system and is, therefore, acceptable to the IESO.

3.2 Equipment Data

The connection equipment specifications were assessed based on the information provided by the connection applicant.

3.2.1 Tap Line

Table 1: 230 kV Overhead Tap Line

Length (km)	Maximum Operating (kV)	Summer Ratings (A) 35ºC 4 km/h			Positive Sequence Impedance (pu, S_B= 100 MVA, V_B=220 kV)		
		Cont	LTE	STE	R	X	B
13	250	1060	1400	1900	0.002168	0.01332	0.021006

3.2.2 230 kV Disconnect Switch

Table 2: Specifications of the 230 kV Disconnect Switch

Number to be installed	Maximum Continuous Voltage Rating (kV)	Continuous Current Rating (A)	Short Circuit Symmetrical Rating (kA)
2	250	To be provided by Hydro One	63

The 230 kV disconnect switch has a maximum continuous voltage rating of 250 kV and a short circuit symmetrical rating of 63 kA which meet the requirements and standards in the Market Rules and TSC.

3.2.3 230 kV Transformer

Table 3: Specifications of the 230 kV Transformer

Unit	Transformation (kV)	Rating (MVA) (ONAN/ONAF/OFAF)	Positive Sequence Impedance (pu) S_B= 62.5 MVA	Configuration			High Voltage ULTC Tap Changer
				H	L	T	
T1/T2	215.5/27.6-27.6	75/100/125	HT: 0.00487+j0.17867 HL: 0.00489+j0.17750 LT: 0.0199+j0.32559	Yg	Zig-zag Grounded through 1.5 ohm reactor	Zig-zag Grounded through 1.5 ohm reactor	215.5 ± 40 kV in ± 16 steps

3.2.4 Shunt Capacitor

Table 4: Specifications of the 27.6 kV Shunt Capacitor

Rated Capacitance at Rated Voltage (Mvar)	Rated Voltage (kV)	Nominal System Voltage (kV)
21.6	28.8	27.6

– End of Section –

4. Fault Level Assessment

As the LV winding of the transformers is configured Zigzag and there is no major synchronous motor load to be supplied, the project will not change the fault levels in its surrounding area for both 3-phase and L-G faults. Thus, short circuits studies were not conducted.

– End of Section –

5. Protection Impact Assessment

A Protection Impact Assessment (PIA) was completed by Hydro One to examine the impact of the project on existing transmission system protections. A copy of the Protection Impact Assessment can be found in Appendix C of this report.

No changes to the existing protection settings at Keith TS and Chatham SS are required due to the incorporation of the project as the increase in apparent impedance is negligible. The existing zone 1 protection settings at Keith TS will cover the whole 13 km overhead line tap that connects the facility to the IESO-controlled grid. The existing zone 2 protection settings at Chatham SS and Keith TS will reach into a portion of the transformers at the facility.

The incorporation of the project will require installation of new communication links and modifications to the existing C21J and C22J protection systems at Keith TS and Chatham SS. Dual communication links between the project and one of Keith TS or Chatham SS are required to send transfer trip signals

The proposed protection changes will have no material adverse impact on reliability of the IESO-controlled grid.

Hydro One must submit any protection modifications that are different from those considered in this SIA at least six (6) months before any modifications are to be implemented on the existing protection systems. If those modifications result in adverse reliability impacts, mitigation solutions must be developed.

– End of Section –

6. Impact on System Reliability

The technical studies focused on identifying the impact of the project on the reliability of the IESO-controlled grid. They include a thermal loading assessment of local transmission lines and transformers and a voltage assessment of local buses under specific flow conditions.

6.1 Existing System

The Windsor area is bounded by 230 kV circuits C23Z and C24Z from Chatham to Lauzon, C21J and C22J from Chatham to Keith and J5D from Keith to Michigan. There are three wind generating stations Comber West and East connected to C23Z and C24Z respectively, Port Alma I and II connected to C24Z and Dillon connected to C23Z. The Windsor 115 kV area load is supplied from Lauzon 230/115 kV autotransformers T1 and T2, Keith 230/115 kV autotransformers T11 and T12, West Windsor GS G1 and G2, East Windsor G1 and G2, Windsor TransAlta CGS G1 and G2, Brighton Beach CGS G1A, Pointe Aux Roches WGS and Goshen WGS.

The Windsor area is summer peaking and is susceptible to a variety of operational problems including pre-contingency voltage instability, post-contingency voltage decline and thermal overload. As a result, a number of special protection schemes are employed to facilitate operation of the area which are all included as part of the Windsor Area Special Protection Scheme (SPS). This SPS includes contingency based generation rejection and cross-tripping scheme at Keith TS, a contingency based load rejection scheme at Lauzon TS, under-voltage load rejection scheme at Kingsville TS and high voltage switching scheme at Kingsville TS.

Past completed SIAs relating to new or modified connections in the Windsor area have identified thermal overload and under-voltage concerns. Thermal overloads on circuits K2Z or K6Z and under-voltages at Kingsville have been previously identified in SIA 2008-332. Thermal overloads or congestion on circuits J3E, J4E and Keith T12 have been highlighted in previous SIAs (2005-203, 2007-268, 2008-343, 2010-381, 2010-382, 2010-383, 2010-405).

Figure 2 provides an overview of the transmission system in the vicinity of the proposed project.

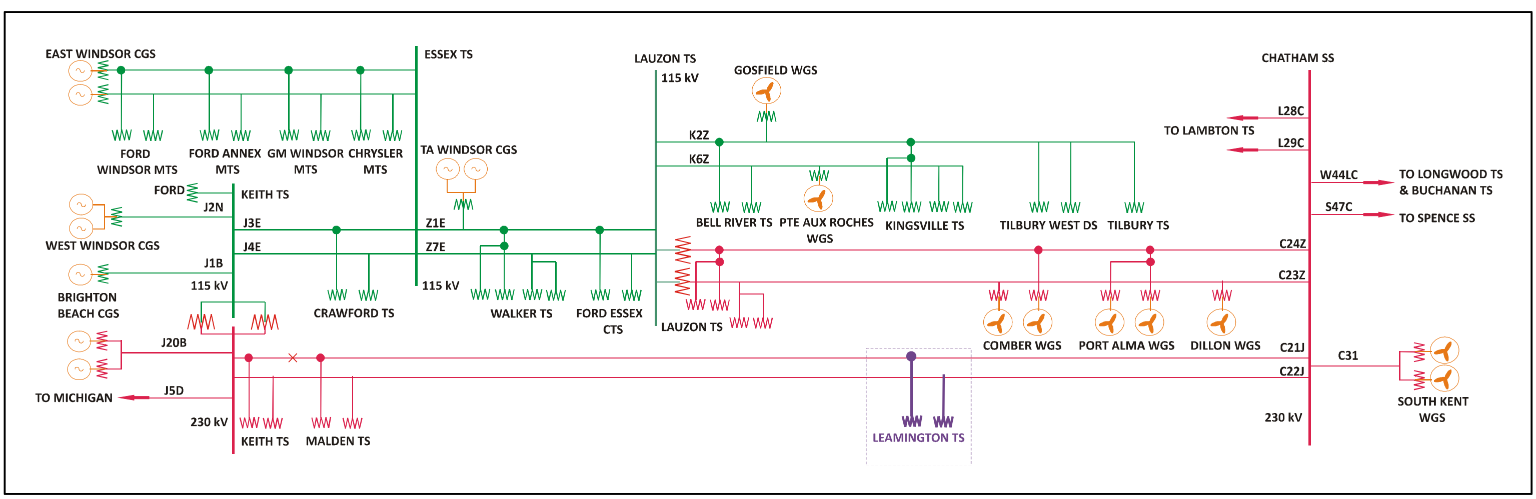

Figure 2: Transmission System in the vicinity of Leamington TS

6.2 Assumptions

In this assessment, the 2014 summer base case was used with the following assumptions:

(1) **Transmission facilities**: All existing transmission facilities and future proposed transmission system upgrades with 2016 in-service dates or earlier were assumed in-service.

Of the proposed transmission system upgrades, the following were not assumed in-service:

- Transformer Replacement at Keith TS (2007-265)
- Tilbury West DS Second 115 kV Connection (2008-332)

(2) **Generation facilities:** All existing and committed major generation facilities with 2016 in-service dates or earlier were assumed in-service unless otherwise specified.

(3) **Load Facilities:** All major load facilities with 2016 in-service dates or earlier were assumed in-service.

(4) **Load Forecast:** Hydro One provided the extreme weather coincident peak load forecast after conservation from 2016 to 2026 for the project and the stations in its vicinity in the Windsor 230 / 115 kV area. For the purposes of the study any embedded generation at these stations was assumed out of service. The load forecast for the Windsor 230/115 kV area is displayed in Table 5.

Table 5: Load Forecast for Windsor 230/115 kV area stations

Station	Load Forecast (MW)										
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Belle River TS	45.4	46.0	46.5	47.0	47.5	48.0	48.6	49.1	49.6	50.1	50.6
Chrysler MTS	32.7	32.7	32.8	32.8	32.9	32.9	33.0	33.1	33.1	33.2	33.2
Crawford TS	66.1	66.3	66.5	66.8	67.0	67.3	67.5	67.7	68.0	68.2	68.5
Essex TS	54.3	54.6	54.8	55.0	55.2	55.4	55.6	55.9	56.1	56.3	56.5
Ford Annex MTS	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
Ford Essex CTS	8.0	8.0	8.1	8.1	8.1	8.1	8.1	8.2	8.2	8.2	8.2
* Ford Windsor MTS	17.6	17.6	17.6	17.7	17.7	17.8	17.8	17.8	17.9	17.9	17.9
G.M.Windsor MTS	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Keith TS T1	5.6	5.7	5.7	5.8	5.8	5.9	6.0	6.0	6.1	6.2	6.2
Tilbury TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tilbury West DS	17.5	17.6	17.6	17.7	17.8	17.9	18.0	18.1	18.1	18.2	18.3
Walker TS #1	74.1	74.3	74.6	74.8	75.0	75.3	75.5	75.7	75.9	76.2	76.4
Walker MTS #2	86.5	86.7	87.0	87.2	87.5	87.8	88.0	88.3	88.5	88.8	89.1
Kingsville TS – Option A	124.0	124.0	124.0	124.0	124.0	124.0	124.0	124.0	124.0	124.0	124.0
Kingsville TS – Option B	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0
Leamington TS – Option A	22.5	26.9	28.4	29.9	31.5	33.0	34.6	36.2	37.8	39.4	41.0
Leamington TS – Option B	92.5	96.9	98.4	99.9	101.5	103.0	104.6	106.2	107.8	109.4	111.0
Keith TS T22/T23	44.0	44.3	44.6	45.0	45.5	46.0	46.5	47.0	47.5	48.0	48.5
Malden TS	119.0	119.7	120.5	121.2	121.9	122.6	123.3	124.1	124.8	125.5	126.2
Lauzon TS	185.3	186.2	187.1	188.0	188.9	189.8	190.7	191.6	192.4	193.3	194.2
TOTAL	911.7	919.7	924.9	930.1	935.4	940.9	946.3	951.9	957.1	962.6	967.9

* The Windsor area motor plants were assumed in full production at the time of the summer peak. Hence, the forecast at Ford Windsor MTS was assumed to be close to the 2013 historical peak load at this station as opposed to the load at the coincident peak

As seen from the load forecast, Hydro One is considering the following two load transfer options:

A. Retain four transformers with 124 MW of load at Kingsville TS and transfer the remaining Kingsville load to the project.
B. Retain two transformers with 54 MW of load at Kingsville TS and transfer the remaining Kingsville load to the project.

(5) **Load power factor:** The power factor was assumed to be 0.9 at the high-voltage buses of the project

(6) **Base cases:** Four base cases with 2026 summer peak load, under various generation dispatches and load transfer options A & B were used. The generation dispatch was chosen to stress the 230 kV circuits C21J and C22J under high flow east and west conditions. The base cases employed the following assumptions:

- The Ontario demand was assumed 27,820 MW, and the demand in the Western zone was assumed 3,001 MW based on the extreme weather summer peak load forecast available to the IESO for the year 2026;
- Load level at individual stations in the vicinity of the project were set to the forecasted load level for 2026 as shown in Table 5;
- The Windsor 115 kV area was assumed closed in this study which means that there is a continuous path between the 115 kV transmission path between Lauzon TS and Keith TS;
- The Windsor area SPS was assumed in-service;
- Under high flow east conditions, the import from Michigan on J5D and the Brighton Beach output was maximized to achieve a high flow east on the C21J and C22J circuits while not violating the continuous rating of circuits J3E and J4E pre-contingency. In addition, the rest of the generation in the Windsor 230 and 115 kV area was dispatched at full output to stress the C21J and C22J circuits flowing east.
- Under high flow west conditions, the export to Michigan on J5D was assumed to be 400 MW based on historical data. In addition, low wind was assumed with all wind generation out of service and all gas generation dispatched at full output in the Windsor 230 and 115 kV area with the exception of Brighton Beach. At Brighton Beach, one unit was assumed out of service and the other two units were dispatched in order to stress the C21J, C22J, C23Z and C24Z circuits flowing west to the maximum historical levels.
- With load transfer option B (54 MW of load at Kingsville), the Lauzon capacitor was required to be switched out of service and the Keith capacitor was switched in-service pre-contingency in order to maintain acceptable voltages pre- and post-contingency. This was done to avoid post-contingency over-voltages on the Lauzon 115 kV system for the double circuit loss of Z1E and Z7E which is a NERC TPL-001-4 Bulk Electric System Planning Performance Event as there were no control actions available post-contingency. This will be discussed further in Section 6.6.

Table 6 lists the generation dispatch, load assumption at Kingsville, 115 kV capacitor statuses and the flow on J5D, C21J and C22J for the four scenarios, S1, S2, S3 and S4,that were studied:

Table 6: Base case scenarios

Scenario	S1	S2	S3	S4
Condition	High flow east Option A	High flow east Option B	High flow west Option A	High flow west Option B
Flow on J5D (+ out of Ontario)	- 137 MW	- 137 MW	388 MW	388 MW
Flow on C21J and C22J at Chatham	-222 MW	-186 MW	494 MW	527 MW
Brighton Beach	530 MW	530 MW	186 MW	186 MW
West Windsor	116 MW	116 MW	116 MW	116 MW
TA Windsor	69 MW	69 MW	69 MW	69 MW
East Windsor	90 MW	90 MW	90 MW	90 MW
Gosfield	50 MW	50 MW	0 MW	0 MW
Pointe Aux Roches	49 MW	49 MW	0 MW	0 MW
Comber East and West	166 MW	166 MW	0 MW	0 MW
Port Alma I & II	202 MW	202 MW	0 MW	0 MW
Dillon	78 MW	78 MW	0 MW	0 MW
South Kent	269 MW	269 MW	0 MW	0 MW
Kingsville TS load in 2026	124 MW	54 MW	124 MW	54 MW
115 kV Capacitor Status	Keith Cap O/S Lauzon Cap I/S	Keith Cap I/S Lauzon Cap O/S	Keith Cap O/S Lauzon Cap I/S	Keith Cap I/S Lauzon Cap O/S

6.3 Contingencies

Contingencies were performed based on the NERC TPL-001-4 BES Planning Performance Events. All four scenarios were subjected to the same contingencies for voltage and thermal analysis.

The following is the list of all contingencies simulated for thermal and voltage analysis.

Table 7: List of Simulated Contingencies

N-1 Contingencies (All elements I/S – Single Contingencies)			
C21J /C22J	C23Z / C24Z	J5D	J20B
C31	J3E/J4E	Z1E / Z7E	J1B
J2N	Keith A Bus	K2Z	K6Z
N-2: Tower Contingencies (All elements I/S – Double Contingencies)			
C21J+C23Z	C21J+C22J	C22J+C24Z	C23Z+C24Z
J3E+J4E	Z1E+Z7E		
N-2: Breaker Failure (BF) Contingencies (All elements I/S – Double Contingencies)			
J20B + C22J- Keith 230 HL20 BF	J5D + C22J – Keith 230 HL5 BF	J20B + Keith A Bus – Keith 230 AL20 BF	J5D + Keith A Bus – Keith 230 AL5 BF
C21J + Keith A Bus - Keith 230 C21J BF	C21J + Chatham D Bus – Chatham 230 DL21 BF	C23Z + Chatham D Bus – Chatham 230 DL23 BF	C31 + Chatham D Bus – Chatham 230 DL31 BF
C22J+J2N – Keith T12P BF	J1B+J2N – Keith L1P BF	J3E+J2N – Keith L3P BF	Keith A Bus +J2N – Keith T11P BF
J4E+J1B – Keith L1L4 BF	Z7E+C23Z – Lauzon T1L7 BF	C24Z+Lauzon cap – Lauzon T2K BF	

N-1-1: Contingencies (Outage condition + contingency)			
J20B+C21J	Keith A Bus + C23Z/C24Z	Keith A Bus + C22J	Keith A Bus +J1B
Chatham K Bus + loss of Chatham D Bus	C22J open ended at Chatham + Keith C21J IBO	C21J open ended at Chatham + Keith C21J IBO	Z7E + C21J
Z7E + C24Z	J3E+C21J	J3E + C23Z/C24Z	J3E+Z7E

6.4 Permissible Control Actions

In the Windsor area, permissible control actions can be used to manage thermal or voltage concerns following the contingencies listed in Table 7. These include generation re-dispatch or curtailment of imports or exports on circuit J5D within 15 minutes following contingencies and arming of the Windsor Area SPS. Listed below are some of the control actions available with the Windsor Area SPS:-

- Kingsville transformer switching – This is part of the Kingsville high voltage switching scheme which switches back in a third transformer at Kingsville TS following the loss of two of the four transformers at Kingsville TS.
- Mode A Essex Bus Split- This is part of the Keith generation rejection and cross-tripping scheme which splits the Essex bus by opening Essex breakers L1L9, L7L8 and T6Z for contingencies included in the scheme. This split results in circuits J3E, J4E, E8F and E9F being supplied from Keith TS and circuits Z1E, Z7E and load at Essex TS being supplied from Lauzon TS.
- Brighton Beach generation rejection (BB G/R) –This is part of the Keith generation rejection and cross-tripping scheme which rejects Brighton Beach units that are armed for contingencies included in the scheme.
- Kingsville load rejection (L/R) – This is part of the Lauzon load rejection scheme which provides selection of load to be rejected at Kingsville TS in two stages for contingencies included in the scheme with each stage consisting of half the Kingsville load.
- Bell River load rejection (L/R) – This is part of the Lauzon load rejection scheme for which all the load at Bell River TS can be rejected for contingencies included in the scheme.
- Kingsville capacitor switching – This is part of the Lauzon load rejection scheme which provides selection of capacitors at Kingsville TS to be switched out in two stages for contingencies included in the scheme with each stage consisting of two Kingsville capacitors.

6.5 Thermal Assessment and Load Security

The *Ontario Resources and Transmission Assessment Criteria* (*ORTAC*) specify the following criteria for load security on thermal loading of transmission facilities:

Criterion I: With all the transmission facilities in service, equipment loading must be within continuous ratings.

Criterion II: With one element out of service, equipment loading must be within applicable long-term ratings and not more than 150 MW of load may be interrupted by configuration. Planned load curtailment or load rejection, excluding voluntary demand management, is permissible only to account for local generation outages.

Criterion III: With two elements out of service, equipment loading must be within applicable short-term emergency ratings. The equipment loading must be reduced to the applicable long-term emergency ratings in the time afforded by the short-time ratings. Planned load curtailment or load rejection exceeding 150 MW is permissible only to account for local generation outages. Not more than 600 MW of load may be interrupted by configuration and by planned load curtailment.

Table 8 lists the thermal ratings of the monitored circuits in Amperes and transformers in MVA that were provided by Hydro One. The circuit's conductor ratings were calculated for summer weather conditions with ambient temperature of 35^{o}C and wind speed of 4 km/h. The continuous ratings for the conductors were calculated at the lower of the sag temperature or 93^{o}C operating temperature. The LTE ratings for the conductors were calculated at the lower of the sag temperature or 127^{o}C operating temperature. The STE ratings were calculated at the sag temperature with 100% continuous pre-load.

Table 8: Circuit Section and Transformer Summer Thermal Ratings

Circuit/ Transformer	Circuit Section		Continuous	LTE	STE
	From	To	A/MVA	A/MVA	A/MVA
C21J	Keith TS	Malden TS	840	1020	1100
C21J	Malden TS	Sandwich JCT	840	1020	1100
C21J	Sandwich JCT	Leamington TS	1060	1370	1570
C21J	Leamington TS	Chatham SS	1060	1370	1570
C22J	Keith TS	Malden TS	840	1020	1100
C22J	Malden TS	Sandwich JCT	840	1050	1150
C22J	Sandwich JCT	Leamington TS	840	1020	1100
C22J	Leamington TS	Chatham SS	840	1020	1100
C23Z	Lauzon TS	Sandwich JCT	1060	1400	1900
C23Z	Sandwich JCT	Comber WF JCT	1060	1400	1840
C23Z	Comber WF JCT	KEPA WF JCT	1060	1400	1840
C23Z	KEPA WF JCT	Dillon RWEC JCT	1060	1400	1690
C23Z	Dillon RWEC JCT	Chatham SS	1060	1400	1690
C24Z	Lauzon TS	Sandwich JCT	1060	1400	1900
C24Z	Sandwich JCT	Comber WF JCT	840	1040	1130
C24Z	Comber WF JCT	KEPA WF JCT	840	1040	1130
C24Z	KEPA WF JCT	Chatham SS	840	1020	1100
J3E	Keith TS	Crawford JCT	810	1070	1390
J3E	Crawford JCT	Essex TS	810	1070	1390
J4E	Keith TS	Crawford JCT	810	1000	1090
J4E	Crawford JCT	Essex TS	810	1000	1090
Z1E	Essex TS	Windsor Transalta JCT	970	1260	1430
Z1E	Windsor Transalta JCT	Walker JCT	970	1260	1430
Z1E	Walker JCT	Jefferson JCT	870	1140	1390
Z1E	Jefferson JCT	Lauzon TS	910	1190	1370
Z7E	Essex TS	Walker JCT	970	1260	1430
Z7E	Walker JCT	Jefferson JCT	870	1140	1390
Z7E	Jefferson JCT	Lauzon TS	910	1190	1370
Lauzon T1			250	296.8	364.2
Lauzon T2			250	296.8	364.2
Keith T11			115	180.3	224.5
Keith T12			115	160.3	187.5

6.5.1 Kingsville Local Supply

Kingsville TS is connected to 115 kV radial circuits K2Z and K6Z through four transformers with two transformers on each circuit. For loss of one of the circuits, the Kingsville load is supplied by the remaining two transformers connected to the companion circuit.

Thermal analysis was performed to compare the two load transfer options from Kingsville. The loading on K6Z for loss of K2Z is presented below as K6Z has lower thermal ratings than K2Z. Under option A, with four transformers and 124 MW of load at Kingsville, for the loss of K2Z the two remaining transformers are above their combined summer 10-day LTR of 112 MVA. This overload can be mitigated by using the Kingsville transformer switching control action in option A. Under option B, with two transformers and 54 MW of load at Kingsville, for the loss of K2Z the remaining transformer with the more limiting rating is above its summer 10-day LTR of 54.5 MVA. Hydro One has indicated that for option B they have plans to replace this transformer with a new transformer that has a higher 10-day LTR.

Table 9 shows a comparison of the two load transfer options from Kingsville TS to the project with the Kingsville transformer switching control action used in option A.

Table 9: Thermal Loading on K6Z for the two load transfer options

Circuit	Circuit Section		LTE	STE	Option A: 124 MW with 4 transformers at Kingsville				Option B: 54 MW with 2 transformers at Kingsville	
					K2Z		K2Z – 62 MW Kingsville L/R		K2Z	
	From	To	A	A	A	% LTE	A	% LTE	A	% LTE
K6Z	Lauzon TS	Lauzon JCT	1070	1200	728.9	68.1	316.2	29.5	427.1	39.9
K6Z	Lauzon JCT	Rourke Line JCT	1070	1200	728.9	68.1	316.2	29.5	427.2	39.9
K6Z	Rourke Line JCT	Belle River TS	620	640	260.1	42	243.3	39.2	259.7	41.9
K6Z	Belle River JCT	Rourke Line JCT	1070	1200	479.4	44.8	104.8	9.8	252.4	23.6
K6Z	Pte-Aux-Roches WF JCT	Belle River JCT	620	730	479.7	77.4	104.4	16.8	253	40.8
K6Z	Kingsville TS	Pte-Aux-Roches WF JCT	580	590	665.7	**114.8**	322.8	55.7	331.4	57.1

From Table 9 it is noticed that under option A for loss of K2Z, there are post-contingency overloads above the short-term emergency rating on a section of circuit K6Z that supplies Kingsville TS. The Lauzon load rejection (L/R) scheme which is part of the Windsor Area SPS can be used in this scenario to reject half the load at Kingsville (62 MW) and reduce the loading within the LTE rating of K6Z. However, this is a violation of the *ORTAC* criteria as with one element out of service, equipment loading must be within applicable long-term ratings, and any load rejection is permissible only to account for local generation outages. Since there are no generation outages in this scenario, load rejection is not permitted. Under option B for this scenario, there is no overload condition on K6Z. Hence, option B is the recommended option.

6.5.2 High Flow East Conditions

<u>All elements in-service: Pre-contingency</u>

The pre-contingency thermal loading for the two load transfer options from Kingsville under high flow east (HFE) conditions, which represent past historical maximum transfers, in scenarios S1 and S2 are presented in Table 10. The pre-contingency flows on all monitored elements are within their continuous ratings for both load transfer options under HFE conditions. The flows are in Ampere for circuits and MVA for transformers.

Table 10: Pre-contingency thermal loading under HFE conditions - All Elements I/S

Circuit/ Transformer	Circuit Section		Continuous	S1 – 124 MW at Kingsville		S2- 54 MW at Kingsville	
	From	To	A/MVA	A/MVA	% Cont	A/MVA	% Cont
C21J	Keith TS	Malden TS	840	499.2	59.4	538	64
C21J	Malden TS	Sandwich JCT	840	358.5	42.7	391.6	46.6
C21J	Sandwich JCT	Leamington TS	1060	355.5	33.5	389.4	36.7
C21J	Leamington TS	Chatham SS	1060	314.2	29.6	290.1	27.4
C22J	Keith TS	Malden TS	840	493.5	58.7	531.6	63.3
C22J	Malden TS	Sandwich JCT	840	353.7	42.1	385.6	45.9
C22J	Sandwich JCT	Leamington TS	840	350.5	41.7	383.2	45.6
C22J	Leamington TS	Chatham SS	840	310.1	36.9	286.9	34.2
C23Z	Lauzon TS	Sandwich JCT	1060	223.9	21.1	216.4	20.4
C23Z	Sandwich JCT	Comber WF JCT	1060	216.4	20.4	207.2	19.5
C23Z	Comber WF JCT	KEPA WF JCT	1060	155.2	14.6	188.5	17.8
C23Z	KEPA WF JCT	Dillon RWEC JCT	1060	146.1	13.8	180.1	17
C23Z	Dillon RWEC JCT	Chatham SS	1060	286.5	27	332.8	31.4
C24Z	Lauzon TS	Sandwich JCT	1060	284.1	26.8	263.8	24.9
C24Z	Sandwich JCT	Comber WF JCT	840	279	33.2	257.2	30.6
C24Z	Comber WF JCT	KEPA WF JCT	840	145.6	17.3	157.4	18.7
C24Z	KEPA WF JCT	Chatham SS	840	476.4	56.7	523.3	62.3
J3E	Keith TS	Crawford JCT	810	803.2	99.2	755.9	93.3
J3E	Crawford JCT	Essex TS	810	609.9	75.3	547.5	67.6
J4E	Keith TS	Crawford JCT	810	778.8	96.2	726.2	89.7
J4E	Crawford JCT	Essex TS	810	630.6	77.8	575	71
Z1E	Essex TS	Windsor Transalta JCT	970	410.1	42.3	313.4	32.3
Z1E	Windsor Transalta JCT	Walker JCT	970	727	74.9	643.6	66.3
Z1E	Walker JCT	Jefferson JCT	870	399.2	45.9	267.5	30.7
Z1E	Jefferson JCT	Lauzon TS	910	387.3	42.6	251.7	27.7
Z7E	Essex TS	Walker JCT	970	719.3	74.2	652.8	67.3
Z7E	Walker JCT	Jefferson JCT	870	396.9	45.6	263.3	30.3
Z7E	Jefferson JCT	Lauzon TS	910	385.5	42.4	248.2	27.3
Lauzon T1			250	50.3	20.1	70.1	28
Lauzon T2			250	34.4	13.7	49.5	19.8
Keith T11			115	50.3	43.7	34.9	30.4
Keith T12			115	56.7	49.3	39.4	34.3

Post-contingency

Table 14 to Table 19 in Appendix A show the post-contingency flows for the monitored circuits for scenarios S1 and S2 under HFE conditions following contingencies listed in Table 7. The simulation results show that the post-contingency thermal loadings in the Windsor 230 and 115 kV systems remain within applicable *ORTAC* criteria with the utilization of appropriate control actions. For scenario S2 with Kingsville load transfer option B, the post-contingency loadings are lower and less control actions are required. Hence, option B is better than option A.

Under scenarios S1 and S2 for the Lauzon T1L7 breaker failure which results in the loss of circuits Z7E and C23Z shown in Table 16 and Table 17 respectively, multiple control actions are needed to mitigate post-contingency thermal loadings in the Windsor 115 kV system. Arming load rejection as part of the Lauzon L/R scheme in the Windsor Area SPS for loss of Z7E or C23Z with all elements in-service and all local generation in-service was not considered. This is not allowed based on the *ORTAC* criteria, where load rejection is permissible only to account for local generation outages when one element is out of service. It is recommended that Hydro One consider expanding the Lauzon L/R scheme as part of the Windsor Area SPS to include the Lauzon T1L7 breaker failure which is a NERC TPL-001-04 BES Planning Performance Event so that load rejection (L/R) can be armed for this contingency.This would provide greater operating flexibility.

Load Restoration

For the loss of double circuits C23Z and C24Z, the load at Lauzon is tripped and can be restored by opening the 230 kV disconnect switches at Lauzon on the C23Z and C24Z circuits and closing the 115 kV and 27.6 kV transformer breakers at Lauzon. This was studied as it shows a comparison in the capability to restore load on the Windsor 115 kV system with the two load transfer options.

Under HFE conditions with 194.2 MW of load at Lauzon for the year 2026, it was found that 102 MW of load at Lauzon can be restored in scenario S1 and 160 MW of load at Lauzon can be restored in scenario S2 without additional load transfers out of the Windsor 115 kV system. However, there is capability to transfer 68 MW of load supplied by the Windsor 115 kV system to the 230 kV system and 20 MW of load supplied by the Windsor 115 kV system to the Scott 115 kV system depending on the loading within that system. Transferring 68 MW of load from the Windsor 115 kV to the 230 kV system will enable all the load to be restored in scenario S2. Hence option B is better than option A as it allows all the load at Lauzon to be restored.

Sensitivity Studies: With no TA Windsor and West Windsor Generation Facilities

Sensitivity studies were performed under HFE conditions without the TA Windsor and West Windsor generation facilities in-service given that their contracts are expiring in 2016. These results are not presented in this report but summarized below.

Without these facilities in-service, the Brighton Beach output can be maximized and imports can be kept similar to that in scenarios S1 and S2. Studies show that under these conditions the post-contingency thermal loadings in the Windsor 230 and 115 kV systems remain within applicable *ORTAC* criteria with the utilization of appropriate control actions. When compared to scenarios S1 and S2, the post-contingency thermal loading on the Keith transformers are higher and the post-contingency thermal loading on the J4E/J3E and Z1E/Z7E circuits are lower. For these conditions with Kingsville load transfer option A, a lot more control actions would need to be taken under outage conditions which include pre-contingency control actions followed by automatic and manual actions post-contingency. Hence, option B is better than option A.

6.5.3 High Flow West Conditions

All elements in-service: Pre-contingency

The pre-contingency thermal loading for the two load transfer options from Kingsville under high flow west (HFW) conditions, which represent past historical maximum transfers, in scenarios S3 and S4 are presented in Table 11. The pre-contingency flows on all monitored elements are within their continuous ratings for both load transfer options under HFW conditions. The flows are in Ampere for circuits and MVA for transformers.

Table 11: Pre-contingency thermal loading under HFW conditions - All Elements I/S

Circuit/ Transformer	Circuit Section		Continuous	S3 – 124 MW at Kingsville		S4- 54 MW at Kingsville	
	From	To	A/MVA	A/MVA	% Cont	A/MVA	% Cont
C21J	Keith TS	Malden TS	840	394.2	46.9	349.1	41.6
C21J	Malden TS	Sandwich JCT	840	551.8	65.7	506.5	60.3
C21J	Sandwich JCT	Leamington TS	1060	550.9	52	506	47.7
C21J	Leamington TS	Chatham SS	1060	599	56.5	644.4	60.8
C22J	Keith TS	Malden TS	840	385.9	45.9	342	40.7
C22J	Malden TS	Sandwich JCT	840	543.5	64.7	498.9	59.4
C22J	Sandwich JCT	Leamington TS	840	542.8	64.6	498.7	59.4
C22J	Leamington TS	Chatham SS	840	591.2	70.4	636	75.7
C23Z	Lauzon TS	Sandwich JCT	1060	544.1	51.3	504.1	47.6
C23Z	Sandwich JCT	Comber WF JCT	1060	541.7	51.1	501.1	47.3
C23Z	Comber WF JCT	KEPA WF JCT	1060	538.9	50.8	497.8	47
C23Z	KEPA WF JCT	Dillon RWEC JCT	1060	537.5	50.7	496.1	46.8
C23Z	Dillon RWEC JCT	Chatham SS	1060	535.9	50.6	494.2	46.6
C24Z	Lauzon TS	Sandwich JCT	1060	538	50.8	499	47.1
C24Z	Sandwich JCT	Comber WF JCT	840	535.9	63.8	496.2	59.1
C24Z	Comber WF JCT	KEPA WF JCT	840	533.3	63.5	493.1	58.7
C24Z	KEPA WF JCT	Chatham SS	840	526.9	62.7	484.8	57.7
J3E	Keith TS	Crawford JCT	810	449.8	55.5	442.8	54.7
J3E	Crawford JCT	Essex TS	810	235.6	29.1	221.2	27.3
J4E	Keith TS	Crawford JCT	810	413.7	51.1	395.8	48.9
J4E	Crawford JCT	Essex TS	810	268.7	33.2	271.3	33.5
Z1E	Essex TS	Windsor Transalta JCT	970	159	16.4	81.5	8.4
Z1E	Windsor Transalta JCT	Walker JCT	970	341	35.2	270.3	27.9
Z1E	Walker JCT	Jefferson JCT	870	141.7	16.3	132.6	15.2
Z1E	Jefferson JCT	Lauzon TS	910	156.1	17.2	152.8	16.8
Z7E	Essex TS	Walker JCT	970	346	35.7	332.4	34.3
Z7E	Walker JCT	Jefferson JCT	870	159.2	18.3	142.7	16.4
Z7E	Jefferson JCT	Lauzon TS	910	173.6	19.1	163.2	17.9
Lauzon T1			250	118	47.2	100.5	40.2
Lauzon T2			250	115.5	46.2	98.2	39.3
Keith T11			115	17	14.8	31.5	27.4
Keith T12			115	19.1	16.6	35.5	30.9

Post-contingency

Table 20 to Table 25 in Appendix A show the post-contingency flows for the monitored circuits for scenarios S3 and S4 under HFW conditions following contingencies listed in Table 7. The simulation results show that the post-contingency thermal loadings in the Windsor 230 and 115 kV systems remain within applicable *ORTAC* criteria with the utilization of appropriate control actions. For scenario S2 with Kingsville load transfer option B, the post-contingency loadings are lower and less control actions are required. Hence, option B is better than option A.

Load Restoration

Load restoration at Lauzon was analyzed following the loss of double circuits C23Z and C24Z similar to the description provided earlier in section 6.5.2 under HFE conditions.

Under HFW conditions with 194.2 MW of load at Lauzon for the year 2026, it was found that 10 MW of load at Lauzon can be restored in scenario S3 and 86 MW of load at Lauzon can be restored in scenario S4 without any additional load transfers out of the Windsor 115 kV system. Taking into account the load transfer capability discussed in section 6.5.2, with 68 MW of load transferred from the Windsor 115 kV system to the 230 kV system and with the generation at Pte Aux Roches and Gosfield in-service at full output, all the load can be restored in scenario S4. Hence option B is better than option A as it allows all the load at Lauzon to be restored.

Reverse Power Flow

Reverse power flow through the project's transformers was observed in all four scenarios S1 to S4 with the maximum reverse power flow in scenario S3 for the outage combinations with C21J or C22J open at Chatham and the inadvertent breaker open (IBO) of C21J at Keith. There were no post-contingency thermal or voltage violations observed for these outage combinations in all four scenarios.

In scenario S3 for the outage combination with C22J open at Chatham and IBO of C21J at Keith, the maximum reverse power flow of 44 MW through the project's transformers was observed. Under these conditions, the reverse power flow through the Malden transformer is 7 MW and would increase to 14 MW without the incorporation of the project.

In addition in scenario S3, for the outage combination with C21J open at Chatham and IBO of C21J at Keith, the reverse power flow through the project's transformer is 33 MW. Under these conditions, without the incorporation of the project there is no reverse power flow at Malden TS.

It is recommended that Hydro One assess the reverse power flow on the project's transformers and confirm that there is no unacceptable tripping or loading concern on the transformers.

Sensitivity Studies: With no TA Windsor and West Windsor Generation Facilities

Sensitivity studies were performed under high flow west conditions without the TA Windsor and West Windsor generation facilities in-service given that their contracts are expiring in 2016. These results are not presented in this report but summarized below

Without these facilities in-service, the Brighton Beach output can be increased to make up for this generation while keeping the total flow out of Chatham on circuits C21J,C22J, C23Z and C24Z similar to that in scenarios S3 and S4. Studies show that under these conditions the post-contingency thermal loadings in the Windsor 230 and 115 kV systems remain within applicable *ORTAC* criteria with the utilization of appropriate control actions. When compared to scenarios S3 and S4, the post-contingency thermal loading on the Keith transformers and J4E/J3E circuits are higher and the post-contingency thermal loading on the C22J and Z1E circuits are lower. For these conditions with Kingsville load transfer option A, a lot more control actions would need to be taken under outage conditions which include pre-contingency control actions followed by automatic and manual actions post-contingency. Hence, option B is better than option A.

6.5.4 Load Tripped by Configuration

To assess that *ORTAC* load security criteria will be met after the incorporation of the project, the total amount of load tripped by configuration for loss of either one or two elements that involve the project was examined.

Single contingencies involving the loss of C21J or C22J result in no load interruption at Malden TS and the project.

The simultaneous loss of double circuits C21J and C22J will interrupt load at Malden TS and the project of up to 237 MW for the 2016 to 2026 period based on the Hydro One load forecast under option B. The interrupted load does not exceed 600 MW and is within the *ORTAC* criteria.

The *ORTAC* load restoration criteria states that all load must be restored within approximately 8 hours and the amount of load in excess of 150 MW must be restored within approximately 4 hours. This means that of the load that is interrupted for loss of C21J and C22J as mentioned above, up to 87 MW of load will need to be restored within approximately 4 hours and up to 237 MW of load will need to be restored within approximately 8 hours. Hydro One and the affected Local Distribution Companies (LDCs) are expected to work together to ensure that these load restoration targets can be achieved.

6.6 Voltage Assessment

The *ORTAC* states that with all facilities in service pre-contingency, or with a critical element out of service after permissible control actions, the following criteria shall be satisfied:

- The pre-contingency voltages on 230 kV buses must not be less than 220 kV and no greater than 250 kV and 115kV buses must not be less than 113 kV and no greater than 127 kV;
- The post-contingency voltages on 230 kV buses must not be less than 207 kV and no greater than 250 kV and 115 kV buses must not be less than 108 kV and no greater than 127 kV; and
- The voltage change following a contingency must not exceed 10% pre-ULTC and 10% post-ULTC on both 115 kV and 230 kV buses.

All the loads were modeled as constant MVA unless otherwise specified.

6.6.1 Kingsville Local Supply

Voltage Analysis was performed to compare the two load transfer options from Kingsville. The loss of K2Z is presented in Table 12 below as the voltage declines are greater for the loss of K2Z than K6Z. Under option A, the Kingsville transformer switching control action was used so that the loading on the remaining Kingsville transformers do not exceed their summer 10-day LTR as discussed earlier in Section 6.5.1.

Table 12: Voltage Results for loss of K2Z with the two load transfer options

Bus Name	Option A: 124 MW with 4 transformers at Kingsville									Option B: 54 MW with 2 transformers at Kingsville				
	Pre-cont.	* K2Z				K2Z – 62 MW Kingsville L/R				Pre-cont.	K2Z			
		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC			Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%		kV	%	kV	%
Lauzon 115 kV	122.7	122.1	-0.53	121.8	-0.78	124.4	1.37	124.2	1.18	121.1	120.4	-0.52	120.5	-0.44
Bell River K6Z 115 kV	120.9	117.1	-3.11	116.3	-3.84	124.3	2.82	123.6	2.26	119.4	115.8	-3.00	116.1	-2.74
Pointe Aux Roches 115	120.5	116.2	-3.56	115.2	-4.44	124.6	3.34	123.8	2.70	119.1	115.1	-3.42	115.4	-3.16
Kingsville K6Z 115 kV	117.3	109.1	-6.97	**106.8**	-8.92	125.5	7.02	124.1	5.81	116.9	109.2	-6.64	109.5	-6.37

* Kingsville load was converted for this contingency both Pre and Post ULTC

From Table 12 it is noticed that with option A, the post-contingency voltage at Kingsville is below 108 kV for loss of K2Z with the load at Kingsville converted both pre and post ULTC. Note that in this scenario without the Kingsville transformer switching control action, the voltage at Kingsville would be even lower. The Lauzon L/R scheme which is part of the Windsor Area SPS can be used in this scenario to reject half the load at Kingsville (62 MW) to bring the voltage above 108 kV.

However, this is a violation of the *ORTAC* criteria as with one element out of service, equipment loading must be within applicable long-term ratings, and any load rejection is permissible only to account for local generation outages. Since there are no generation outages in this scenario, load rejection is not permitted.

Under option B the post-contingency voltages are above 108 kV which is within the *ORTAC* criteria. Hence option B is the recommended option. Note that under option B, with 54 MW of load at Kingsville, the Lauzon capacitor was switched out of service pre-contingency to avoid high voltages at Lauzon post-contingency for the loss of Z1E+Z7E with all elements in-service.

6.6.1 High Flow East or West Conditions

The pre- and post-contingency voltage results for scenarios S1 and S2 under HFE conditions following contingencies listed in Table 7 are presented in Table 26 to Table 31 in Appendix B. The pre- and post-contingency voltage results for scenarios S3 and S4 under HFW conditions following contingencies listed in Table 7 are presented in Table 32 to Table 37 in Appendix B.

Study results show that for all four scenarios S1, S2, S3 and S4 the pre and post-contingency voltages in the Windsor 230 and 115 kV systems remain within applicable *ORTAC* criteria with the utilization of appropriate control actions.

In all four scenarios for the loss of double circuit Z1E and Z7E, control actions were taken to mitigate post-contingency over-voltages on the Lauzon 115 kV system. For scenarios S1 and S3 with Kingsville load transfer option A, the Lauzon L/R scheme as part of the Windsor Area SPS was armed to switch out the Kingsville capacitors. However, switching out the Lauzon capacitor would be a better control action. For scenarios S2 and S4 with Kingsville load transfer option B, the Lauzon capacitor was switched out-service pre-contingency and the Keith capacitor was switched in-service pre-contingency to maintain acceptable voltages pre- and post –contingency as there were no control actions available post-contingency. This resulted in lower voltages on the Lauzon 230 kV and 115 kV systems compared to scenarios S1 and S3 even though more load was transferred out of Kingsville in scenarios S2 and S4.

Therefore under both load transfer options A or B, It is recommended that Hydro One consider adding the selection of the Lauzon capacitor to be tripped for the Z1E+Z7E contingency which is a contingency that is already included in the Lauzon L/R scheme as part of the Windsor Area SPS. This would provide greater operating flexibility.

Sensitivity Studies: With no TA Windsor and West Windsor Generation Facilities

Sensitivity studies were performed under high flow east or west conditions without the TA Windsor and West Windsor generation facilities in-service given that their contracts are expiring in 2016. These results are not presented in this report but summarized below.

Without these facilities in-service, the pre- and post-contingency voltage in the Windsor 230 and 115 kV systems remain within applicable *ORTAC* criteria with the utilization of appropriate control actions. However when compared to scenarios S1, S2, S3 and S4, the pre and post-contingency voltages are lower and voltage changes are higher without these facilities in-service.

6.7 Switching Studies

The *ORTAC* states that reactive devices should be sized to ensure that voltage declines or rises at delivery point buses on switching operations will not exceed 4% of steady-state rms voltage before tap changer action using a voltage dependent load model.

The switching of the proposed capacitor bank of 21.6 Mvar @ 28.8 kV was tested under various outage conditions for the two different load transfer options A and B at 2026 load levels. Table 13 shows the capacitor switching results for the project’s 230 kV buses. In all studied scenarios, the voltage change following the capacitor switching is within the prescribed 4% permissible voltage change limit.

Table 13: Capacitor Switching Study for Leamington TS

	Load transfer option A						Load transfer option B					
230 kV Bus	Leamington C21J			Leamington C22J			Leamington C21J			Leamington C22J		
Outage Condition	Cap O/S	Cap I/S	Change	Cap O/S	Cap I/S	Change	Cap O/S	Cap I/S	Change	Cap O/S	Cap I/S	Change
	kV	kV	%	kV	kV	%	kV	kV	%	kV	kV	%
None	236.7	238.2	0.66%	236.6	238.1	0.66%	229.9	231.4	0.67%	229.7	231.3	0.67%
C22J Chatham end open	232.2	233.9	0.72%	230.2	232.4	0.96%	224.8	226.5	0.73%	221.2	223.3	0.98%
C22J Keith end open	235.2	236.7	0.66%	235.1	237.0	0.82%	229.8	231.4	0.67%	229.0	230.9	0.82%
J5D	235.5	237.7	0.92%	235.4	237.6	0.93%	229.0	231.2	0.94%	228.8	231.0	0.94%
C21J				227.3	229.7	1.06%				217.1	219.3	1.04%
C22J	227.6	230.0	1.06%				216.5	218.8	1.07%			

– End of Section –

Appendix A Thermal Loading

Table 14: Thermal loading with all elements in-service for single contingencies – Scenario S1

Circuit/ Xformer	Circuit Section		LTE	STE	C22J		C23Z		** J3E (Mode A Essex Bus Split)*		** Z7E (BB G/R)*		Keith A Bus	
	From	To	A/MVA	A/MVA	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE
C21J	Keith TS	Malden TS	1020	1100	819.5	80.3	521	51.1	718.8	70.5	423.6	41.5	0	0
C21J	Malden TS	Sandwich JCT	1020	1100	525.7	51.5	382.1	37.5	570	55.9	289.7	28.4	48	4.7
C21J	Sandwich JCT	Leamington TS	1370	1570	523.3	38.2	379	27.7	568.3	41.5	285.8	20.9	41.5	3
C21J	Leamington	Chatham SS	1370	1570	445.9	32.6	338.6	24.7	522.9	38.2	248.9	18.2	40.3	2.9
C22J	Keith TS	Malden TS	1020	1100	0	0	514.8	50.5	710.6	69.7	418.5	41	799.7	78.4
C22J	Malden TS	Sandwich JCT	1050	1150	0	0	377	35.9	562.5	53.6	285.7	27.2	534.4	50.9
C22J	Sandwich JCT	Leamington TS	1020	1100	0	0	373.6	36.6	560.5	55	281.7	27.6	532	52.2
C22J	Leamington	Chatham SS	1020	1100	0	0	334.1	32.8	515.7	50.6	245.7	24.1	432.9	42.4
C23Z	Lauzon TS	Sandwich JCT	1400	1900	226.8	16.2	0	0	566.2	40.4	293	20.9	219	15.6
C23Z	Sandwich JCT	Comber WF JCT	1400	1840	218.7	15.6	0	0	562.8	40.2	287.1	20.5	210.7	15
C23Z	Comber WF	KEPA WF JCT	1400	1840	170.4	12.2	0	0	368.8	26.3	153.1	10.9	171.3	12.2
C23Z	KEPA WF JCT	Dillon RWEC	1400	1690	161.3	11.5	0	0	366.3	26.2	147.7	10.6	162.4	11.6
C23Z	Dillon RWEC	Chatham SS	1400	1690	302.8	21.6	0	0	250.9	17.9	233.8	16.7	308.6	22
C24Z	Lauzon TS	Sandwich JCT	1400	1900	282.6	20.2	426.6	30.5	640.4	45.7	360.7	25.8	273.7	19.5
C24Z	Sandwich JCT	Comber WF JCT	1040	1130	277	26.6	421	40.5	637.8	61.3	356.6	34.3	267.9	25.8
C24Z	Comber WF	KEPA WF JCT	1040	1130	154.8	14.9	269.3	25.9	443.4	42.6	193.3	18.6	150.8	14.5
C24Z	KEPA WF JCT	Chatham SS	1020	1100	491.3	48.2	437.9	42.9	239.9	23.5	407.9	40	498.5	48.9
J3E	Keith TS	Crawford JCT	1070	1390	820	76.6	886.2	82.8	0	0	661.7	61.8	838.5	78.4
J3E	Crawford JCT	Essex TS	1070	1390	630.6	58.9	685.8	64.1	0	0	458.3	42.8	648.6	60.6
J4E	Keith TS	Crawford JCT	1000	1090	797.2	79.7	863.1	86.3	531.3	53.1	634.1	63.4	815.5	81.6
J4E	Crawford JCT	Essex TS	1000	1090	649.4	64.9	707.2	70.7	163.8	16.4	482.3	48.2	667.7	66.8
Z1E	Essex TS	Windsor Transalta JCT	1260	1430	438.7	34.8	454.5	36.1	347.3	27.6	800.6	63.5	454.5	36.1
Z1E	Windsor Transalta JCT	Walker JCT	1260	1430	751.4	59.6	787.1	62.5	87.6	6.9	1129.7	89.7	768.7	61
Z1E	Walker JCT	Jefferson JCT	1140	1390	427.9	37.5	402.7	35.3	412.5	36.2	559.9	49.1	441.5	38.7
Z1E	Jefferson JCT	Lauzon TS	1190	1370	416.2	35	385.1	32.4	433.7	36.4	550.5	46.3	429.3	36.1
Z7E	Essex TS	Walker JCT	1260	1430	741.8	58.9	793.8	63	43	3.4	0	0	759.6	60.3
Z7E	Walker JCT	Jefferson JCT	1140	1390	425.8	37.4	396.4	34.8	426	37.4	0	0	439	38.5
Z7E	Jefferson JCT	Lauzon TS	1190	1370	414.6	34.8	379.2	31.9	447	37.6	0	0	427.3	35.9
Lauzon T1			296.8	364.2	56.7	19.1	0	0	126.2	42.5	41.8	14.1	58.6	19.8
Lauzon T2			296.8	364.2	39.7	13.4	56.6	19.1	146.4	49.3	46.6	15.7	39.9	13.4
Keith T11			180.3	224.5	104.8	58.1	64.5	35.8	77.6	43	80.5	44.7	0	0
Keith T12			160.3	187.5	0	0	72.7	45.3	87.5	54.6	90.8	56.6	114.5	71.4

* Control Action shown in brackets

Table 15: Thermal loading with all elements in-service for single contingencies – Scenario S2

Circuit/ Xformer	Circuit Section		LTE	STE	C22J		C23Z		*J3E-(Mode A Essex Bus Split)		* Z7E-(BB G/R)		Keith A Bus	
	From	To	A/MVA	A/MVA	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE
C21J	Keith TS	Malden TS	1020	1100	897.9	88	568.7	55.8	729	71.5	456.9	44.8	0	0
C21J	Malden TS	Sandwich JCT	1020	1100	588.6	57.7	423.8	41.6	577.5	56.6	314.3	30.8	40.3	4
C21J	Sandwich JCT	Leamington TS	1370	1570	587.3	42.9	421.4	30.8	576.2	42.1	311.4	22.7	33.5	2.4
C21J	Leamington	Chatham SS	1370	1570	401.6	29.3	324.6	23.7	461	33.7	226.9	16.6	116.6	8.5
C22J	Keith TS	Malden TS	1020	1100	0	0	561.6	55.1	720.5	70.6	451.3	44.2	853.6	83.7
C22J	Malden TS	Sandwich JCT	1050	1150	0	0	417.3	39.7	569.3	54.2	309.1	29.4	575	54.8
C22J	Sandwich JCT	Leamington TS	1020	1100	0	0	414.7	40.7	567.8	55.7	306.1	30	573.1	56.2
C22J	Leamington	Chatham SS	1020	1100	0	0	320.9	31.5	455.1	44.6	224.8	22	408.8	40.1
C23Z	Lauzon TS	Sandwich JCT	1400	1900	218.6	15.6	0	0	515.8	36.8	268.5	19.2	211.6	15.1
C23Z	Sandwich JCT	Comber WF	1400	1840	208.9	14.9	0	0	510.6	36.5	261.1	18.7	201.7	14.4
C23Z	Comber WF	KEPA WF JCT	1400	1840	207.6	14.8	0	0	327.8	23.4	171.2	12.2	211.4	15.1
C23Z	KEPA WF JCT	Dillon RWEC	1400	1690	199.5	14.2	0	0	324	23.1	161.8	11.6	203.5	14.5
C23Z	Dillon RWEC	Chatham SS	1400	1690	354.5	25.3	0	0	232.4	16.6	276.1	19.7	362.3	25.9
C24Z	Lauzon TS	Sandwich JCT	1400	1900	259.1	18.5	394.7	28.2	585	41.8	328.8	23.5	249.5	17.8
C24Z	Sandwich JCT	Comber WF	1040	1130	251.7	24.2	387.7	37.3	580.9	55.9	323.5	31.1	241.9	23.3
C24Z	Comber WF	KEPA WF JCT	1040	1130	179	17.2	259.3	24.9	390.4	37.5	179.1	17.2	177.9	17.1
C24Z	KEPA WF JCT	Chatham SS	1020	1100	544.6	53.4	497.3	48.8	309.4	30.3	456.1	44.7	553.6	54.3
J3E	Keith TS	Crawford JCT	1070	1390	782.4	73.1	828.5	77.4	0	0	639.2	59.7	805.5	75.3
J3E	Crawford JCT	Essex TS	1070	1390	577.2	53.9	613.6	57.3	0	0	422	39.4	600.4	56.1
J4E	Keith TS	Crawford JCT	1000	1090	754.4	75.4	797.4	79.7	533.9	53.4	604.9	60.5	777.5	77.8
J4E	Crawford JCT	Essex TS	1000	1090	602.4	60.2	643.5	64.4	172.4	17.2	455.5	45.6	625.8	62.6
Z1E	Essex TS	Windsor Transalta JCT	1260	1430	352.2	28	361	28.7	364.9	29	683.6	54.3	374	29.7
Z1E	Windsor Transalta JCT	Walker JCT	1260	1430	680.6	54	704.3	55.9	70.9	5.6	1015.3	80.6	703.1	55.8
Z1E	Walker JCT	Jefferson JCT	1140	1390	308.7	27.1	291.3	25.5	419.4	36.8	263.6	23.1	328.5	28.8
Z1E	Jefferson JCT	Lauzon TS	1190	1370	293.2	24.6	270.3	22.7	441.4	37.1	249.6	21	312.5	26.3
Z7E	Essex TS	Walker JCT	1260	1430	686.4	54.5	731.9	58.1	54.8	4.3	0	0	709.1	56.3
Z7E	Walker JCT	Jefferson JCT	1140	1390	304.8	26.7	281	24.6	433.1	38	0	0	324.1	28.4
Z7E	Jefferson JCT	Lauzon TS	1190	1370	290	24.4	260.2	21.9	454.9	38.2	0	0	308.7	25.9
Lauzon T1			296.8	364.2	78.6	26.5	0	0	108.7	36.6	53	17.8	81.5	27.5
Lauzon T2			296.8	364.2	57.1	19.2	86.8	29.2	123.8	41.7	45.4	15.3	59	19.9
Keith T11			180.3	224.5	76.1	42.2	45.4	25.2	74.5	41.3	62.8	34.8	0	0
Keith T12			160.3	187.5	0	0	51.2	32	84	52.4	70.8	44.2	88.1	54.9

* Control Actions shown in brackets

Table 16: Thermal loading with all elements in-service for double contingencies – Scenario S1

Circuit/ Xformer	Circuit Section		LTE	STE	C21J+C23Z		* C21J+C22J (Lower BB to 417 MW post)		C22J+C24Z		C23Z+C24Z		* Keith T11P BF: Keith A Bus + J2N – (Lower imports to 80 MW post)		* Lauzon T1L7 BF: Z7E+C23Z – (BB G/R and manually shed 62 MW at Kingsville post)	
	From	To	A/ MVA	A/ MVA	A/ MVA	% LTE	A/ MVA	% LTE	A/ MVA	% LTE	A/ MVA	% LTE	A/ MVA	% LTE	A/ MVA	% LTE
C21J	Keith TS	Malden TS	1020	1100	0	0	0	0	873.5	85.6	593.1	58.2	0	0	446.1	43.7
C21J	Malden TS	Sandwich	1020	1100	0	0	0	0	582.2	57.1	455.8	44.7	59.9	5.9	314.3	30.8
C21J	Sandwich	Leamington	1370	1570	0	0	0	0	579.8	42.3	452.5	33	54.9	4	310.2	22.6
C21J	Leamington	Chatham SS	1370	1570	0	0	0	0	503.8	36.8	412.6	30.1	57.2	4.2	274	20
C22J	Keith TS	Malden TS	1020	1100	821.5	80.5	0	0	0	0	585.8	57.4	694.9	68.1	440.6	43.2
C22J	Malden TS	Sandwich	1050	1150	534.4	50.9	0	0	0	0	449.6	42.8	449.5	42.8	309.9	29.5
C22J	Sandwich	Leamington	1020	1100	531.6	52.1	0	0	0	0	446.2	43.7	446.6	43.8	305.7	30
C22J	Leamington	Chatham SS	1020	1100	459.7	45.1	0	0	0	0	407.1	39.9	357.4	35	270.5	26.5
C23Z	Lauzon TS	Sandwich	1400	1900	0	0	202	14.4	403.1	28.8	0	0	282.2	20.2	0	0
C23Z	Sandwich	Comber WF	1400	1840	0	0	191.5	13.7	396	28.3	0	0	275.8	19.7	0	0
C23Z	Comber WF	KEPA WF	1400	1840	0	0	234.7	16.8	263.1	18.8	0	0	155.6	11.1	0	0
C23Z	KEPA WF	Dillon	1400	1690	0	0	227	16.2	257.9	18.4	0	0	150	10.7	0	0
C23Z	Dillon	Chatham SS	1400	1690	0	0	390.6	27.9	303.6	21.7	0	0	249.7	17.8	0	0
C24Z	Lauzon TS	Sandwich	1400	1900	385.1	27.5	229.3	16.4	0	0	0	0	347.5	24.8	462.5	33
C24Z	Sandwich	Comber WF	1040	1130	378.3	36.4	221.2	21.3	0	0	0	0	343.1	33	457.8	44
C24Z	Comber WF	KEPA WF	1040	1130	253.9	24.4	190.4	18.3	0	0	0	0	187.2	18	292.3	28.1
C24Z	KEPA WF	Chatham SS	1020	1100	497.8	48.8	583.3	57.2	0	0	0	0	426.1	41.8	391.2	38.4
J3E	Keith TS	Crawford	1070	1390	946	88.4	991.1	92.6	935.4	87.4	778.9	72.8	674.5	63	683.7	63.9
J3E	Crawford	Essex TS	1070	1390	745.8	69.7	807.1	75.4	737	68.9	567.5	53	482.2	45.1	478.1	44.7
J4E	Keith TS	Crawford	1000	1090	921.4	92.1	970.3	97	911.6	91.2	748.4	74.8	650.4	65	656.6	65.7
J4E	Crawford	Essex TS	1000	1090	767.7	76.8	824.1	82.4	757.7	75.8	596	59.6	501.6	50.2	502.3	50.2
Z1E	Essex TS	Windsor Transalta	1260	1430	519.4	41.2	616.8	49	516.2	41	327	26	299.3	23.8	828	65.7
Z1E	Windsor Transalta	Walker JCT	1260	1430	851.5	67.6	930.3	73.8	845.6	67.1	663	52.6	603.6	47.9	1163.1	92.3
Z1E	Walker JCT	Jefferson	1140	1390	467.7	41	596.8	52.4	464.6	40.8	269.1	23.6	309.5	27.2	506.5	44.4
Z1E	Jefferson	Lauzon TS	1190	1370	450.1	37.8	583.2	49	447.4	37.6	251	21.1	302.6	25.4	491.1	41.3
Z7E	Essex TS	Walker JCT	1260	1430	856.5	68	919.3	73	849.2	67.4	676.1	53.7	593.1	47.1	0	0
Z7E	Walker JCT	Jefferson	1140	1390	461.4	40.5	593.4	52.1	459.3	40.3	262.4	23	310.5	27.2	0	0
Z7E	Jefferson	Lauzon TS	1190	1370	444.1	37.3	580.1	48.7	442.5	37.2	244.8	20.6	304.2	25.6	0	0
LauzonT1			296.8	364.2	0	0	89.6	30.2	83.2	28	0	0	44.1	14.8	0	0
LauzonT2			296.8	364.2	83.6	28.2	64.6	21.8	0	0	0	0	44.4	14.9	32.8	11.1
Keith T11			180.3	224.5	72.8	40.4	179.6	99.6	146.3	81.1	47.6	26.4	0	0	84.7	47
Keith T12			160.3	187.5	82.1	51.2	0	0	0	0	53.6	33.5	159.1	99.3	95.5	59.6

* Control Actions shown in brackets

Table 17: Thermal loading with all elements in-service for double contingencies – Scenario S2

Circuit/ Xformer	Circuit Section		LTE	STE	C21J+C23Z		*C21J+C22J (Lower BB to 505 MW post)*		C22J+C24Z		C23Z+C24Z		Keith T11P BF: Keith A Bus + J2N		*Lauzon T1L7 BF: Z7E+C23Z – (BB G/R and lower TA Windsor to 58 MW post)*	
	From	To	A/ MVA	A/ MVA	A/ MVA	% LTE	A/ MVA	% LTE	A/ MVA	% LTE	A/ MVA	% LTE	A/ MVA	% LTE	A/ MVA	% LTE
C21J	Keith TS	Malden TS	1020	1100	0	0	0	0	963.5	94.5	662.9	65	0	0	470	46.1
C21J	Malden TS	Sandwich	1020	1100	0	0	0	0	656.6	64.4	519.4	50.9	44.1	4.3	330.5	32.4
C21J	Sandwich	Leamington	1370	1570	0	0	0	0	655.1	47.8	516.9	37.7	37.9	2.8	327.3	23.9
C21J	Leamington	Chatham SS	1370	1570	0	0	0	0	471.5	34.4	420	30.7	123.5	9	249	18.2
C22J	Keith TS	Malden TS	1020	1100	919.1	90.1	0	0	0	0	654.3	64.1	817.9	80.2	463.8	45.5
C22J	Malden TS	Sandwich	1050	1150	614.2	58.5	0	0	0	0	511.5	48.7	545.9	52	325	31
C22J	Sandwich	Leamington	1020	1100	612.6	60.1	0	0	0	0	508.8	49.9	543.9	53.3	321.6	31.5
C22J	Leamington	Chatham SS	1020	1100	440.6	43.2	0	0	0	0	414.9	40.7	385	37.7	246.6	24.2
C23Z	Lauzon TS	Sandwich	1400	1900	0	0	233.8	16.7	370	26.4	0	0	242.2	17.3	0	0
C23Z	Sandwich	Comber WF	1400	1840	0	0	228.4	16.3	361.3	25.8	0	0	233.9	16.7	0	0
C23Z	Comber WF	KEPA WF	1400	1840	0	0	310.8	22.2	266	19	0	0	178.8	12.8	0	0
C23Z	KEPA WF	Dillon	1400	1690	0	0	304.2	21.7	260.3	18.6	0	0	169.7	12.1	0	0
C23Z	Dillon	Chatham SS	1400	1690	0	0	475.5	34	352.4	25.2	0	0	305.7	21.8	0	0
C24Z	Lauzon TS	Sandwich	1400	1900	362.4	25.9	220.2	15.7	0	0	0	0	296.5	21.2	504.5	36
C24Z	Sandwich	Comber WF	1040	1130	354.2	34.1	209.9	20.2	0	0	0	0	290.5	27.9	498.9	48
C24Z	Comber WF	KEPA WF	1040	1130	261.7	25.2	250.4	24.1	0	0	0	0	166.7	16	334	32.1
C24Z	KEPA WF	Chatham SS	1020	1100	559.9	54.9	668.8	65.6	0	0	0	0	491.3	48.2	414.9	40.7
J3E	Keith TS	Crawford	1070	1390	882.3	82.5	1007.	94.2	884.9	82.7	692.7	64.7	681.1	63.7	757.6	70.8
J3E	Crawford	Essex TS	1070	1390	669.1	62.5	810.7	75.8	672.9	62.9	473.2	44.2	471	44	545.7	51
J4E	Keith TS	Crawford	1000	1090	852.7	85.3	983	98.3	856.2	85.6	656.5	65.6	650.8	65.1	731.2	73.1
J4E	Crawford	Essex TS	1000	1090	697.1	69.7	832.3	83.2	699.7	70	509.8	51	499.2	49.9	571.6	57.2
Z1E	Essex TS	Windsor Transalta	1260	1430	420.3	33.4	595.6	47.3	427.6	33.9	216.4	17.2	237.4	18.8	950.6	75.4
Z1E	Windsor Transalta	Walker JCT	1260	1430	766	60.8	921.7	73.1	773.8	61.4	543.9	43.2	566.9	45	1246.9	99
Z1E	Walker JCT	Jefferson	1140	1390	354.4	31.1	549	48.2	362.8	31.8	156.9	13.8	198.9	17.5	326.5	28.6
Z1E	Jefferson	Lauzon TS	1190	1370	333.7	28	532.2	44.7	342.3	28.8	139.8	11.8	185.6	15.6	283.7	23.8
Z7E	Essex TS	Walker JCT	1260	1430	793.6	63	921.4	73.1	798.8	63.4	599.2	47.6	576.7	45.8	0	0
Z7E	Walker JCT	Jefferson	1140	1390	344.7	30.2	543.9	47.7	353.6	31	141.5	12.4	196.9	17.3	0	0
Z7E	Jefferson	Lauzon TS	1190	1370	324.2	27.2	527.5	44.3	333.4	28	124.6	10.5	184.7	15.5	0	0
LauzonT1			296.8	364.2	0	0	125.5	42.3	120.4	40.6	0	0	60.9	20.5	0	0
LauzonT2			296.8	364.2	114.2	38.5	99	33.4	0	0	0	0	45.7	15.4	45.7	15.4
Keith T11			180.3	224.5	51.8	28.7	178	98.7	107.9	59.9	36.8	20.4	0	0	84.1	46.6
Keith T12			160.3	187.5	58.4	36.4	0	0	0	0	41.5	25.9	145	90.4	94.8	59.2

* Control Actions shown in brackets

Table 18: Thermal loading under outage contingencies – Scenario S1

Circuit/ Xformer	Circuit Section		LTE	STE	** Keith A bus + J1B – (Lower imports to 155 MW post)*		Keith A bus + C24Z		** Z7E+C21J- (After 1st outage lower imports to 0 MW and BB to 460 MW)*		** Z7E+C24Z – (After 1st outage lower imports to 0 MW, BB to 478 MW and TA Windsor to 44 MW + Arm 62 MW Kingsville L/R for next contingency)*	
	From	To	A/MVA	A/MVA	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE /MVA
C21J	Keith TS	Malden TS	1020	1100	0	0	0	0	0	0	367.7	36.1
C21J	Malden TS	Sandwich JCT	1020	1100	65.8	6.5	47.3	4.6	0	0	243.6	23.9
C21J	Sandwich JCT	Leamington TS	1370	1570	61.3	4.5	39.4	2.9	0	0	238.8	17.4
C21J	Leamington	Chatham SS	1370	1570	66.2	4.8	42	3.1	0	0	208	15.2
C22J	Keith TS	Malden TS	1020	1100	649.2	63.6	861.8	84.5	541.9	53.1	363	35.6
C22J	Malden TS	Sandwich JCT	1050	1150	412.9	39.3	588.6	56.1	273.4	26	240.1	22.9
C22J	Sandwich JCT	Leamington TS	1020	1100	409.6	40.2	586	57.5	269	26.4	235.1	23
C22J	Leamington	Chatham SS	1020	1100	325.2	31.9	483.1	47.4	224.9	22	205.5	20.1
C23Z	Lauzon TS	Sandwich JCT	1400	1900	300.7	21.5	388.4	27.7	276.5	19.8	425.5	30.4
C23Z	Sandwich JCT	Comber WF JCT	1400	1840	294.6	21	381.1	27.2	270.3	19.3	420	30
C23Z	Comber WF	KEPA WF JCT	1400	1840	164.4	11.7	253.8	18.1	152.3	10.9	261	18.6
C23Z	KEPA WF JCT	Dillon RWEC JCT	1400	1690	159	11.4	248.5	17.8	146.7	10.5	256.7	18.3
C23Z	Dillon RWEC	Chatham SS	1400	1690	242.5	17.3	304.6	21.8	249.5	17.8	253.6	18.1
C24Z	Lauzon TS	Sandwich JCT	1400	1900	366.8	26.2	0	0	342.2	24.4	0	0
C24Z	Sandwich JCT	Comber WF JCT	1040	1130	362.5	34.9	0	0	338	32.5	0	0
C24Z	Comber WF	KEPA WF JCT	1040	1130	202.5	19.5	0	0	182.9	17.6	0	0
C24Z	KEPA WF JCT	Chatham SS	1020	1100	413	40.5	0	0	427.4	41.9	0	0
J3E	Keith TS	Crawford JCT	1070	1390	638.2	59.6	951.6	88.9	695.5	65	781	73
J3E	Crawford JCT	Essex TS	1070	1390	447.2	41.8	753.1	70.4	493	46.1	576.2	53.9
J4E	Keith TS	Crawford JCT	1000	1090	614.5	61.4	927.8	92.8	668.1	66.8	752.9	75.3
J4E	Crawford JCT	Essex TS	1000	1090	465.6	46.6	774.1	77.4	517.2	51.7	601.7	60.2
Z1E	Essex TS	Windsor Transalta JCT	1260	1430	273.8	21.7	531.4	42.2	869.3	69	1025.8	81.4
Z1E	Windsor Transalta JCT	Walker JCT	1260	1430	570.1	45.2	861.1	68.3	1197.4	95	1237.4	98.2
Z1E	Walker JCT	Jefferson JCT	1140	1390	291.2	25.5	479.5	42.1	611.1	53.6	570.2	50
Z1E	Jefferson JCT	Lauzon TS	1190	1370	286.3	24.1	462.2	38.8	598.2	50.3	551.1	46.3
Z7E	Essex TS	Walker JCT	1260	1430	558.4	44.3	864.8	68.6	0	0	0	0
Z7E	Walker JCT	Jefferson JCT	1140	1390	293.4	25.7	474	41.6	0	0	0	0
Z7E	Jefferson JCT	Lauzon TS	1190	1370	289.4	24.3	457.1	38.4	0	0	0	0
Lauzon T1			296.8	364.2	45.8	15.4	89.2	30.1	42.3	14.3	50.3	17
Lauzon T2			296.8	364.2	50	16.8	0	0	42.3	14.3	0	0
Keith T11			180.3	224.5	0	0	0	0	43.4	24.1	58.4	32.4
Keith T12			160.3	187.5	159.2	99.3	155.4	97	48.9	30.5	65.8	41.1

* Control Actions shown in brackets

Table 18: Thermal loading under outage contingencies – Scenario S1 (continued)

Circuit/ Xformer	Circuit Section		LTE	STE	* J3E+Z7E-(After 1st outage lower Imports to 0 MW and BB to 305 MW)		* J3E+C21J- (After 1st outage lower Imports to 0 MW and BB to 305 MW)		* J3E+C24Z – (After 1st outage lower imports to 0 MW and BB to 260 MW + Arm 62 MW Kingsville & 50 MW Bell River L/R for next contingency)	
	From	To	A/MVA	A/MVA	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE /MVA
C21J	Keith TS	Malden TS	1020	1100	235.6	23.1	0	0	227.2	22.3
C21J	Malden TS	Sandwich JCT	1020	1100	138.3	13.6	0	0	144.9	14.2
C21J	Sandwich JCT	Leamington TS	1370	1570	131.2	9.6	0	0	137.4	10
C21J	Leamington	Chatham SS	1370	1570	125.8	9.2	0	0	115.2	8.4
C22J	Keith TS	Malden TS	1020	1100	232.1	22.8	403.5	39.6	223.3	21.9
C22J	Malden TS	Sandwich JCT	1050	1150	135.7	12.9	165.5	15.8	142.1	13.5
C22J	Sandwich JCT	Leamington TS	1020	1100	128.6	12.6	158.9	15.6	134.5	13.2
C22J	Leamington	Chatham SS	1020	1100	124.5	12.2	147	14.4	114.2	11.2
C23Z	Lauzon TS	Sandwich JCT	1400	1900	376.6	26.9	373.4	26.7	503.4	36
C23Z	Sandwich JCT	Comber WF JCT	1400	1840	371.8	26.6	368.4	26.3	498.7	35.6
C23Z	Comber WF	KEPA WF JCT	1400	1840	207.1	14.8	208.2	14.9	325.1	23.2
C23Z	KEPA WF JCT	Dillon RWEC JCT	1400	1690	202.9	14.5	203.8	14.6	321.5	23
C23Z	Dillon RWEC	Chatham SS	1400	1690	207.8	14.8	216.5	15.5	265	18.9
C24Z	Lauzon TS	Sandwich JCT	1400	1900	447.4	32	443	31.6	0	0
C24Z	Sandwich JCT	Comber WF JCT	1040	1130	444	42.7	439.5	42.3	0	0
C24Z	Comber WF	KEPA WF JCT	1040	1130	267.2	25.7	265.5	25.5	0	0
C24Z	KEPA WF JCT	Chatham SS	1020	1100	345	33.8	355.1	34.8	0	0
J3E	Keith TS	Crawford JCT	1070	1390	0	0	0	0	0	0
J3E	Crawford JCT	Essex TS	1070	1390	0	0	0	0	0	0
J4E	Keith TS	Crawford JCT	1000	1090	967.4	96.7	955.1	95.5	994.8	99.5
J4E	Crawford JCT	Essex TS	1000	1090	595.7	59.6	600.5	60.1	631.5	63.2
Z1E	Essex TS	Windsor Transalta JCT	1260	1430	460.8	36.6	174.1	13.8	155.8	12.4
Z1E	Windsor Transalta JCT	Walker JCT	1260	1430	789.1	62.6	419.7	33.3	425.6	33.8
Z1E	Walker JCT	Jefferson JCT	1140	1390	448.1	39.3	228.9	20.1	200.1	17.6
Z1E	Jefferson JCT	Lauzon TS	1190	1370	466.4	39.2	235.3	19.8	205.6	17.3
Z7E	Essex TS	Walker JCT	1260	1430	0	0	401.7	31.9	415	32.9
Z7E	Walker JCT	Jefferson JCT	1140	1390	0	0	239	21	209.6	18.4
Z7E	Jefferson JCT	Lauzon TS	1190	1370	0	0	246	20.7	215.4	18.1
Lauzon T1			296.8	364.2	60.3	20.3	60	20.2	19.9	6.7
Lauzon T2			296.8	364.2	76.2	25.7	74.9	25.3	0	0
Keith T11			180.3	224.5	50.5	28	46.7	25.9	53.4	29.6
Keith T12			160.3	187.5	57	35.5	52.6	32.8	60.2	37.6

* Control Actions shown in brackets

Table 19: Thermal loading under outage contingencies – Scenario S2

Circuit/ Xformer	Circuit Section		LTE	STE	Keith A bus + J1B		Keith A bus + C24Z		* Z7E+C21J- (After 1st outage lower Imports to 0 MW and BB to 513 MW)		* Z7E+C24Z – (After 1st outage lower imports to 0 MW, BB to 478 MW and TA Windsor to 44 MW + Arm 27 MW Kingsville L/R for next contingency)	
	From	To	A/MVA	A/MVA	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE /MVA
C21J	Keith TS	Malden TS	1020	1100	0	0	0	0	0	0	401.4	39.4
C21J	Malden TS	Sandwich JCT	1020	1100	52.6	5.2	40.3	4	0	0	265.9	26.1
C21J	Sandwich JCT	Leamington TS	1370	1570	47.7	3.5	31.7	2.3	0	0	262.1	19.1
C21J	Leamington	Chatham SS	1370	1570	138.3	10.1	109.1	8	0	0	200.6	14.6
C22J	Keith TS	Malden TS	1020	1100	736.9	72.2	930.5	91.2	681.8	66.8	396	38.8
C22J	Malden TS	Sandwich JCT	1050	1150	479.1	45.6	641.7	61.1	378.2	36	261	24.9
C22J	Sandwich JCT	Leamington TS	1020	1100	476.8	46.7	639.7	62.7	376.2	36.9	257.1	25.2
C22J	Leamington	Chatham SS	1020	1100	329.6	32.3	471.7	46.2	263.4	25.8	199.1	19.5
C23Z	Lauzon TS	Sandwich JCT	1400	1900	259.2	18.5	356.7	25.5	245.9	17.6	436.4	31.2
C23Z	Sandwich JCT	Comber WF JCT	1400	1840	251.5	18	347.8	24.8	237.3	17	429.6	30.7
C23Z	Comber WF	KEPA WF JCT	1400	1840	174.8	12.5	270.9	19.4	188.2	13.4	280.2	20
C23Z	KEPA WF JCT	Dillon RWEC JCT	1400	1690	165.4	11.8	261.6	18.7	179.1	12.8	275.2	19.7
C23Z	Dillon RWEC	Chatham SS	1400	1690	288	20.6	357.5	25.5	315.2	22.5	296.3	21.2
C24Z	Lauzon TS	Sandwich JCT	1400	1900	317.2	22.7	0	0	297.5	21.3	0	0
C24Z	Sandwich JCT	Comber WF JCT	1040	1130	311.6	30	0	0	291.3	28	0	0
C24Z	Comber WF	KEPA WF JCT	1040	1130	175.1	16.8	0	0	173.4	16.7	0	0
C24Z	KEPA WF JCT	Chatham SS	1020	1100	469.9	46.1	0	0	499.8	49	0	0
J3E	Keith TS	Crawford JCT	1070	1390	635.3	59.4	904.1	84.5	707.8	66.2	791.4	74
J3E	Crawford JCT	Essex TS	1070	1390	423.3	39.6	692.2	64.7	494	46.2	574.8	53.7
J4E	Keith TS	Crawford JCT	1000	1090	604	60.4	875.3	87.5	676.1	67.6	759.1	75.9
J4E	Crawford JCT	Essex TS	1000	1090	452.7	45.3	719.1	71.9	524	52.4	606.3	60.6
Z1E	Essex TS	Windsor Transalta JCT	1260	1430	187	14.8	446.3	35.4	843.8	67	1005.1	79.8
Z1E	Windsor Transalta JCT	Walker JCT	1260	1430	516.6	41	792	62.9	1180.1	93.7	1235.9	98.1
Z1E	Walker JCT	Jefferson JCT	1140	1390	155.1	13.6	381.2	33.4	428.4	37.6	342.5	30
Z1E	Jefferson JCT	Lauzon TS	1190	1370	144.5	12.1	360.7	30.3	404.9	34	302.5	25.4
Z7E	Essex TS	Walker JCT	1260	1430	527.8	41.9	817	64.8	0	0	0	0
Z7E	Walker JCT	Jefferson JCT	1140	1390	155.1	13.6	371.9	32.6	0	0	0	0
Z7E	Jefferson JCT	Lauzon TS	1190	1370	146	12.3	351.6	29.6	0	0	0	0
Lauzon T1			296.8	364.2	55.7	18.8	127	42.8	64.8	21.8	72.7	24.5
Lauzon T2			296.8	364.2	45.1	15.2	0	0	49.1	16.6	0	0
Keith T11			180.3	224.5	0	0	0	0	25.9	14.4	50.2	27.8
Keith T12			160.3	187.5	138.1	86.2	118.5	74	29.2	18.2	56.6	35.3

* Control Actions shown in brackets

Table 19: Thermal loading under outage contingencies – Scenario S2 (continued)

Circuit/ Xformer	Circuit Section		LTE	STE	* J3E+Z7E- (After 1st outage lower Imports to 0 MW and BB to 335 MW)		* J3E+C21J- (After 1st outage lower Imports to 0 MW and BB to 335 MW)		* J3E+C24Z – (After 1st outage lower imports to 0 MW and BB to 260 MW + Arm 27 MW Kingsville & 50 MW Bell River L/R for next contingency)	
	From	To	A/MVA	A/MVA	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE /MVA
C21J	Keith TS	Malden TS	1020	1100	286.5	28.1	0	0	198.5	19.5
C21J	Malden TS	Sandwich JCT	1020	1100	156.3	15.3	0	0	109.1	10.7
C21J	Sandwich JCT	Leamington TS	1370	1570	151.5	11.1	0	0	101.6	7.4
C21J	Leamington	Chatham SS	1370	1570	118.7	8.7	0	0	164.6	12
C22J	Keith TS	Malden TS	1020	1100	282.9	27.7	519.8	51	194.8	19.1
C22J	Malden TS	Sandwich JCT	1050	1150	152.6	14.5	218.4	20.8	104.6	10
C22J	Sandwich JCT	Leamington TS	1020	1100	147.7	14.5	215.8	21.2	97	9.5
C22J	Leamington	Chatham SS	1020	1100	118.6	11.6	207.5	20.3	163.8	16.1
C23Z	Lauzon TS	Sandwich JCT	1400	1900	338.1	24.2	331.4	23.7	516.7	36.9
C23Z	Sandwich JCT	Comber WF JCT	1400	1840	331.9	23.7	325.1	23.2	511.2	36.5
C23Z	Comber WF	KEPA WF JCT	1400	1840	189.3	13.5	187.2	13.4	338.8	24.2
C23Z	KEPA WF JCT	Dillon RWEC JCT	1400	1690	184.1	13.2	182	13	334.7	23.9
C23Z	Dillon RWEC	Chatham SS	1400	1690	243.1	17.4	247.2	17.7	291.5	20.8
C24Z	Lauzon TS	Sandwich JCT	1400	1900	403.4	28.8	396.1	28.3	0	0
C24Z	Sandwich JCT	Comber WF JCT	1040	1130	398.8	38.4	391.5	37.6	0	0
C24Z	Comber WF	KEPA WF JCT	1040	1130	233.8	22.5	229.2	22	0	0
C24Z	KEPA WF JCT	Chatham SS	1020	1100	399.9	39.2	406.4	39.8	0	0
J3E	Keith TS	Crawford JCT	1070	1390	0	0	0	0	0	0
J3E	Crawford JCT	Essex TS	1070	1390	0	0	0	0	0	0
J4E	Keith TS	Crawford JCT	1000	1090	962.5	96.2	932.8	93.3	994.7	99.5
J4E	Crawford JCT	Essex TS	1000	1090	573.3	57.3	548	54.8	607.9	60.8
Z1E	Essex TS	Windsor Transalta JCT	1260	1430	387.9	30.8	60.2	4.8	28.7	2.3
Z1E	Windsor Transalta JCT	Walker JCT	1260	1430	725.4	57.6	354.4	28.1	367.2	29.1
Z1E	Walker JCT	Jefferson JCT	1140	1390	247.5	21.7	110.1	9.7	47.1	4.1
Z1E	Jefferson JCT	Lauzon TS	1190	1370	281.3	23.6	125.3	10.5	67.5	5.7
Z7E	Essex TS	Walker JCT	1260	1430	0	0	370.2	29.4	412	32.7
Z7E	Walker JCT	Jefferson JCT	1140	1390	0	0	124.8	10.9	57	5
Z7E	Jefferson JCT	Lauzon TS	1190	1370	0	0	140	11.8	78.2	6.6
Lauzon T1			296.8	364.2	57	19.2	56.1	18.9	39.2	13.2
Lauzon T2			296.8	364.2	63.4	21.4	61.5	20.7	0	0
Keith T11			180.3	224.5	34.6	19.2	32.5	18	37.4	20.7
Keith T12			160.3	187.5	39	24.3	36.6	22.8	42.2	26.3

* Control Actions shown in brackets

Table 20: Thermal loading with all elements in-service for single contingencies – Scenario S3

Circuit/ Xformer	Circuit Section		LTE	STE	C21J		C23Z		J3E		Z7E		Keith A bus	
	From	To	A/MVA	A/MVA	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE
C21J	Keith TS	Malden TS	1020	1100	0	0	479.7	47	382.3	37.5	394.8	38.7	0	0
C21J	Malden TS	Sandwich JCT	1020	1100	0	0	637.8	62.5	539.9	52.9	552.7	54.2	256.8	25.2
C21J	Sandwich JCT	Leamington TS	1370	1570	0	0	637	46.5	539	39.3	551.7	40.3	255.2	18.6
C21J	Leamington	Chatham SS	1370	1570	0	0	685.4	50	587.4	42.9	599.9	43.8	349.7	25.5
C22J	Keith TS	Malden TS	1020	1100	422.8	41.4	470.4	46.1	374.2	36.7	386.5	37.9	616.2	60.4
C22J	Malden TS	Sandwich JCT	1050	1150	726.1	69.1	628.2	59.8	531.8	50.6	544.3	51.8	672.5	64
C22J	Sandwich JCT	Leamington TS	1020	1100	725.9	71.2	627.8	61.5	531.2	52.1	543.6	53.3	672.1	65.9
C22J	Leamington	Chatham SS	1020	1100	826.6	81	676.3	66.3	579.7	56.8	592	58	673.4	66
C23Z	Lauzon TS	Sandwich JCT	1400	1900	619	44.2	0	0	568.1	40.6	545	38.9	567.5	40.5
C23Z	Sandwich JCT	Comber WF JCT	1400	1840	616.7	44.1	0	0	565.5	40.4	542.6	38.8	565.1	40.4
C23Z	Comber WF	KEPA WF JCT	1400	1840	614	43.9	0	0	562.6	40.2	539.8	38.6	562.3	40.2
C23Z	KEPA WF JCT	Dillon RWEC JCT	1400	1690	612.6	43.8	0	0	561	40.1	538.3	38.5	560.8	40.1
C23Z	Dillon RWEC	Chatham SS	1400	1690	610.9	43.6	0	0	559.3	39.9	536.6	38.3	559.1	39.9
C24Z	Lauzon TS	Sandwich JCT	1400	1900	611.9	43.7	842.7	60.2	561.9	40.1	539	38.5	561.2	40.1
C24Z	Sandwich JCT	Comber WF JCT	1040	1130	609.8	58.6	840.5	80.8	559.5	53.8	536.8	51.6	559	53.7
C24Z	Comber WF	KEPA WF JCT	1040	1130	607.3	58.4	837.5	80.5	556.8	53.5	534.2	51.4	556.4	53.5
C24Z	KEPA WF JCT	Chatham SS	1020	1100	600.7	58.9	828.2	81.2	549.5	53.9	527.6	51.7	549.7	53.9
J3E	Keith TS	Crawford JCT	1070	1390	334.5	31.3	733.3	68.5	0	0	473.4	44.2	407.8	38.1
J3E	Crawford JCT	Essex TS	1070	1390	111	10.4	516.8	48.3	0	0	252.5	23.6	191.5	17.9
J4E	Keith TS	Crawford JCT	1000	1090	291.3	29.1	699.2	69.9	802.1	80.2	434	43.4	370.5	37
J4E	Crawford JCT	Essex TS	1000	1090	157.9	15.8	548.8	54.9	426.1	42.6	291.1	29.1	226.6	22.7
Z1E	Essex TS	Windsor Transalta JCT	1260	1430	196.6	15.6	271.5	21.6	173.3	13.8	354.1	28.1	167.2	13.3
Z1E	Windsor Transalta JCT	Walker JCT	1260	1430	202.1	16	614	48.7	312.4	24.8	696.6	55.3	298.2	23.7
Z1E	Walker JCT	Jefferson JCT	1140	1390	223.5	19.6	208.1	18.3	162.7	14.3	303.5	26.6	167.3	14.7
Z1E	Jefferson JCT	Lauzon TS	1190	1370	243.9	20.5	187.9	15.8	179.6	15.1	333.3	28	184.6	15.5
Z7E	Essex TS	Walker JCT	1260	1430	220.8	17.5	646.8	51.3	316.4	25.1	0	0	301.7	23.9
Z7E	Walker JCT	Jefferson JCT	1140	1390	239	21	199.4	17.5	180.5	15.8	0	0	184.8	16.2
Z7E	Jefferson JCT	Lauzon TS	1190	1370	259.1	21.8	179.9	15.1	197	16.6	0	0	201.8	17
Lauzon T1			296.8	364.2	147.4	49.7	0	0	125.6	42.3	117.9	39.7	127.7	43
Lauzon T2			296.8	364.2	144.4	48.7	124.2	41.8	122.9	41.4	115.4	38.9	125	42.1
Keith T11			180.3	224.5	43.1	23.9	38.7	21.4	22.5	12.5	18	10	0	0
Keith T12			160.3	187.5	48.6	30.3	43.6	27.2	25.4	15.8	20.3	12.7	52.6	32.8

Table 21: Thermal loading with all elements in-service for single contingencies – Scenario S4

Circuit/ Xformer	Circuit Section		LTE	STE	C21J		C23Z		J3E		Z7E		Keith A bus	
	From	To	A/MVA	A/MVA	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE
C21J	Keith TS	Malden TS	1020	1100	0	0	425.7	41.7	340.9	33.4	351.4	34.4	0	0
C21J	Malden TS	Sandwich JCT	1020	1100	0	0	583.4	57.2	498	48.8	509	49.9	247.8	24.3
C21J	Sandwich JCT	Leamington TS	1370	1570	0	0	583	42.6	497.6	36.3	508.5	37.1	246.4	18
C21J	Leamington	Chatham SS	1370	1570	0	0	721.6	52.7	635.9	46.4	647.1	47.2	428.1	31.2
C22J	Keith TS	Malden TS	1020	1100	356.4	34.9	417.7	40.9	334.1	32.8	344.3	33.8	553.4	54.3
C22J	Malden TS	Sandwich JCT	1050	1150	636.8	60.7	574.7	54.7	490.5	46.7	501.3	47.7	620.5	59.1
C22J	Sandwich JCT	Leamington TS	1020	1100	637.6	62.5	574.6	56.3	490.5	48.1	501.1	49.1	620.5	60.8
C22J	Leamington	Chatham SS	1020	1100	917.6	90	712.1	69.8	627.6	61.5	638.6	62.6	714.6	70.1
C23Z	Lauzon TS	Sandwich JCT	1400	1900	579.4	41.4	0	0	525.1	37.5	504.5	36	517.1	36.9
C23Z	Sandwich JCT	Comber WF JCT	1400	1840	576.6	41.2	0	0	521.9	37.3	501.4	35.8	514.1	36.7
C23Z	Comber WF	KEPA WF JCT	1400	1840	573.4	41	0	0	518.2	37	497.8	35.6	510.7	36.5
C23Z	KEPA WF JCT	Dillon RWEC JCT	1400	1690	571.8	40.8	0	0	516.4	36.9	496.1	35.4	509	36.4
C23Z	Dillon RWEC	Chatham SS	1400	1690	569.9	40.7	0	0	514.3	36.7	494.1	35.3	507.1	36.2
C24Z	Lauzon TS	Sandwich JCT	1400	1900	573.1	40.9	780.2	55.7	519.9	37.1	499.6	35.7	511.8	36.6
C24Z	Sandwich JCT	Comber WF JCT	1040	1130	570.6	54.9	777.6	74.8	516.9	49.7	496.6	47.8	509	48.9
C24Z	Comber WF	KEPA WF JCT	1040	1130	567.6	54.6	774.3	74.4	513.5	49.4	493.3	47.4	505.9	48.6
C24Z	KEPA WF JCT	Chatham SS	1020	1100	559.4	54.8	763.7	74.9	503.8	49.4	484.2	47.5	497.3	48.8
J3E	Keith TS	Crawford JCT	1070	1390	359.7	33.6	689.4	64.4	0	0	476	44.5	421.4	39.4
J3E	Crawford JCT	Essex TS	1070	1390	170.8	16	463.6	43.3	0	0	254.8	23.8	201.5	18.8
J4E	Keith TS	Crawford JCT	1000	1090	306.5	30.6	647.4	64.7	773.7	77.4	427.7	42.8	373.6	37.4
J4E	Crawford JCT	Essex TS	1000	1090	223.2	22.3	506.2	50.6	391.1	39.1	306	30.6	252.9	25.3
Z1E	Essex TS	Windsor Transalta JCT	1260	1430	212.6	16.9	196.2	15.6	111.8	8.9	326.9	25.9	106.2	8.4
Z1E	Windsor Transalta JCT	Walker JCT	1260	1430	151.5	12	548.5	43.5	246.6	19.6	653.9	51.9	244.7	19.4
Z1E	Walker JCT	Jefferson JCT	1140	1390	273.3	24	162.4	14.2	159.9	14	266.2	23.3	157.7	13.8
Z1E	Jefferson JCT	Lauzon TS	1190	1370	293	24.6	145.3	12.2	180.9	15.2	308.1	25.9	177.9	15
Z7E	Essex TS	Walker JCT	1260	1430	254.1	20.2	603.6	47.9	304.1	24.1	0	0	309.5	24.6
Z7E	Walker JCT	Jefferson JCT	1140	1390	281.8	24.7	146.3	12.8	171.7	15.1	0	0	168	14.7
Z7E	Jefferson JCT	Lauzon TS	1190	1370	301.7	25.4	129.3	10.9	192.8	16.2	0	0	188.5	15.8
Lauzon T1			296.8	364.2	129.3	43.6	0	0	106.7	36	99.9	33.7	106	35.7
Lauzon T2			296.8	364.2	126.6	42.7	95.5	32.2	104.4	35.2	97.7	32.9	103.6	34.9
Keith T11			180.3	224.5	58.9	32.7	17.5	9.7	35.5	19.7	30.2	16.8	0	0
Keith T12			160.3	187.5	66.4	41.4	19.8	12.3	40	25	34.1	21.3	77.4	48.3

Table 22: Thermal loading with all elements in-service for double contingencies – Scenario S3

Circuit/ Xformer	Circuit Section		LTE	STE	C21J+C23Z		C21J+C22J		C22J+C24Z		C23Z+C24Z		** Lauzon T1L7 BF: Z7E+C23Z – (Lower TA Windsor to 44 MW post)*	
	From	To	A/MVA	A/MVA	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE
C21J	Keith TS	Malden TS	1020	1100	0	0	0	0	561.8	55.1	641.3	62.9	483.9	47.4
C21J	Malden TS	Sandwich JCT	1020	1100	0	0	0	0	865.2	84.8	799.5	78.4	642.2	63
C21J	Sandwich JCT	Leamington TS	1370	1570	0	0	0	0	865.1	63.1	798.5	58.3	641.5	46.8
C21J	Leamington	Chatham SS	1370	1570	0	0	0	0	966	70.5	846.1	61.8	690.1	50.4
C22J	Keith TS	Malden TS	1020	1100	564	55.3	0	0	0	0	629.7	61.7	474.6	46.5
C22J	Malden TS	Sandwich JCT	1050	1150	864.9	82.4	0	0	0	0	787.7	75	632.6	60.2
C22J	Sandwich JCT	Leamington TS	1020	1100	864.9	84.8	0	0	0	0	787	77.2	632.2	62
C22J	Leamington	Chatham SS	1020	1100	965.8	94.7	0	0	0	0	834.7	81.8	680.9	66.8
C23Z	Lauzon TS	Sandwich JCT	1400	1900	0	0	692.1	49.4	982	70.1	0	0	0	0
C23Z	Sandwich JCT	Comber WF JCT	1400	1840	0	0	689.6	49.3	979.9	70	0	0	0	0
C23Z	Comber WF	KEPA WF JCT	1400	1840	0	0	686.6	49	976.9	69.8	0	0	0	0
C23Z	KEPA WF JCT	Dillon RWEC JCT	1400	1690	0	0	685	48.9	975.2	69.7	0	0	0	0
C23Z	Dillon RWEC	Chatham SS	1400	1690	0	0	683.1	48.8	973.1	69.5	0	0	0	0
C24Z	Lauzon TS	Sandwich JCT	1400	1900	968.8	69.2	684.1	48.9	0	0	0	0	880.1	62.9
C24Z	Sandwich JCT	Comber WF JCT	1040	1130	966.8	93	681.8	65.6	0	0	0	0	877.9	84.4
C24Z	Comber WF	KEPA WF JCT	1040	1130	964	92.7	679.1	65.3	0	0	0	0	874.9	84.1
C24Z	KEPA WF JCT	Chatham SS	1020	1100	954.7	93.6	671.2	65.8	0	0	0	0	865.2	84.8
J3E	Keith TS	Crawford JCT	1070	1390	637.1	59.5	227.2	21.2	624.1	58.3	1003.6	93.8	786.9	73.5
J3E	Crawford JCT	Essex TS	1070	1390	414.8	38.8	80	7.5	401.5	37.5	800.8	74.8	566.8	53
J4E	Keith TS	Crawford JCT	1000	1090	599.6	60	174.5	17.5	586.6	58.7	978.4	97.8	751.7	75.2
J4E	Crawford JCT	Essex TS	1000	1090	451.2	45.1	116.3	11.6	438	43.8	823.6	82.4	600.5	60
Z1E	Essex TS	Windsor Transalta JCT	1260	1430	157.3	12.5	316.8	25.1	144.9	11.5	573.3	45.5	1003.3	79.6
Z1E	Windsor Transalta JCT	Walker JCT	1260	1430	509.7	40.5	81.7	6.5	495.1	39.3	907.2	72	1253.9	99.5
Z1E	Walker JCT	Jefferson JCT	1140	1390	98.6	8.6	361.8	31.7	85.7	7.5	507.9	44.6	356.8	31.3
Z1E	Jefferson JCT	Lauzon TS	1190	1370	77.3	6.5	382.3	32.1	64.5	5.4	488.6	41.1	316.7	26.6
Z7E	Essex TS	Walker JCT	1260	1430	548.4	43.5	90.2	7.2	539.4	42.8	922.7	73.2	0	0
Z7E	Walker JCT	Jefferson JCT	1140	1390	86.8	7.6	375.6	32.9	73.8	6.5	500.8	43.9	0	0
Z7E	Jefferson JCT	Lauzon TS	1190	1370	65.9	5.5	396	33.3	53.1	4.5	481.9	40.5	0	0
Lauzon T1			296.8	364.2	0	0	179.1	60.3	176.3	59.4	0	0	0	0
Lauzon T2			296.8	364.2	171.5	57.8	175.6	59.2	0	0	0	0	134.9	45.4
Keith T11			180.3	224.5	16	8.9	154.2	85.5	26.9	14.9	96.5	53.5	46.5	25.8
Keith T12			160.3	187.5	18	11.2	0	0	0	0	108.8	67.9	52.4	32.7

* Control Actions shown in brackets

Table 23: Thermal loading with all elements in-service for double contingencies – Scenario S4

Circuit/ Xformer	Circuit Section		LTE	STE	*C21J+C23Z – (Lower exports to 208 MW post)*		C21J+C22J		C22J+C24Z		C23Z+C24Z		Lauzon T1L7 BF: Z7E+C23Z	
	From	To	A/MVA	A/MVA	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE
C21J	Keith TS	Malden TS	1020	1100	0	0	0	0	481.3	47.2	563.9	55.3	424.7	41.6
C21J	Malden TS	Sandwich JCT	1020	1100	0	0	0	0	771	75.6	722	70.8	582.7	57.1
C21J	Sandwich JCT	Leamington TS	1370	1570	0	0	0	0	771.7	56.3	721.2	52.6	582.2	42.5
C21J	Leamington	Chatham SS	1370	1570	0	0	0	0	1053.2	76.9	859.3	62.7	721.1	52.6
C22J	Keith TS	Malden TS	1020	1100	436.7	42.8	0	0	0	0	553.6	54.3	416.7	40.9
C22J	Malden TS	Sandwich JCT	1050	1150	720.8	68.7	0	0	0	0	711.2	67.7	574	54.7
C22J	Sandwich JCT	Leamington TS	1020	1100	721.6	70.7	0	0	0	0	710.8	69.7	573.9	56.3
C22J	Leamington	Chatham SS	1020	1100	1002	98.2	0	0	0	0	847.9	83.1	711.6	69.8
C23Z	Lauzon TS	Sandwich JCT	1400	1900	0	0	640.3	45.7	900.1	64.3	0	0	0	0
C23Z	Sandwich JCT	Comber WF JCT	1400	1840	0	0	637.2	45.5	897.6	64.1	0	0	0	0
C23Z	Comber WF	KEPA WF JCT	1400	1840	0	0	633.6	45.3	894.3	63.9	0	0	0	0
C23Z	KEPA WF JCT	Dillon RWEC JCT	1400	1690	0	0	631.8	45.1	892.5	63.7	0	0	0	0
C23Z	Dillon RWEC	Chatham SS	1400	1690	0	0	629.6	45	890.2	63.6	0	0	0	0
C24Z	Lauzon TS	Sandwich JCT	1400	1900	886	63.3	633.3	45.2	0	0	0	0	793.5	56.7
C24Z	Sandwich JCT	Comber WF JCT	1040	1130	883.5	85	630.5	60.6	0	0	0	0	790.7	76
C24Z	Comber WF	KEPA WF JCT	1040	1130	880.3	84.6	627.2	60.3	0	0	0	0	787.1	75.7
C24Z	KEPA WF JCT	Chatham SS	1020	1100	869.6	85.3	617.4	60.5	0	0	0	0	775.6	76
J3E	Keith TS	Crawford JCT	1070	1390	623.1	58.2	290.5	27.2	609.5	57	883.1	82.5	715.7	66.9
J3E	Crawford JCT	Essex TS	1070	1390	396.9	37.1	188.4	17.6	383.4	35.8	662.4	61.9	488.2	45.6
J4E	Keith TS	Crawford JCT	1000	1090	577.8	57.8	235.7	23.6	564	56.4	847.1	84.7	672.1	67.2
J4E	Crawford JCT	Essex TS	1000	1090	443.8	44.4	223.8	22.4	430.6	43.1	697	69.7	532.6	53.3
Z1E	Essex TS	Windsor Transalta JCT	1260	1430	140.7	11.2	338.3	26.8	131	10.4	403.5	32	859.5	68.2
Z1E	Windsor Transalta JCT	Walker JCT	1260	1430	471.1	37.4	46.8	3.7	457.2	36.3	760.3	60.3	1202.8	95.5
Z1E	Walker JCT	Jefferson JCT	1140	1390	149.8	13.1	395	34.7	147	12.9	348.8	30.6	284.5	25
Z1E	Jefferson JCT	Lauzon TS	1190	1370	144.4	12.1	415.2	34.9	142.8	12	327.4	27.5	247.1	20.8
Z7E	Essex TS	Walker JCT	1260	1430	547.8	43.5	180.1	14.3	534.9	42.4	803.5	63.8	0	0
Z7E	Walker JCT	Jefferson JCT	1140	1390	135.4	11.9	405	35.5	132.8	11.6	335.9	29.5	0	0
Z7E	Jefferson JCT	Lauzon TS	1190	1370	130.9	11	425.3	35.7	130.5	11	314.6	26.4	0	0
Lauzon T1			296.8	364.2	0	0	157.6	53.1	140.5	47.4	0	0	0	0
Lauzon T2			296.8	364.2	134.9	45.5	154.4	52	0	0	0	0	96.5	32.5
Keith T11			180.3	224.5	7.5	4.2	178.5	99	17.2	9.5	61	33.8	19.3	10.7
Keith T12			160.3	187.5	8.5	5.3	0	0	0	0	68.8	42.9	21.7	13.5

* Control Actions shown in brackets

Table 24: Thermal loading under outage conditions – Scenario S3

Circuit/ Xformer	Circuit Section		LTE	STE	J20B+C21J		J3E+Z7E		Keith A bus + C23Z		** J3E+C23Z –(After 1st outage, Arm 62 MW Kingsville & 50 MW Bell River L/R for next contingency)*	
	From	To	A/MVA	A/MVA	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE
C21J	Keith TS	Malden TS	1020	1100	0	0	383.4	37.6	0	0	442.6	43.4
C21J	Malden TS	Sandwich JCT	1020	1100	0	0	541.2	53.1	277.7	27.2	600.2	58.8
C21J	Sandwich JCT	Leamington TS	1370	1570	0	0	540.3	39.4	276	20.1	599.2	43.7
C21J	Leamington	Chatham SS	1370	1570	0	0	588.7	43	379.9	27.7	647	47.2
C22J	Keith TS	Malden TS	1020	1100	472.2	46.3	375.3	36.8	738.6	72.4	433.6	42.5
C22J	Malden TS	Sandwich JCT	1050	1150	781.4	74.4	533	50.8	775.7	73.9	591.1	56.3
C22J	Sandwich JCT	Leamington TS	1020	1100	781.1	76.6	532.4	52.2	775.5	76	590.4	57.9
C22J	Leamington	Chatham SS	1020	1100	883.2	86.6	581	57	767.8	75.3	638.5	62.6
C23Z	Lauzon TS	Sandwich JCT	1400	1900	641.4	45.8	569.2	40.7	0	0	0	0
C23Z	Sandwich JCT	Comber WF JCT	1400	1840	639.1	45.7	566.5	40.5	0	0	0	0
C23Z	Comber WF	KEPA WF JCT	1400	1840	636.4	45.5	563.4	40.2	0	0	0	0
C23Z	KEPA WF JCT	Dillon RWEC JCT	1400	1690	635	45.4	561.8	40.1	0	0	0	0
C23Z	Dillon RWEC	Chatham SS	1400	1690	633.3	45.2	560	40	0	0	0	0
C24Z	Lauzon TS	Sandwich JCT	1400	1900	633.9	45.3	563	40.2	922.5	65.9	753.6	53.8
C24Z	Sandwich JCT	Comber WF JCT	1040	1130	631.9	60.8	560.6	53.9	920.5	88.5	751.3	72.2
C24Z	Comber WF	KEPA WF JCT	1040	1130	629.5	60.5	557.7	53.6	917.6	88.2	748.5	72
C24Z	KEPA WF JCT	Chatham SS	1020	1100	622.8	61.1	550	53.9	908.3	89.1	739.8	72.5
J3E	Keith TS	Crawford JCT	1070	1390	313	29.3	0	0	669.9	62.6	0	0
J3E	Crawford JCT	Essex TS	1070	1390	88.9	8.3	0	0	449.9	42.1	0	0
J4E	Keith TS	Crawford JCT	1000	1090	267.4	26.7	844.2	84.4	633.9	63.4	943	94.3
J4E	Crawford JCT	Essex TS	1000	1090	140.2	14	461.2	46.1	484.4	48.4	576.6	57.7
Z1E	Essex TS	Windsor Transalta JCT	1260	1430	209.1	16.6	295.2	23.4	197.7	15.7	192.3	15.3
Z1E	Windsor Transalta JCT	Walker JCT	1260	1430	168.2	13.3	640.2	50.8	546.5	43.4	392.3	31.1
Z1E	Walker JCT	Jefferson JCT	1140	1390	245.1	21.5	355.2	31.2	136.3	12	151.3	13.3
Z1E	Jefferson JCT	Lauzon TS	1190	1370	266	22.4	389	32.7	115.5	9.7	160.4	13.5
Z7E	Essex TS	Walker JCT	1260	1430	204.6	16.2	0	0	580.6	46.1	391.2	31.1
Z7E	Walker JCT	Jefferson JCT	1140	1390	259.3	22.7	0	0	126.4	11.1	167.4	14.7
Z7E	Jefferson JCT	Lauzon TS	1190	1370	280	23.5	0	0	106.3	8.9	177.1	14.9
Lauzon T1			296.8	364.2	154.2	51.9	125.3	42.2	0	0	0	0
Lauzon T2			296.8	364.2	151.1	50.9	122.7	41.3	154.4	52	96.4	32.5
Keith T11			180.3	224.5	49.8	27.6	22.5	12.5	0	0	8.4	4.7
Keith T12			160.3	187.5	56.2	35	25.3	15.8	50.8	31.7	9.5	5.9

* Control Actions shown in brackets

Table 25: Thermal loading under outage conditions – Scenario S4

Circuit/ Xformer	Circuit Section		LTE	STE	J20B+C21J		J3E+Z7E		Keith A bus + C23Z		** J3E+C23Z – (After 1st outage place Lauzon cap I/S +arm 54 MW Kingsville L/R for next contingency)*	
	From	To	A/MVA	A/MVA	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE	A/MVA	%LTE
C21J	Keith TS	Malden TS	1020	1100	0	0	343.4	33.7	0	0	402.5	39.5
C21J	Malden TS	Sandwich JCT	1020	1100	0	0	500.7	49.1	266	26.1	559.5	54.8
C21J	Sandwich JCT	Leamington TS	1370	1570	0	0	500.3	36.5	264.5	19.3	559	40.8
C21J	Leamington	Chatham SS	1370	1570	0	0	638.7	46.6	454.8	33.2	696.8	50.9
C22J	Keith TS	Malden TS	1020	1100	397.2	38.9	336.5	33	661.2	64.8	394.7	38.7
C22J	Malden TS	Sandwich JCT	1050	1150	689.9	65.7	493.1	47	711.2	67.7	551.1	52.5
C22J	Sandwich JCT	Leamington TS	1020	1100	690.5	67.7	493.1	48.3	711.3	69.7	550.9	54
C22J	Leamington	Chatham SS	1020	1100	976.4	95.7	630.4	61.8	797.3	78.2	687.6	67.4
C23Z	Lauzon TS	Sandwich JCT	1400	1900	600.6	42.9	525.6	37.5	0	0	0	0
C23Z	Sandwich JCT	Comber WF JCT	1400	1840	597.9	42.7	522.1	37.3	0	0	0	0
C23Z	Comber WF	KEPA WF JCT	1400	1840	594.8	42.5	518.3	37	0	0	0	0
C23Z	KEPA WF JCT	Dillon RWEC JCT	1400	1690	593.2	42.4	516.4	36.9	0	0	0	0
C23Z	Dillon RWEC	Chatham SS	1400	1690	591.3	42.2	514.2	36.7	0	0	0	0
C24Z	Lauzon TS	Sandwich JCT	1400	1900	594	42.4	520.5	37.2	838.8	59.9	745.8	53.3
C24Z	Sandwich JCT	Comber WF JCT	1040	1130	591.5	56.9	517.3	49.7	836.2	80.4	743.5	71.5
C24Z	Comber WF	KEPA WF JCT	1040	1130	588.7	56.6	513.7	49.4	833	80.1	740.5	71.2
C24Z	KEPA WF JCT	Chatham SS	1020	1100	580.6	56.9	503.3	49.3	822.5	80.6	731.6	71.7
J3E	Keith TS	Crawford JCT	1070	1390	341.4	31.9	0	0	649.3	60.7	0	0
J3E	Crawford JCT	Essex TS	1070	1390	169	15.8	0	0	423	39.5	0	0
J4E	Keith TS	Crawford JCT	1000	1090	287.3	28.7	830	83	605.5	60.6	951.3	95.1
J4E	Crawford JCT	Essex TS	1000	1090	218.4	21.8	452.4	45.2	467.9	46.8	570.9	57.1
Z1E	Essex TS	Windsor Transalta JCT	1260	1430	246	19.5	268	21.3	161.2	12.8	124.2	9.9
Z1E	Windsor Transalta JCT	Walker JCT	1260	1430	143.2	11.4	599.8	47.6	504.2	40	370.7	29.4
Z1E	Walker JCT	Jefferson JCT	1140	1390	308.8	27.1	329	28.9	144.5	12.7	88.6	7.8
Z1E	Jefferson JCT	Lauzon TS	1190	1370	328.3	27.6	372	31.3	133	11.2	102.3	8.6
Z7E	Essex TS	Walker JCT	1260	1430	242.8	19.3	0	0	565.2	44.9	392.1	31.1
Z7E	Walker JCT	Jefferson JCT	1140	1390	316.8	27.8	0	0	128.9	11.3	105.9	9.3
Z7E	Jefferson JCT	Lauzon TS	1190	1370	336.7	28.3	0	0	118.3	9.9	119.8	10.1
Lauzon T1			296.8	364.2	135.9	45.8	106.6	35.9	0	0	0	0
Lauzon T2			296.8	364.2	133.1	44.8	104.3	35.1	117.9	39.7	91	30.7
Keith T11			180.3	224.5	66.2	36.7	33.8	18.7	0	0	9.2	5.1
Keith T12			160.3	187.5	74.7	46.6	38.1	23.8	18.8	11.8	10.4	6.5

* Control Actions shown in brackets

Appendix B Voltage Assessment

Table 26: Voltage assessment results with all elements in-service for single contingencies – Scenario S1

Bus Name	Pre-Cont.	C21J				C23Z				J3E				Z7E				Keith A Bus			
		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	235.2	233.3	-0.82	233.4	-0.77	234.7	-0.23	234.9	-0.14	235.2	-0.03	235.3	0.01	235.0	-0.11	235.0	-0.10	234.6	-0.26	234.6	-0.25
Malden C21J 230 kV	235.3					234.8	-0.21	235.1	-0.12	235.2	-0.04	235.3	-0.01	235.1	-0.11	235.1	-0.10	240.1	2.04	240.1	2.04
Malden C22J 230 kV	235.4	233.1	-0.98	233.2	-0.92	234.9	-0.21	235.1	-0.12	235.3	-0.04	235.4	0.00	235.1	-0.11	235.1	-0.10	234.6	-0.30	234.7	-0.30
Leamington C21J 230 kV	237.9					237.9	0.01	238.1	0.11	237.6	-0.11	237.7	-0.08	237.7	-0.09	237.7	-0.08	241.0	1.33	241.0	1.33
Leamington C22J 230 kV	237.9	235.6	-1.01	235.7	-0.96	238.0	0.01	238.2	0.11	237.7	-0.11	237.8	-0.08	237.7	-0.09	237.8	-0.08	237.4	-0.24	237.4	-0.24
Lauzon C23Z 230 kV	232.1	232.0	-0.05	232.0	-0.03					230.4	-0.75	230.6	-0.65	231.8	-0.13	231.9	-0.10	231.9	-0.10	231.9	-0.10
Lauzon C24Z 230 kV	231.6	231.5	-0.03	231.5	-0.02	223.3	-3.56	225.7	-2.55	229.8	-0.76	230.1	-0.66	231.3	-0.14	231.3	-0.10	231.4	-0.09	231.4	-0.09
Chatham 230 kV	242.9	243.4	0.18	243.4	0.19	243.7	0.32	244.0	0.44	242.6	-0.15	242.6	-0.12	242.8	-0.05	242.8	-0.04	243.3	0.17	243.3	0.17
Keith 115 kV	124.1	123.7	-0.31	123.7	-0.29	122.9	-0.97	123.2	-0.74	124.0	-0.04	124.2	0.08	123.6	-0.38	123.6	-0.35	123.5	-0.44	123.5	-0.44
Crawford J3E 115 kV	122.6	122.3	-0.30	122.3	-0.28	120.8	-1.47	121.3	-1.11					122.0	-0.56	122.0	-0.51	122.2	-0.38	122.2	-0.38
Crawford J4E 115 kV	122.8	122.5	-0.29	122.5	-0.28	121.0	-1.47	121.4	-1.16	121.5	-1.11	121.8	-0.89	122.2	-0.56	122.2	-0.51	122.4	-0.38	122.4	-0.38
Essex 115 kV	122.0	121.7	-0.25	121.7	-0.24	119.6	-1.96	120.1	-1.52	120.6	-1.11	120.8	-0.96	121.1	-0.73	121.2	-0.67	121.6	-0.31	121.6	-0.31
Windsor Transalta 115 kV	122.0	121.7	-0.25	121.7	-0.24	119.6	-1.96	120.2	-1.52	120.7	-1.10	120.9	-0.95	121.1	-0.74	121.2	-0.69	121.7	-0.30	121.7	-0.30
Walker Z1E 115 kV	122.0	121.7	-0.25	121.7	-0.24	119.5	-2.01	120.1	-1.56	120.6	-1.10	120.8	-0.95	121.0	-0.83	121.0	-0.77	121.6	-0.30	121.6	-0.30
Walker Z7E 115 kV	121.9	121.6	-0.25	121.6	-0.24	119.5	-2.02	120.0	-1.56	120.6	-1.11	120.8	-0.96					121.6	-0.30	121.6	-0.30
Ford Essex Z1E 115 kV	122.5	122.2	-0.23	122.2	-0.21	119.5	-2.40	120.2	-1.87	121.2	-1.02	121.4	-0.88	122.0	-0.37	122.1	-0.32	122.1	-0.27	122.1	-0.27
Ford Essex Z7E 115 kV	122.5	122.2	-0.23	122.2	-0.21	119.5	-2.41	120.2	-1.87	121.2	-1.02	121.4	-0.88					122.1	-0.27	122.1	-0.27
Lauzon 115 kV	122.7	122.4	-0.22	122.5	-0.20	119.5	-2.58	120.2	-2.01	121.5	-0.98	121.7	-0.85	122.5	-0.16	122.6	-0.11	122.4	-0.26	122.4	-0.26
Bell River K2Z 115 kV	122.1	121.8	-0.22	121.8	-0.21	118.9	-2.65	119.6	-2.05	120.9	-1.01	121.0	-0.87	121.9	-0.16	122.0	-0.11	121.8	-0.26	121.8	-0.26
Bell River K6Z 115 kV	120.9	120.6	-0.24	120.6	-0.22	117.5	-2.81	118.3	-2.13	119.6	-1.07	119.8	-0.92	120.7	-0.17	120.8	-0.12	120.6	-0.28	120.6	-0.28
Kingsville K2Z 115 kV	118.9	118.6	-0.21	118.6	-0.20	115.9	-2.52	116.7	-1.84	117.7	-0.96	117.9	-0.83	118.7	-0.16	118.7	-0.11	118.6	-0.25	118.6	-0.25
Kingsville K6Z 115 kV	117.3	117.0	-0.26	117.0	-0.25	113.6	-3.15	114.6	-2.29	115.9	-1.19	116.1	-1.03	117.1	-0.19	117.1	-0.13	116.9	-0.31	116.9	-0.31
Tilbury West 115 kV	119.8	119.5	-0.21	119.5	-0.20	116.7	-2.54	117.5	-1.93	118.6	-0.97	118.8	-0.83	119.6	-0.16	119.6	-0.11	119.5	-0.25	119.5	-0.25
Kent 115 kV	119.9	119.7	-0.21	119.7	-0.20	116.9	-2.54	117.6	-1.93	118.8	-0.97	118.9	-0.83	119.7	-0.16	119.8	-0.11	119.6	-0.25	119.6	-0.25

Table 27: Voltage assessment results with all elements in-service for single contingencies – Scenario S2

Bus Name	Pre-Cont.	C21J				C23Z				J3E				Z7E				Keith A Bus			
		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	234.2	232.0	-0.94	232.2	-0.84	233.7	-0.23	233.9	-0.13	234.2	0.01	234.3	0.06	234.0	-0.11	234.0	-0.10	233.7	-0.22	233.7	-0.22
Malden C21J 230 kV	234.2					233.7	-0.21	233.9	-0.11	234.2	0.00	234.3	0.04	233.9	-0.11	234.0	-0.10	237.3	1.32	237.3	1.32
Malden C22J 230 kV	234.2	231.4	-1.20	231.7	-1.07	233.7	-0.21	234.0	-0.11	234.2	0.00	234.3	0.04	234.0	-0.11	234.0	-0.10	233.5	-0.30	233.5	-0.30
Leamington C21J 230 kV	235.2					235.2	0.02	235.5	0.13	235.0	-0.09	235.1	-0.05	235.0	-0.10	235.0	-0.09	237.5	0.96	237.5	0.96
Leamington C22J 230 kV	235.2	229.8	-2.31	230.2	-2.12	235.3	0.02	235.5	0.13	235.0	-0.09	235.1	-0.04	235.0	-0.10	235.0	-0.09	234.3	-0.37	234.3	-0.37
Lauzon C23Z 230 kV	229.9	229.6	-0.11	229.7	-0.08					228.0	-0.84	228.3	-0.68	229.2	-0.31	229.3	-0.26	229.6	-0.13	229.6	-0.13
Lauzon C24Z 230 kV	229.5	229.3	-0.09	229.3	-0.06	221.1	-3.65	223.7	-2.53	227.6	-0.84	227.9	-0.69	228.8	-0.31	228.9	-0.26	229.2	-0.11	229.2	-0.11
Chatham 230 kV	241.9	242.1	0.10	242.2	0.13	242.8	0.36	243.1	0.48	241.5	-0.15	241.6	-0.11	241.7	-0.08	241.7	-0.07	242.1	0.08	242.1	0.08
Keith 115 kV	123.8	123.3	-0.36	123.4	-0.32	122.5	-1.01	122.8	-0.77	123.9	0.14	124.1	0.27	123.4	-0.34	123.4	-0.30	123.3	-0.40	123.3	-0.39
Crawford J3E 115 kV	121.9	121.5	-0.34	121.6	-0.30	120.1	-1.52	120.5	-1.17					121.3	-0.49	121.4	-0.44	121.5	-0.36	121.5	-0.36
Crawford J4E 115 kV	122.1	121.7	-0.34	121.8	-0.30	120.3	-1.52	120.7	-1.17	120.8	-1.11	121.1	-0.85	121.5	-0.49	121.6	-0.43	121.7	-0.36	121.7	-0.36
Essex 115 kV	120.9	120.5	-0.30	120.6	-0.26	118.4	-2.02	119.0	-1.57	119.3	-1.32	119.5	-1.11	120.1	-0.65	120.2	-0.57	120.5	-0.31	120.5	-0.30
Windsor Transalta 115 kV	120.9	120.6	-0.30	120.6	-0.26	118.5	-2.02	119.0	-1.58	119.3	-1.30	119.6	-1.10	120.1	-0.67	120.2	-0.59	120.6	-0.30	120.6	-0.30
Walker Z1E 115 kV	120.8	120.5	-0.30	120.5	-0.26	118.3	-2.08	118.9	-1.62	119.3	-1.30	119.5	-1.10	119.9	-0.78	120.0	-0.70	120.5	-0.30	120.5	-0.30
Walker Z7E 115 kV	120.8	120.4	-0.30	120.5	-0.26	118.3	-2.08	118.8	-1.62	119.2	-1.30	119.5	-1.10					120.4	-0.30	120.4	-0.30
Ford Essex Z1E 115 kV	121.0	120.7	-0.28	120.7	-0.24	118.0	-2.49	118.6	-1.95	119.6	-1.19	119.8	-0.99	120.4	-0.53	120.4	-0.46	120.7	-0.28	120.7	-0.28
Ford Essex Z7E 115 kV	121.0	120.6	-0.28	120.7	-0.24	118.0	-2.49	118.6	-1.95	119.5	-1.19	119.8	-0.99					120.6	-0.28	120.6	-0.28
Lauzon 115 kV	121.1	120.8	-0.27	120.8	-0.24	117.8	-2.68	118.5	-2.10	119.7	-1.14	119.9	-0.95	120.6	-0.42	120.7	-0.36	120.8	-0.27	120.8	-0.27
Bell River K2Z 115 kV	120.5	120.2	-0.28	120.2	-0.24	117.2	-2.74	117.9	-2.12	119.1	-1.17	119.3	-0.96	120.0	-0.43	120.1	-0.36	120.2	-0.28	120.2	-0.28
Bell River K6Z 115 kV	119.4	119.1	-0.28	119.1	-0.25	116.1	-2.81	116.8	-2.17	118.0	-1.20	118.3	-0.98	118.9	-0.44	119.0	-0.37	119.1	-0.28	119.1	-0.28
Kingsville K2Z 115 kV	118.6	118.3	-0.23	118.3	-0.20	115.9	-2.26	116.5	-1.78	117.4	-0.97	117.6	-0.80	118.2	-0.35	118.2	-0.30	118.3	-0.23	118.3	-0.23
Kingsville K6Z 115 kV	116.9	116.6	-0.29	116.7	-0.25	113.6	-2.88	114.3	-2.23	115.5	-1.23	115.8	-1.00	116.4	-0.45	116.5	-0.38	116.6	-0.29	116.6	-0.29
Tilbury West 115 kV	118.7	118.4	-0.25	118.5	-0.22	115.8	-2.49	116.4	-1.95	117.5	-1.06	117.7	-0.88	118.3	-0.39	118.3	-0.33	118.4	-0.25	118.4	-0.25
Kent 115 kV	118.9	118.6	-0.25	118.6	-0.22	115.9	-2.49	116.6	-1.95	117.6	-1.06	117.8	-0.88	118.4	-0.39	118.5	-0.33	118.6	-0.25	118.6	-0.25

Table 28: Voltage assessment results with all elements in-service for double contingencies – Scenario S1

Bus Name	Pre-Cont.	C21J+C23Z				C22J+C24Z				C23Z+C24Z				J3E +J4E				* Z1E+Z7E – (Kingsville capacitor switching with four caps. out)			
		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	235.2	232.6	-1.12	233.0	-0.95	232.9	-0.98	233.2	-0.85	235.6	0.15	235.6	0.15	235.4	0.05	235.4	0.06	234.9	-0.15	234.9	-0.15
Malden C21J 230 kV	235.3					232.6	-1.14	233.0	-1.00	235.8	0.20	235.8	0.21	235.2	-0.06	235.2	-0.05	234.9	-0.19	234.9	-0.19
Malden C22J 230 kV	235.4	232.4	-1.26	232.8	-1.07					235.8	0.21	235.9	0.21	235.2	-0.05	235.3	-0.04	234.9	-0.18	234.9	-0.18
Leamington C21J 230 kV	237.9					235.6	-0.95	235.9	-0.81	239.7	0.79	239.7	0.78	236.3	-0.66	236.4	-0.64	237.0	-0.38	237.0	-0.38
Leamington C22J 230 kV	237.9	235.5	-1.02	235.9	-0.85					239.8	0.80	239.8	0.79	236.5	-0.62	236.5	-0.59	237.1	-0.35	237.1	-0.36
Lauzon C23Z 230 kV	232.1					223.4	-3.74	225.9	-2.68					226.4	-2.46	226.8	-2.26	230.1	-0.85	229.8	-0.97
Lauzon C24Z 230 kV	231.6	223.3	-3.57	225.7	-2.54									225.6	-2.58	226.1	-2.39	234.2	1.12	234.2	1.14
Chatham 230 kV	242.9	244.4	0.59	244.7	0.73	244.7	0.75	245.1	0.88	247.1	1.71	247.0	1.69	241.2	-0.69	241.3	-0.65	242.5	-0.18	242.5	-0.18
Keith 115 kV	124.1	122.4	-1.34	122.7	-1.07	121.8	-1.82	122.2	-1.53	123.1	-0.78	123.2	-0.74	125.5	1.16	125.5	1.16	123.7	-0.34	123.7	-0.34
Crawford J3E 115 kV	122.6	120.4	-1.83	120.9	-1.45	119.9	-2.21	120.4	-1.82	121.1	-1.23	121.2	-1.16					122.4	-0.20	122.4	-0.19
Crawford J4E 115 kV	122.8	120.6	-1.82	121.1	-1.45	120.1	-2.21	120.6	-1.82	121.3	-1.22	121.4	-1.16					122.6	-0.20	122.6	-0.19
Essex 115 kV	122.0	119.2	-2.27	119.8	-1.80	118.9	-2.56	119.5	-2.07	119.9	-1.68	120.0	-1.59	118.7	-2.68	119.0	-2.48	121.9	-0.11	121.9	-0.10
Windsor Transalta 115 kV	122.0	119.3	-2.27	119.8	-1.81	118.9	-2.56	119.5	-2.06	120.0	-1.69	120.1	-1.60	118.8	-2.66	119.0	-2.46				
Walker Z1E 115 kV	122.0	119.1	-2.33	119.7	-1.85	118.8	-2.61	119.4	-2.10	119.9	-1.74	120.0	-1.65	118.7	-2.66	119.0	-2.46				
Walker Z7E 115 kV	121.9	119.1	-2.33	119.7	-1.85	118.7	-2.61	119.4	-2.11	119.8	-1.74	119.9	-1.65	118.7	-2.67	118.9	-2.47				
Ford Essex Z1E 115 kV	122.5	119.2	-2.70	119.8	-2.15	118.9	-2.95	119.6	-2.36	119.9	-2.12	120.0	-2.01	119.4	-2.54	119.6	-2.33				
Ford Essex Z7E 115 kV	122.5	119.2	-2.71	119.8	-2.15	118.9	-2.95	119.6	-2.36	119.9	-2.12	120.0	-2.01	119.3	-2.54	119.6	-2.34				
Lauzon 115 kV	122.7	119.2	-2.87	119.9	-2.28	118.9	-3.09	119.7	-2.47	119.9	-2.29	120.0	-2.17	119.7	-2.49	119.9	-2.28	125.9	2.64	126.0	2.70
Bell River K2Z 115 kV	122.1	118.5	-2.95	119.3	-2.32	118.2	-3.18	119.0	-2.52	119.2	-2.35	119.4	-2.22	119.0	-2.56	119.3	-2.32	124.8	2.20	124.8	2.23
Bell River K6Z 115 kV	120.9	117.1	-3.13	118.0	-2.42	116.8	-3.38	117.7	-2.64	117.9	-2.49	118.1	-2.31	117.6	-2.72	118.0	-2.42	118.0	-2.37	117.7	-2.68
Kingsville K2Z 115 kV	118.9	115.5	-2.81	116.4	-2.11	115.3	-3.03	116.1	-2.30	116.2	-2.24	116.5	-2.01	116.0	-2.44	116.4	-2.11	115.9	-2.46	116.3	-2.14
Kingsville K6Z 115 kV	117.3	113.2	-3.51	114.2	-2.61	112.9	-3.78	113.9	-2.86	114.0	-2.79	114.4	-2.49	113.7	-3.04	114.2	-2.62	110.8	-5.55	110.1	-6.11
Tilbury West 115 kV	119.8	116.4	-2.84	117.1	-2.20	116.1	-3.06	116.9	-2.39	117.1	-2.26	117.3	-2.10	116.8	-2.46	117.1	-2.20	120.3	0.45	120.5	0.62
Kent 115 kV	119.9	116.5	-2.83	117.3	-2.19	116.3	-3.05	117.1	-2.39	117.2	-2.26	117.4	-2.09	117.0	-2.46	117.3	-2.19	120.5	0.45	120.7	0.62

* Control Actions shown in brackets

Table 28: Voltage assessment results with all elements in-service for double contingencies – Scenario S1 (continued)

Bus Name	Pre-Cont.	Chatham 230 DL23 BF: C23Z + Chatham D Bus				Chatham 230 DL21 BF: C21J + Chatham D Bus				Lauzon T2K BF: C24Z + Lauzon cap				Lauzon T1L7 BF: Z7E+C23Z			
		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	235.2	233.3	-0.83	233.6	-0.71	232.4	-1.21	232.6	-1.10	234.0	-0.54	234.3	-0.39	234.4	-0.37	234.7	-0.24
Malden C21J 230 kV	235.3	233.3	-0.88	233.5	-0.76					234.1	-0.51	234.5	-0.37	234.5	-0.34	234.8	-0.22
Malden C22J 230 kV	235.4	233.3	-0.88	233.6	-0.76	231.9	-1.46	232.2	-1.33	234.2	-0.51	234.5	-0.37	234.6	-0.34	234.8	-0.22
Leamington C21J 230 kV	237.9	234.8	-1.30	235.1	-1.16					237.3	-0.24	237.7	-0.07	237.6	-0.12	237.9	0.02
Leamington C22J 230 kV	237.9	234.9	-1.30	235.2	-1.16	232.7	-2.19	233.1	-2.04	237.4	-0.24	237.8	-0.07	237.7	-0.12	238.0	0.02
Lauzon C23Z 230 kV	232.1					229.3	-1.19	229.7	-1.02	220.2	-5.12	223.5	-3.69				
Lauzon C24Z 230 kV	231.6	220.7	-4.71	223.7	-3.41	229.0	-1.12	229.3	-0.99					221.7	-4.25	224.8	-2.93
Chatham 230 kV	242.9	238.6	-1.78	239.0	-1.62	238.4	-1.88	238.7	-1.73	243.3	0.16	243.8	0.36	243.5	0.22	243.8	0.38
Keith 115 kV	124.1	122.3	-1.39	122.7	-1.08	123.2	-0.71	123.3	-0.63	121.8	-1.80	122.3	-1.44	122.4	-1.39	122.7	-1.07
Crawford J3E 115 kV	122.6	120.2	-1.97	120.8	-1.52	121.7	-0.80	121.8	-0.72	119.3	-2.69	120.0	-2.18	120.1	-2.08	120.7	-1.62
Crawford J4E 115 kV	122.8	120.4	-1.96	121.0	-1.52	121.9	-0.80	122.0	-0.72	119.5	-2.69	120.2	-2.17	120.3	-2.08	120.9	-1.62
Essex 115 kV	122.0	118.9	-2.52	119.6	-1.94	120.9	-0.87	121.0	-0.78	117.7	-3.55	118.5	-2.88	118.6	-2.76	119.4	-2.16
Windsor Transalta 115 kV	122.0	118.9	-2.52	119.7	-1.94	121.0	-0.87	121.1	-0.78	117.7	-3.55	118.5	-2.89	118.6	-2.79	119.4	-2.18
Walker Z1E 115 kV	122.0	118.8	-2.59	119.6	-1.99	120.9	-0.89	121.0	-0.79	117.5	-3.65	118.4	-2.96	118.4	-2.97	119.1	-2.34
Walker Z7E 115 kV	121.9	118.8	-2.59	119.5	-2.00	120.9	-0.89	121.0	-0.80	117.5	-3.66	118.3	-2.98				
Ford Essex Z1E 115 kV	122.5	118.7	-3.05	119.6	-2.35	121.3	-0.97	121.4	-0.86	117.2	-4.35	118.1	-3.54	118.4	-3.29	119.4	-2.48
Ford Essex Z7E 115 kV	122.5	118.7	-3.05	119.6	-2.35	121.3	-0.97	121.4	-0.86	117.1	-4.35	118.1	-3.54				
Lauzon 115 kV	122.7	118.7	-3.26	119.6	-2.51	121.5	-1.00	121.6	-0.89	117.0	-4.65	118.1	-3.79	118.5	-3.43	119.6	-2.53
Bell River K2Z 115 kV	122.1	118.0	-3.35	119.0	-2.55	120.8	-1.03	121.0	-0.91	116.3	-4.79	117.4	-3.85	117.8	-3.53	119.0	-2.58
Bell River K6Z 115 kV	120.9	116.6	-3.56	117.7	-2.62	119.6	-1.09	119.7	-0.97	114.8	-5.09	116.0	-4.04	116.4	-3.75	117.7	-2.65
Kingsville K2Z 115 kV	118.9	115.1	-3.19	116.2	-2.21	117.7	-0.98	117.8	-0.87	113.4	-4.58	115.0	-3.23	114.9	-3.36	116.2	-2.24
Kingsville K6Z 115 kV	117.3	112.6	-3.98	114.1	-2.74	115.9	-1.22	116.0	-1.08	110.6	-5.72	112.1	-4.44	112.4	-4.20	114.0	-2.77
Tilbury West 115 kV	119.8	115.9	-3.22	116.9	-2.37	118.6	-0.99	118.7	-0.88	114.3	-4.61	115.5	-3.54	115.7	-3.39	116.9	-2.40
Kent 115 kV	119.9	116.1	-3.22	117.1	-2.37	118.7	-0.99	118.9	-0.88	114.4	-4.60	115.7	-3.54	115.9	-3.39	117.1	-2.39

Table 29: Voltage assessment results with all elements in-service for double contingencies – Scenario S2

Bus Name	Pre-Cont.	C21J+C23Z				C22J+C24Z				C23Z+C24Z				J3E +J4E				Z1E+Z7E			
		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	234.2	231.3	-1.25	231.7	-1.05	231.6	-1.13	232.0	-0.93	234.5	0.11	234.5	0.11	234.8	0.27	234.9	0.29	234.5	0.11	234.5	0.11
Malden C21J 230 kV	234.2					230.9	-1.38	231.5	-1.15	234.6	0.16	234.6	0.16	234.6	0.16	234.6	0.18	234.3	0.07	234.3	0.07
Malden C22J 230 kV	234.2	230.7	-1.48	231.3	-1.26					234.6	0.16	234.6	0.17	234.6	0.17	234.7	0.19	234.4	0.08	234.4	0.08
Leamington C21J 230 kV	235.2					230.0	-2.23	230.7	-1.90	237.0	0.77	237.0	0.76	234.1	-0.47	234.2	-0.44	235.0	-0.07	235.0	-0.07
Leamington C22J 230 kV	235.2	229.7	-2.34	230.5	-2.02					237.1	0.79	237.0	0.78	234.2	-0.43	234.3	-0.40	235.1	-0.05	235.1	-0.04
Lauzon C23Z 230 kV	229.9					220.9	-3.92	223.7	-2.70					223.5	-2.80	224.0	-2.55	232.9	1.29	232.9	1.29
Lauzon C24Z 230 kV	229.5	220.9	-3.76	223.5	-2.59									222.9	-2.89	223.4	-2.65	231.9	1.03	231.9	1.03
Chatham 230 kV	241.9	243.2	0.54	243.6	0.71	243.6	0.70	244.1	0.89	246.2	1.77	246.1	1.75	240.4	-0.63	240.5	-0.58	242.2	0.11	242.2	0.11
Keith 115 kV	123.8	122.0	-1.43	122.4	-1.15	121.5	-1.85	121.9	-1.53	122.6	-0.96	122.6	-0.93	126.2	1.94	126.2	1.95	124.2	0.37	124.2	0.38
Crawford J3E 115 kV	121.9	119.6	-1.92	120.1	-1.53	119.2	-2.28	119.7	-1.85	120.2	-1.45	120.2	-1.40					122.9	0.81	122.9	0.82
Crawford J4E 115 kV	122.1	119.8	-1.92	120.3	-1.53	119.4	-2.27	119.9	-1.85	120.4	-1.45	120.4	-1.40					123.1	0.81	123.1	0.82
Essex 115 kV	120.9	118.0	-2.39	118.6	-1.90	117.7	-2.66	118.3	-2.13	118.5	-1.96	118.6	-1.90	116.4	-3.67	116.7	-3.44	122.4	1.21	122.4	1.22
Windsor Transalta 115 kV	120.9	118.0	-2.39	118.6	-1.90	117.7	-2.66	118.3	-2.13	118.5	-1.96	118.6	-1.91	116.5	-3.64	116.8	-3.40				
Walker Z1E 115 kV	120.8	117.9	-2.45	118.5	-1.95	117.6	-2.72	118.2	-2.17	118.4	-2.02	118.5	-1.96	116.4	-3.64	116.7	-3.40				
Walker Z7E 115 kV	120.8	117.8	-2.45	118.4	-1.96	117.5	-2.72	118.1	-2.18	118.3	-2.03	118.4	-1.97	116.4	-3.65	116.7	-3.41				
Ford Essex Z1E 115 kV	121.0	117.5	-2.85	118.2	-2.27	117.3	-3.09	118.0	-2.46	118.0	-2.46	118.1	-2.40	116.9	-3.38	117.2	-3.13				
Ford Essex Z7E 115 kV	121.0	117.5	-2.85	118.2	-2.28	117.2	-3.09	118.0	-2.47	118.0	-2.46	118.1	-2.40	116.9	-3.38	117.2	-3.14				
Lauzon 115 kV	121.1	117.4	-3.03	118.2	-2.42	117.1	-3.26	117.9	-2.59	117.9	-2.66	117.9	-2.59	117.1	-3.26	117.4	-3.01	123.3	1.79	123.3	1.79
Bell River K2Z 115 kV	120.5	116.8	-3.10	117.5	-2.45	116.5	-3.34	117.3	-2.62	117.2	-2.72	117.3	-2.63	116.5	-3.34	116.8	-3.05	122.7	1.86	122.7	1.86
Bell River K6Z 115 kV	119.4	115.6	-3.19	116.4	-2.57	115.3	-3.42	116.2	-2.69	116.1	-2.79	116.2	-2.69	115.3	-3.43	115.6	-3.18	122.1	2.23	122.1	2.23
Kingsville K2Z 115 kV	118.6	115.5	-2.57	116.3	-1.91	115.3	-2.76	116.0	-2.19	115.9	-2.25	116.0	-2.20	115.3	-2.76	115.7	-2.41	120.4	1.54	120.4	1.55
Kingsville K6Z 115 kV	116.9	113.1	-3.27	113.7	-2.75	112.8	-3.51	113.7	-2.76	113.6	-2.86	113.7	-2.76	112.8	-3.51	113.0	-3.38	119.6	2.26	119.6	2.27
Tilbury West 115 kV	118.7	115.4	-2.82	116.1	-2.19	115.1	-3.03	115.9	-2.41	115.8	-2.47	115.9	-2.41	115.1	-3.03	115.5	-2.74	120.7	1.68	120.7	1.68
Kent 115 kV	118.9	115.5	-2.82	116.3	-2.19	115.3	-3.03	116.0	-2.41	116.0	-2.47	116.0	-2.41	115.3	-3.03	115.6	-2.74	120.9	1.68	120.9	1.68

Table 29: Voltage assessment results with all elements in-service for double contingencies – Scenario S2 (continued)

Bus Name	Pre-Cont.	Chatham 230 DL23 BF: C23Z + Chatham D Bus				Chatham 230 DL21 BF: C21J + Chatham D Bus				Lauzon T1L7 BF: Z7E+C23Z			
		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	234.2	232.2	-0.84	232.6	-0.69	231.1	-1.34	231.5	-1.17	233.4	-0.36	233.7	-0.22
Malden C21J 230 kV	234.2	232.1	-0.89	232.4	-0.74					233.4	-0.34	233.7	-0.20
Malden C22J 230 kV	234.2	232.1	-0.89	232.5	-0.74	230.3	-1.68	230.8	-1.47	233.4	-0.34	233.7	-0.20
Leamington C21J 230 kV	235.2	232.1	-1.34	232.5	-1.15					234.9	-0.12	235.3	0.04
Leamington C22J 230 kV	235.2	232.1	-1.33	232.5	-1.15	226.8	-3.56	227.8	-3.16	235.0	-0.11	235.3	0.05
Lauzon C23Z 230 kV	229.9					227.0	-1.25	227.9	-0.88				
Lauzon C24Z 230 kV	229.5	218.3	-4.86	221.7	-3.39	226.8	-1.17	227.4	-0.89	219.0	-4.56	222.6	-3.01
Chatham 230 kV	241.9	237.6	-1.77	238.1	-1.57	237.1	-1.97	237.9	-1.66	242.5	0.24	242.9	0.42
Keith 115 kV	123.8	122.0	-1.43	122.4	-1.11	122.8	-0.75	123.0	-0.61	122.1	-1.39	122.5	-1.05
Crawford J3E 115 kV	121.9	119.5	-2.02	120.0	-1.56	120.9	-0.84	121.1	-0.67	119.4	-2.07	120.0	-1.57
Crawford J4E 115 kV	122.1	119.7	-2.01	120.2	-1.55	121.1	-0.84	121.3	-0.67	119.6	-2.07	120.2	-1.57
Essex 115 kV	120.9	117.8	-2.59	118.5	-2.00	119.8	-0.90	120.0	-0.71	117.6	-2.74	118.4	-2.10
Windsor Transalta 115 kV	120.9	117.8	-2.59	118.5	-2.00	119.8	-0.90	120.1	-0.71	117.6	-2.79	118.3	-2.13
Walker Z1E 115 kV	120.8	117.6	-2.66	118.4	-2.05	119.7	-0.91	120.0	-0.71	117.2	-3.00	118.0	-2.32
Walker Z7E 115 kV	120.8	117.6	-2.66	118.3	-2.06	119.7	-0.92	119.9	-0.72				
Ford Essex Z1E 115 kV	121.0	117.2	-3.15	118.1	-2.43	119.8	-0.99	120.1	-0.77	116.7	-3.58	117.7	-2.71
Ford Essex Z7E 115 kV	121.0	117.2	-3.15	118.0	-2.43	119.8	-1.00	120.1	-0.77				
Lauzon 115 kV	121.1	117.0	-3.36	117.9	-2.60	119.8	-1.03	120.1	-0.79	116.4	-3.83	117.6	-2.88
Bell River K2Z 115 kV	120.5	116.4	-3.44	117.3	-2.62	119.2	-1.05	119.5	-0.80	115.8	-3.92	117.0	-2.90
Bell River K6Z 115 kV	119.4	115.2	-3.53	116.2	-2.68	118.1	-1.08	118.4	-0.82	114.6	-4.03	115.9	-2.96
Kingsville K2Z 115 kV	118.6	115.2	-2.85	116.0	-2.20	117.5	-0.87	117.8	-0.67	114.7	-3.24	115.7	-2.43
Kingsville K6Z 115 kV	116.9	112.7	-3.62	113.7	-2.75	115.7	-1.11	116.0	-0.83	112.1	-4.13	113.4	-3.02
Tilbury West 115 kV	118.7	115.0	-3.13	115.9	-2.42	117.6	-0.96	117.9	-0.74	114.5	-3.57	115.6	-2.68
Kent 115 kV	118.9	115.2	-3.13	116.0	-2.41	117.8	-0.96	118.0	-0.74	114.7	-3.56	115.7	-2.67

Table 30: Voltage assessment results under outage conditions – Scenario S1

Bus Name	KEITH A Bus O/S	KEITH A Bus + C23Z				KEITH A Bus + Keith H Bus				J3E O/S	J3E + C24Z				C21J Chatham end open	C21J Chatham end open + Keith C21J IBO			
	Pre-Cont.	Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-Cont.	Pre-ULTC		Post-ULTC		Pre-Cont.	Post-ULTC		Pre-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	234.6	234.2	-0.20	234.3	-0.13					235.3	234.5	-0.31	235.0	-0.12	234.3	234.0	-0.15	234.0	-0.15
Malden C21J 230 kV	240.1	240.8	0.26	241.1	0.39	231.2	-3.71	232.9	-2.99	235.3	234.6	-0.29	235.1	-0.10	234.2	234.0	-0.09	234.0	-0.07
Malden C22J 230 kV	234.7	234.2	-0.18	234.4	-0.10					235.4	234.7	-0.29	235.1	-0.10	234.5	233.9	-0.25	233.9	-0.25
Leamington C21J 230 kV	241.0	241.8	0.30	242.1	0.42	235.1	-2.45	236.2	-2.00	237.7	237.6	-0.05	238.1	0.17	234.2	234.6	0.15	234.6	0.17
Leamington C22J 230 kV	237.4	237.5	0.05	237.7	0.16					237.8	237.7	-0.04	238.2	0.17	237.4	236.4	-0.42	236.4	-0.42
Lauzon C23Z 230 kV	231.9					231.5	-0.17	231.6	-0.13	230.6	220.2	-4.51	224.3	-2.74	232.3	232.2	-0.06	232.2	-0.06
Lauzon C24Z 230 kV	231.4	222.8	-3.69	225.4	-2.59	230.8	-0.24	230.9	-0.20	230.1					231.8	231.7	-0.05	231.7	-0.05
Chatham 230 kV	243.3	244.3	0.39	244.6	0.52	243.9	0.24	244.1	0.32	242.6	243.4	0.31	244.0	0.55	243.7	243.5	-0.05	243.5	-0.05
Keith 115 kV	123.5	122.1	-1.19	122.4	-0.91	122.9	-0.54	122.9	-0.53	124.2	122.8	-1.11	123.4	-0.62	123.9	123.8	-0.07	123.8	-0.07
Crawford J3E 115 kV	122.2	120.1	-1.69	120.6	-1.29	121.7	-0.35	121.8	-0.33						122.5	122.4	-0.07	122.4	-0.07
Crawford J4E 115 kV	122.4	120.3	-1.68	120.8	-1.29	121.9	-0.35	122.0	-0.33	121.8	119.0	-2.26	120.1	-1.32	122.7	122.6	-0.07	122.6	-0.07
Essex 115 kV	121.6	119.0	-2.16	119.6	-1.67	121.4	-0.18	121.4	-0.16	120.8	117.1	-3.07	118.5	-1.95	121.9	121.8	-0.07	121.8	-0.07
Windsor Transalta 115 kV	121.7	119.0	-2.16	119.6	-1.67	121.4	-0.18	121.5	-0.15	120.9	117.2	-3.07	118.5	-1.95	121.9	121.8	-0.07	121.8	-0.07
Walker Z1E 115 kV	121.6	118.9	-2.22	119.5	-1.71	121.4	-0.17	121.4	-0.15	120.8	117.0	-3.13	118.4	-1.99	121.9	121.8	-0.07	121.8	-0.07
Walker Z7E 115 kV	121.6	118.9	-2.22	119.5	-1.72	121.3	-0.18	121.4	-0.15	120.8	117.0	-3.13	118.4	-1.99	121.8	121.7	-0.07	121.7	-0.07
Ford Essex Z1E 115 kV	122.1	118.9	-2.62	119.7	-2.03	122.0	-0.13	122.0	-0.10	121.4	117.1	-3.52	118.6	-2.27	122.4	122.3	-0.07	122.3	-0.07
Ford Essex Z7E 115 kV	122.1	118.9	-2.62	119.7	-2.03	122.0	-0.13	122.0	-0.10	121.4	117.1	-3.52	118.6	-2.27	122.4	122.3	-0.07	122.3	-0.07
Lauzon 115 kV	122.4	119.0	-2.80	119.7	-2.17	122.3	-0.11	122.3	-0.08	121.7	117.2	-3.69	118.8	-2.40	122.6	122.5	-0.07	122.5	-0.07
Bell River K2Z 115 kV	121.8	118.3	-2.88	119.1	-2.21	121.6	-0.11	121.7	-0.08	121.0	116.4	-3.80	118.1	-2.43	122.0	121.9	-0.07	121.9	-0.07
Bell River K6Z 115 kV	120.6	116.9	-3.05	117.8	-2.31	120.4	-0.12	120.5	-0.08	119.8	114.9	-4.05	116.8	-2.53	120.8	120.7	-0.08	120.7	-0.08
Kingsville K2Z 115 kV	118.6	115.3	-2.74	116.2	-2.00	118.5	-0.10	118.5	-0.07	117.9	113.6	-3.64	115.7	-1.86	118.8	118.7	-0.07	118.7	-0.07
Kingsville K6Z 115 kV	116.9	112.9	-3.42	114.0	-2.49	116.8	-0.13	116.8	-0.09	116.1	110.8	-4.55	112.9	-2.74	117.2	117.1	-0.09	117.1	-0.09
Tilbury West 115 kV	119.5	116.2	-2.76	117.0	-2.09	119.3	-0.11	119.4	-0.07	118.8	114.4	-3.66	116.2	-2.16	119.7	119.6	-0.07	119.6	-0.07
Kent 115 kV	119.6	116.3	-2.76	117.1	-2.09	119.5	-0.11	119.5	-0.07	118.9	114.6	-3.66	116.4	-2.16	119.9	119.8	-0.07	119.8	-0.07

Table 31: Voltage assessment results under outage conditions – Scenario S2

Bus Name	KEITH A Bus O/S	KEITH A Bus + C23Z				KEITH A Bus + Keith H Bus				J3E O/S	J3E + C24Z				C21J Chatham end open	C21J Chatham end open + Keith C21J IBO			
	Pre-Cont.	Pre-ULTC		Post-ULTC		* Pre-ULTC		Post-ULTC		Pre-Cont.	Pre-ULTC		Post-ULTC		Pre-Cont.	Post-ULTC		Pre-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	233.7	233.2	-0.20	233.4	-0.12					234.3	233.5	-0.34	234.1	-0.11	233.1	232.4	-0.29	232.6	-0.21
Malden C21J 230 kV	237.3	238.0	0.29	238.3	0.42	227.1	-4.30	224.3	-5.47	234.3	233.5	-0.32	234.1	-0.09	232.7	223.8	-3.85	225.7	-3.01
Malden C22J 230 kV	233.5	233.1	-0.18	233.3	-0.10					234.3	233.6	-0.32	234.1	-0.09	233.1	231.9	-0.51	232.2	-0.41
Leamington C21J 230 kV	237.5	238.2	0.33	238.6	0.46	228.8	-3.65	226.1	-4.80	235.1	234.9	-0.09	235.5	0.18	230.5	223.4	-3.12	225.2	-2.31
Leamington C22J 230 kV	234.3	234.5	0.05	234.7	0.16					235.1	234.9	-0.09	235.6	0.19	234.6	231.7	-1.22	232.1	-1.05
Lauzon C23Z 230 kV	229.6					229.3	-0.13	229.1	-0.21	228.3	217.0	-4.96	221.9	-2.83	230.2	229.8	-0.14	229.9	-0.11
Lauzon C24Z 230 kV	229.2	220.6	-3.77	223.2	-2.63	228.8	-0.19	228.6	-0.26	227.9					229.8	229.5	-0.13	229.5	-0.10
Chatham 230 kV	242.1	243.1	0.42	243.4	0.55	242.4	0.13	241.9	-0.10	241.6	242.3	0.29	243.1	0.60	242.8	242.4	-0.17	242.5	-0.14
Keith 115 kV	123.3	121.8	-1.22	122.1	-0.95	122.7	-0.50	122.6	-0.52	124.1	122.6	-1.24	123.3	-0.65	123.6	123.4	-0.14	123.5	-0.10
Crawford J3E 115 kV	121.5	119.4	-1.72	119.9	-1.35	121.1	-0.34	121.1	-0.36						121.8	121.6	-0.14	121.7	-0.11
Crawford J4E 115 kV	121.7	119.6	-1.72	120.1	-1.35	121.3	-0.34	121.3	-0.36	121.1	118.1	-2.49	119.4	-1.38	122.0	121.8	-0.14	121.9	-0.11
Essex 115 kV	120.5	117.9	-2.21	118.4	-1.74	120.3	-0.18	120.3	-0.22	119.5	115.4	-3.44	117.1	-2.09	120.8	120.6	-0.14	120.7	-0.11
Windsor Transalta 115 kV	120.6	117.9	-2.22	118.5	-1.74	120.3	-0.18	120.3	-0.21	119.6	115.5	-3.45	117.1	-2.09	120.8	120.7	-0.14	120.7	-0.11
Walker Z1E 115 kV	120.5	117.7	-2.27	118.3	-1.79	120.3	-0.18	120.2	-0.21	119.5	115.3	-3.51	117.0	-2.13	120.7	120.6	-0.14	120.6	-0.11
Walker Z7E 115 kV	120.4	117.7	-2.28	118.2	-1.80	120.2	-0.18	120.2	-0.21	119.5	115.3	-3.51	116.9	-2.14	120.7	120.5	-0.14	120.5	-0.11
Ford Essex Z1E 115 kV	120.7	117.4	-2.69	118.1	-2.13	120.5	-0.13	120.5	-0.17	119.8	115.1	-3.94	116.8	-2.46	120.9	120.8	-0.15	120.8	-0.12
Ford Essex Z7E 115 kV	120.6	117.4	-2.69	118.1	-2.13	120.5	-0.13	120.4	-0.17	119.8	115.1	-3.94	116.8	-2.46	120.9	120.7	-0.15	120.8	-0.12
Lauzon 115 kV	120.8	117.3	-2.88	118.0	-2.28	120.6	-0.11	120.6	-0.15	119.9	115.0	-4.13	116.8	-2.61	121.0	120.9	-0.15	120.9	-0.12
Bell River K2Z 115 kV	120.2	116.6	-2.95	117.4	-2.31	120.0	-0.11	120.0	-0.14	119.3	114.3	-4.24	116.2	-2.62	120.5	120.3	-0.15	120.3	-0.12
Bell River K6Z 115 kV	119.1	115.5	-3.03	116.2	-2.42	119.0	-0.11	118.9	-0.14	118.3	113.1	-4.36	115.1	-2.68	119.4	119.2	-0.15	119.2	-0.12
Kingsville K2Z 115 kV	118.3	115.4	-2.44	116.2	-1.79	118.2	-0.09	118.2	-0.12	117.6	113.5	-3.49	115.0	-2.20	118.5	118.4	-0.12	118.4	-0.10
Kingsville K6Z 115 kV	116.6	113.0	-3.10	113.6	-2.60	116.5	-0.11	116.4	-0.15	115.8	110.6	-4.48	112.6	-2.74	116.9	116.7	-0.16	116.8	-0.13
Tilbury West 115 kV	118.4	115.3	-2.68	116.0	-2.06	118.3	-0.10	118.3	-0.14	117.7	113.2	-3.84	114.8	-2.42	118.7	118.5	-0.14	118.6	-0.11
Kent 115 kV	118.6	115.4	-2.68	116.2	-2.06	118.5	-0.10	118.4	-0.14	117.8	113.3	-3.84	115.0	-2.42	118.8	118.7	-0.14	118.7	-0.11

* Leamington and Malden load was converted for this contingency Pre-ULTC

Table 32: Voltage assessment results with all elements in-service for single contingencies – Scenario S3

Bus Name	Pre-Cont.	C21J				C23Z				J5D				J3E				Z7E				Keith A Bus			
		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	232.1	230.1	-0.83	230.3	-0.77	230.0	-0.87	230.7	-0.57	238.2	2.63	237.8	2.48	231.8	-0.11	232.0	-0.04	231.7	-0.16	231.7	-0.14	232.1	0.00	232.1	0.00
Malden C21J 230 kV	232.3					230.3	-0.87	231.0	-0.57	238.5	2.67	238.2	2.50	232.1	-0.12	232.2	-0.05	232.0	-0.16	232.0	-0.14	237.2	2.08	237.2	2.08
Malden C22J 230 kV	232.3	229.9	-1.02	230.1	-0.94	230.2	-0.88	230.9	-0.58	238.5	2.69	238.1	2.52	232.0	-0.12	232.2	-0.05	231.9	-0.16	231.9	-0.14	232.4	0.06	232.4	0.06
Leamington C21J 230 kV	236.1					234.1	-0.83	234.9	-0.50	242.5	2.73	242.1	2.58	235.6	-0.19	235.8	-0.12	235.7	-0.14	235.8	-0.12	239.3	1.35	239.3	1.36
Leamington C22J 230 kV	235.8	233.1	-1.17	233.2	-1.11	233.8	-0.85	234.6	-0.51	242.4	2.80	242.0	2.64	235.4	-0.19	235.5	-0.12	235.5	-0.14	235.5	-0.12	236.5	0.28	236.5	0.28
Lauzon C23Z 230 kV	230.6	230.0	-0.23	230.1	-0.21					236.1	2.41	235.4	2.11	228.2	-1.00	228.7	-0.81	230.0	-0.25	230.1	-0.19	230.8	0.12	230.8	0.12
Lauzon C24Z 230 kV	230.3	229.7	-0.26	229.8	-0.24	216.1	-6.20	220.4	-4.30	236.0	2.46	235.3	2.16	228.0	-1.01	228.5	-0.82	229.8	-0.25	229.9	-0.19	230.6	0.11	230.6	0.11
Chatham 230 kV	243.4	244.5	0.45	244.6	0.47	242.2	-0.49	243.1	-0.13	248.6	2.13	248.3	1.98	242.7	-0.30	242.9	-0.23	243.2	-0.10	243.2	-0.08	244.4	0.41	244.4	0.41
Keith 115 kV	123.9	123.4	-0.41	123.4	-0.38	121.8	-1.70	122.5	-1.12	125.8	1.52	125.6	1.37	123.8	-0.13	123.9	0.02	123.4	-0.41	123.5	-0.36	123.8	-0.09	123.8	-0.09
Crawford J3E 115 kV	122.7	122.2	-0.34	122.3	-0.31	119.6	-2.52	120.6	-1.71	124.6	1.56	124.3	1.38					121.9	-0.59	122.0	-0.52	122.6	-0.04	122.6	-0.04
Crawford J4E 115 kV	122.9	122.5	-0.33	122.5	-0.31	119.8	-2.52	120.8	-1.71	124.8	1.56	124.6	1.37	121.5	-1.19	121.8	-0.90	122.2	-0.59	122.3	-0.52	122.9	-0.04	122.9	-0.04
Essex 115 kV	122.2	121.9	-0.26	121.9	-0.24	118.2	-3.30	119.4	-2.27	124.2	1.61	123.9	1.39	120.7	-1.25	121.0	-1.00	121.3	-0.77	121.4	-0.68	122.2	0.01	122.2	0.02
Windsor Transalta 115 kV	122.3	121.9	-0.26	122.0	-0.23	118.2	-3.32	119.5	-2.28	124.2	1.60	123.9	1.38	120.7	-1.25	121.0	-1.00	121.3	-0.79	121.4	-0.70	122.3	0.01	122.3	0.02
Walker Z1E 115 kV	122.2	121.9	-0.26	121.9	-0.23	118.1	-3.39	119.3	-2.33	124.2	1.63	123.9	1.40	120.7	-1.25	121.0	-1.00	121.1	-0.89	121.2	-0.79	122.2	0.02	122.2	0.02
Walker Z7E 115 kV	122.1	121.8	-0.26	121.8	-0.24	118.0	-3.39	119.3	-2.33	124.1	1.63	123.8	1.41	120.6	-1.25	120.9	-1.00					122.1	0.02	122.1	0.02
Ford Essex Z1E 115 kV	122.6	122.3	-0.24	122.3	-0.22	117.8	-3.94	119.2	-2.73	124.8	1.78	124.5	1.53	121.1	-1.21	121.4	-0.97	122.0	-0.49	122.1	-0.40	122.6	0.04	122.6	0.05
Ford Essex Z7E 115 kV	122.6	122.3	-0.24	122.3	-0.22	117.7	-3.94	119.2	-2.73	124.8	1.79	124.4	1.53	121.1	-1.21	121.4	-0.97					122.6	0.04	122.6	0.05
Lauzon 115 kV	122.8	122.5	-0.24	122.5	-0.21	117.6	-4.18	119.2	-2.90	125.1	1.85	124.7	1.59	121.3	-1.20	121.6	-0.96	122.4	-0.31	122.5	-0.23	122.8	0.06	122.8	0.06
Bell River K2Z 115 kV	122.1	121.8	-0.24	121.9	-0.22	116.8	-4.32	118.5	-2.95	124.5	1.91	124.1	1.62	120.6	-1.24	120.9	-0.98	121.7	-0.32	121.8	-0.23	122.2	0.06	122.2	0.06
Bell River K6Z 115 kV	121.1	120.8	-0.26	120.8	-0.23	115.5	-4.61	117.5	-3.02	123.6	2.03	123.2	1.68	119.5	-1.32	120.0	-0.96	120.7	-0.34	120.8	-0.25	121.2	0.06	121.2	0.06
Kingsville K2Z 115 kV	117.3	116.9	-0.30	116.9	-0.27	111.0	-5.36	113.5	-3.25	120.0	2.34	119.4	1.85	115.5	-1.52	115.6	-1.38	116.8	-0.39	116.9	-0.29	117.3	0.07	117.3	0.07
Kingsville K6Z 115 kV	117.3	116.9	-0.31	116.9	-0.27	110.9	-5.43	113.4	-3.27	120.0	2.37	119.4	1.86	115.5	-1.54	116.2	-0.94	116.8	-0.40	116.9	-0.29	117.4	0.07	117.4	0.07
Tilbury West 115 kV	118.8	118.5	-0.28	118.5	-0.25	113.0	-4.88	115.0	-3.17	121.3	2.14	120.9	1.76	117.1	-1.39	117.4	-1.18	118.4	-0.36	118.5	-0.26	118.9	0.06	118.9	0.07
Kent 115 kV	119.0	118.6	-0.27	118.7	-0.25	113.2	-4.87	115.2	-3.16	121.5	2.14	121.0	1.76	117.3	-1.39	117.5	-1.18	118.5	-0.36	118.6	-0.26	119.0	0.06	119.0	0.07

Table 33: Voltage assessment results with all elements in-service for single contingencies – Scenario S4

Bus Name	Pre-Cont.	C21J				C23Z				J5D				J3E				Z7E				Keith A Bus			
		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	231.3	229.0	-0.99	229.2	-0.88	229.6	-0.73	230.2	-0.47	237.0	2.49	236.9	2.42	231.1	-0.07	231.3	0.00	230.9	-0.18	230.9	-0.15	231.4	0.05	231.4	0.06
Malden C21J 230 kV	231.4					229.7	-0.73	230.4	-0.46	237.3	2.53	237.1	2.45	231.2	-0.08	231.4	-0.01	231.0	-0.18	231.1	-0.16	234.3	1.23	234.3	1.23
Malden C22J 230 kV	231.4	228.4	-1.26	228.7	-1.13	229.7	-0.74	230.3	-0.47	237.2	2.54	237.1	2.47	231.2	-0.08	231.3	-0.01	230.9	-0.18	231.0	-0.16	231.6	0.09	231.6	0.10
Leamington C21J 230 kV	233.5					231.9	-0.68	232.6	-0.36	239.7	2.68	239.6	2.61	233.1	-0.18	233.2	-0.12	233.1	-0.18	233.1	-0.16	235.5	0.87	235.5	0.87
Leamington C22J 230 kV	233.2	227.2	-2.57	227.7	-2.34	231.6	-0.69	232.3	-0.37	239.6	2.74	239.4	2.67	232.8	-0.18	232.9	-0.11	232.8	-0.18	232.8	-0.16	233.8	0.25	233.8	0.25
Lauzon C23Z 230 kV	228.7	227.8	-0.37	228.0	-0.31					233.9	2.26	233.6	2.14	226.1	-1.14	226.5	-0.96	227.6	-0.48	227.8	-0.40	229.0	0.15	229.0	0.15
Lauzon C24Z 230 kV	228.5	227.6	-0.39	227.7	-0.34	215.2	-5.83	219.5	-3.95	233.8	2.31	233.5	2.19	225.9	-1.15	226.3	-0.96	227.4	-0.48	227.6	-0.40	228.8	0.14	228.8	0.15
Chatham 230 kV	242.3	243.0	0.30	243.2	0.35	241.5	-0.34	242.4	0.01	247.3	2.07	247.2	2.01	241.6	-0.32	241.7	-0.26	241.9	-0.16	242.0	-0.14	243.1	0.33	243.1	0.33
Keith 115 kV	123.9	123.2	-0.52	123.3	-0.47	122.0	-1.52	122.6	-1.03	125.7	1.46	125.6	1.40	123.9	0.02	124.1	0.18	123.4	-0.40	123.4	-0.34	123.8	-0.01	123.8	-0.01
Crawford J3E 115 kV	122.2	121.6	-0.46	121.7	-0.41	119.4	-2.28	120.2	-1.60	124.0	1.49	123.9	1.39					121.5	-0.58	121.6	-0.50	122.2	0.02	122.2	0.02
Crawford J4E 115 kV	122.4	121.9	-0.46	121.9	-0.41	119.7	-2.28	120.5	-1.60	124.3	1.48	124.2	1.43	120.9	-1.25	121.3	-0.96	121.7	-0.58	121.8	-0.49	122.5	0.02	122.5	0.02
Essex 115 kV	121.3	120.8	-0.39	120.9	-0.34	117.6	-3.03	118.7	-2.16	123.1	1.51	123.0	1.42	119.4	-1.53	119.7	-1.29	120.4	-0.76	120.5	-0.65	121.4	0.06	121.4	0.06
Windsor Transalta 115 kV	121.4	120.9	-0.39	120.9	-0.34	117.7	-3.04	118.7	-2.17	123.2	1.51	123.1	1.42	119.5	-1.53	119.8	-1.28	120.4	-0.79	120.5	-0.67	121.4	0.06	121.4	0.06
Walker Z1E 115 kV	121.3	120.8	-0.39	120.8	-0.34	117.5	-3.11	118.6	-2.22	123.1	1.53	123.0	1.44	119.4	-1.53	119.7	-1.28	120.2	-0.91	120.3	-0.79	121.3	0.06	121.3	0.06
Walker Z7E 115 kV	121.2	120.7	-0.39	120.8	-0.34	117.4	-3.11	118.5	-2.21	123.0	1.53	122.9	1.45	119.3	-1.53	119.6	-1.28					121.2	0.06	121.2	0.06
Ford Essex Z1E 115 kV	121.3	120.9	-0.37	121.0	-0.32	116.9	-3.63	118.2	-2.60	123.3	1.65	123.2	1.56	119.6	-1.46	119.9	-1.22	120.5	-0.71	120.6	-0.61	121.4	0.08	121.4	0.08
Ford Essex Z7E 115 kV	121.3	120.9	-0.37	120.9	-0.32	116.9	-3.63	118.2	-2.60	123.3	1.66	123.2	1.56	119.6	-1.46	119.8	-1.22					121.4	0.08	121.4	0.08
Lauzon 115 kV	121.4	120.9	-0.36	121.0	-0.31	116.7	-3.86	118.0	-2.77	123.5	1.71	123.3	1.61	119.7	-1.42	119.9	-1.19	120.6	-0.63	120.8	-0.52	121.5	0.09	121.5	0.09
Bell River K2Z 115 kV	120.8	120.3	-0.37	120.4	-0.32	116.0	-3.96	117.4	-2.80	122.9	1.75	122.8	1.63	119.0	-1.46	119.3	-1.21	120.0	-0.64	120.1	-0.54	120.9	0.09	120.9	0.09
Bell River K6Z 115 kV	120.0	119.5	-0.38	119.6	-0.33	115.2	-4.03	116.6	-2.85	122.1	1.78	122.0	1.66	118.2	-1.49	118.5	-1.23	119.2	-0.65	119.3	-0.55	120.1	0.09	120.1	0.10
Kingsville K2Z 115 kV	117.3	116.8	-0.40	116.9	-0.34	112.3	-4.23	113.7	-3.03	119.5	1.87	119.3	1.75	115.4	-1.56	115.7	-1.30	116.5	-0.68	116.6	-0.57	117.4	0.10	117.4	0.10
Kingsville K6Z 115 kV	117.4	116.9	-0.40	117.0	-0.34	112.4	-4.24	113.8	-3.01	119.6	1.87	119.4	1.75	115.6	-1.56	115.9	-1.30	116.6	-0.69	116.7	-0.57	117.5	0.10	117.5	0.10
Tilbury West 115 kV	118.1	117.6	-0.39	117.7	-0.34	113.2	-4.16	114.6	-2.99	120.3	1.84	120.1	1.73	116.3	-1.53	116.6	-1.28	117.3	-0.67	117.4	-0.56	118.2	0.10	118.2	0.10
Kent 115 kV	118.3	117.8	-0.39	117.9	-0.34	113.3	-4.16	114.7	-2.99	120.4	1.84	120.3	1.73	116.4	-1.53	116.7	-1.28	117.5	-0.67	117.6	-0.56	118.4	0.10	118.4	0.10

Table 34: Voltage assessment results with all elements in-service for double contingencies – Scenario S3

Bus Name	Pre-Cont.	C21J+C23Z				C22J+C24Z				C23Z+C24Z				J3E +J4E				* Z1E+Z7E – (Kingsville capacitor switching with four caps. out)			
		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	232.1	227.8	-1.85	228.9	-1.37	228.4	-1.56	229.4	-1.15	230.5	-0.67	230.6	-0.63	232.5	0.18	232.6	0.25	231.9	-0.06	231.9	-0.06
Malden C21J 230 kV	232.3					228.1	-1.81	229.2	-1.36	230.9	-0.62	231.0	-0.59	232.7	0.14	232.8	0.22	232.2	-0.04	232.2	-0.04
Malden C22J 230 kV	232.3	227.4	-2.09	228.6	-1.58					230.8	-0.63	230.9	-0.60	232.6	0.15	232.8	0.23	232.2	-0.04	232.2	-0.04
Leamington C21J 230 kV	236.1					230.8	-2.22	232.0	-1.72	236.2	0.06	236.2	0.07	235.4	-0.28	235.8	-0.13	236.3	0.12	236.3	0.11
Leamington C22J 230 kV	235.8	230.4	-2.31	231.6	-1.77					235.8	0.02	235.9	0.03	235.2	-0.26	235.6	-0.11	236.1	0.12	236.1	0.12
Lauzon C23Z 230 kV	230.6					213.5	-7.41	219.5	-4.81					221.0	-4.13	222.9	-3.33	229.3	-0.56	229.1	-0.62
Lauzon C24Z 230 kV	230.3	213.3	-7.42	219.3	-4.81									220.7	-4.19	222.6	-3.38	233.1	1.18	233.1	1.21
Chatham 230 kV	243.4	243.3	-0.06	244.6	0.46	242.2	-0.49	243.5	0.03	247.5	1.69	247.5	1.68	240.8	-1.07	241.4	-0.84	244.0	0.22	244.0	0.22
Keith 115 kV	123.9	120.9	-2.40	122.0	-1.52	120.7	-2.63	121.9	-1.63	122.3	-1.34	122.4	-1.21	125.5	1.26	125.5	1.30	123.6	-0.27	123.6	-0.26
Crawford J3E 115 kV	122.7	118.7	-3.25	120.1	-2.07	118.5	-3.43	120.0	-2.14	120.1	-2.10	120.3	-1.89					122.3	-0.29	122.3	-0.28
Crawford J4E 115 kV	122.9	118.9	-3.25	120.4	-2.07	118.7	-3.43	120.3	-2.14	120.3	-2.10	120.5	-1.93					122.6	-0.29	122.6	-0.28
Essex 115 kV	122.2	117.2	-4.06	119.0	-2.60	117.1	-4.19	119.0	-2.64	118.8	-2.76	119.1	-2.52	116.3	-4.80	117.4	-3.89	121.8	-0.32	121.8	-0.31
Windsor Transalta 115 kV	122.3	117.3	-4.08	119.1	-2.61	117.1	-4.21	119.0	-2.65	118.9	-2.78	119.2	-2.53	116.4	-4.79	117.5	-3.89				
Walker Z1E 115 kV	122.2	117.1	-4.15	118.9	-2.66	117.0	-4.28	118.9	-2.70	118.7	-2.83	119.0	-2.58	116.3	-4.80	117.4	-3.89				
Walker Z7E 115 kV	122.1	117.0	-4.15	118.9	-2.65	116.9	-4.28	118.8	-2.70	118.7	-2.83	119.0	-2.58	116.3	-4.80	117.4	-3.89				
Ford Essex Z1E 115 kV	122.6	116.8	-4.76	118.8	-3.06	116.6	-4.87	118.8	-3.09	118.6	-3.25	119.0	-2.97	116.8	-4.73	117.9	-3.79				
Ford Essex Z7E 115 kV	122.6	116.7	-4.76	118.8	-3.06	116.6	-4.87	118.8	-3.09	118.6	-3.25	118.9	-2.97	116.8	-4.73	117.9	-3.79				
Lauzon 115 kV	122.8	116.6	-5.03	118.8	-3.24	116.5	-5.13	118.8	-3.26	118.6	-3.43	118.9	-3.13	117.0	-4.69	118.2	-3.75	125.0	1.80	125.1	1.86
Bell River K2Z 115 kV	122.1	115.8	-5.20	118.1	-3.29	115.7	-5.30	118.1	-3.31	117.8	-3.54	118.2	-3.19	116.2	-4.84	117.5	-3.82	123.9	1.42	123.9	1.46
Bell River K6Z 115 kV	121.1	114.4	-5.56	117.0	-3.39	114.3	-5.67	117.0	-3.41	116.5	-3.78	117.1	-3.33	114.9	-5.18	116.3	-3.96	117.8	-2.78	117.6	-2.91
Kingsville K2Z 115 kV	117.3	109.7	-6.48	112.9	-3.68	109.5	-6.60	112.9	-3.71	112.1	-4.39	112.9	-3.70	110.2	-6.02	112.2	-4.34	112.9	-3.68	113.2	-3.45
Kingsville K6Z 115 kV	117.3	109.6	-6.56	112.9	-3.69	109.4	-6.69	112.9	-3.72	112.1	-4.44	112.9	-3.72	110.1	-6.10	112.1	-4.38	109.9	-6.25	109.6	-6.52
Tilbury West 115 kV	118.8	111.8	-5.88	114.6	-3.56	111.7	-5.99	114.5	-3.59	114.1	-3.99	114.6	-3.51	112.3	-5.47	113.9	-4.16	118.1	-0.59	118.3	-0.45
Kent 115 kV	119.0	112.0	-5.88	114.7	-3.56	111.8	-5.99	114.7	-3.58	114.2	-3.99	114.8	-3.50	112.4	-5.47	114.0	-4.16	118.2	-0.59	118.4	-0.45

* Control Actions shown in brackets

Table 34: Voltage assessment results with all elements in-service for double contingencies – Scenario S3 (continued)

Bus Name	Pre-Cont.	Chatham 230 DL23 BF: C23Z + Chatham D Bus				Chatham 230 DL21 BF: C21J + Chatham D Bus				Lauzon T2K BF: C24Z + Lauzon cap				Lauzon T1L7 BF: Z7E+C23Z			
		[1] Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		[2] Pre-ULTC		Post-ULTC		[1] Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	232.1	227.7	-1.89	228.5	-1.52	228.3	-1.63	228.5	-1.52	229.6	-1.06	229.7	-1.02	229.7	-1.02	230.4	-0.73
Malden C21J 230 kV	232.3	227.7	-1.99	228.6	-1.62					229.9	-1.06	229.9	-1.03	230.0	-1.02	230.6	-0.73
Malden C22J 230 kV	232.3	227.6	-1.99	228.5	-1.62	227.7	-1.95	228.1	-1.81	229.8	-1.06	229.9	-1.03	229.9	-1.03	230.5	-0.74
Leamington C21J 230 kV	236.1	229.7	-2.71	230.6	-2.30					233.8	-0.97	233.7	-0.99	233.8	-0.97	234.5	-0.64
Leamington C22J 230 kV	235.8	229.4	-2.73	230.3	-2.32	228.6	-3.06	228.9	-2.93	233.5	-0.99	233.4	-1.01	233.5	-0.98	234.3	-0.66
Lauzon C23Z 230 kV	230.6					224.7	-2.55	225.2	-2.32	218.0	-5.45	217.4	-5.68				
Lauzon C24Z 230 kV	230.3	211.5	-8.20	216.8	-5.89	224.4	-2.58	224.9	-2.35					214.4	-6.94	219.1	-4.87
Chatham 230 kV	243.4	235.5	-3.25	236.6	-2.81	237.3	-2.52	237.5	-2.42	242.0	-0.59	241.8	-0.66	241.9	-0.62	242.8	-0.26
Keith 115 kV	123.9	120.9	-2.46	121.7	-1.78	122.3	-1.28	122.5	-1.15	121.2	-2.18	121.4	-2.07	121.3	-2.07	122.0	-1.51
Crawford J3E 115 kV	122.7	118.5	-3.36	119.7	-2.45	120.9	-1.48	121.0	-1.32	118.8	-3.16	119.0	-3.00	118.9	-3.03	119.9	-2.27
Crawford J4E 115 kV	122.9	118.8	-3.36	119.9	-2.49	121.1	-1.47	121.3	-1.32	119.0	-3.16	119.2	-3.05	119.2	-3.02	120.1	-2.26
Essex 115 kV	122.2	117.0	-4.21	118.4	-3.13	120.2	-1.66	120.4	-1.48	117.2	-4.10	117.4	-3.96	117.4	-3.93	118.5	-2.99
Windsor Transalta 115 kV	122.3	117.1	-4.23	118.4	-3.15	120.2	-1.67	120.4	-1.48	117.2	-4.12	117.4	-3.98	117.4	-3.99	118.6	-3.03
Walker Z1E 115 kV	122.2	116.9	-4.31	118.3	-3.21	120.1	-1.70	120.4	-1.51	117.1	-4.21	117.2	-4.06	117.1	-4.21	118.3	-3.22
Walker Z7E 115 kV	122.1	116.8	-4.31	118.2	-3.20	120.0	-1.70	120.3	-1.50	117.0	-4.21	117.2	-4.06				
Ford Essex Z1E 115 kV	122.6	116.5	-4.93	118.1	-3.69	120.3	-1.89	120.5	-1.68	116.6	-4.89	116.8	-4.74	116.7	-4.78	118.2	-3.57
Ford Essex Z7E 115 kV	122.6	116.5	-4.93	118.0	-3.69	120.3	-1.89	120.5	-1.68	116.6	-4.89	116.8	-4.74				
Lauzon 115 kV	122.8	116.4	-5.21	118.0	-3.91	120.4	-1.97	120.6	-1.75	116.4	-5.19	116.6	-5.04	116.6	-5.03	118.2	-3.73
Bell River K2Z 115 kV	122.1	115.6	-5.33	117.3	-3.97	119.6	-2.04	119.9	-1.79	115.6	-5.36	115.9	-5.13	115.8	-5.15	117.5	-3.79
Bell River K6Z 115 kV	121.1	114.6	-5.36	116.2	-4.08	118.5	-2.17	118.9	-1.87	114.2	-5.73	114.7	-5.32	114.8	-5.18	116.4	-3.88
Kingsville K2Z 115 kV	117.3	110.9	-5.45	112.1	-4.39	114.3	-2.52	114.8	-2.08	109.4	-6.68	110.4	-5.86	111.1	-5.26	112.4	-4.16
Kingsville K6Z 115 kV	117.3	110.9	-5.46	112.1	-4.41	114.3	-2.55	114.8	-2.09	109.3	-6.76	110.4	-5.90	111.1	-5.28	112.4	-4.18
Tilbury West 115 kV	118.8	112.3	-5.50	113.7	-4.28	116.1	-2.29	116.5	-1.97	111.6	-6.06	112.1	-5.61	112.5	-5.32	114.0	-4.07
Kent 115 kV	119.0	112.4	-5.50	113.9	-4.27	116.2	-2.29	116.6	-1.96	111.7	-6.06	112.3	-5.60	112.6	-5.31	114.1	-4.06

1) Kingsville load was converted for this contingency Pre-ULTC
2) Lauzon load was converted for this contingency Pre-ULTC

Table 35: Voltage assessment results with all elements in-service for double contingencies – Scenario S4

Bus Name	Pre-Cont.	C21J+C23Z				C22J+C24Z				C23Z+C24Z				J3E +J4E				Z1E+Z7E			
		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		* Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	231.3	227.1	-1.82	228.1	-1.37	227.6	-1.57	228.5	-1.18	230.3	-0.42	230.3	-0.40	232.2	0.39	232.5	0.51	232.1	0.37	232.1	0.35
Malden C21J 230 kV	231.4					227.1	-1.89	228.1	-1.45	230.6	-0.36	230.6	-0.35	232.2	0.33	232.5	0.46	232.4	0.41	232.3	0.38
Malden C22J 230 kV	231.4	226.4	-2.13	227.6	-1.64					230.5	-0.37	230.5	-0.36	232.1	0.33	232.4	0.47	232.3	0.41	232.2	0.38
Leamington C21J 230 kV	233.5					225.6	-3.39	227.0	-2.78	234.3	0.34	234.3	0.34	232.9	-0.26	233.5	-0.01	235.1	0.67	234.9	0.62
Leamington C22J 230 kV	233.2	224.9	-3.53	226.5	-2.87					233.9	0.31	233.9	0.31	232.6	-0.24	233.2	0.00	234.8	0.67	234.6	0.62
Lauzon C23Z 230 kV	228.7					213.6	-6.61	218.5	-4.46					217.0	-5.12	219.8	-3.87	235.2	2.83	234.5	2.56
Lauzon C24Z 230 kV	228.5	212.6	-6.95	217.7	-4.72									216.7	-5.16	219.6	-3.91	234.2	2.49	233.6	2.21
Chatham 230 kV	242.3	242.3	-0.02	243.4	0.46	241.4	-0.37	242.6	0.09	246.9	1.87	246.8	1.86	239.4	-1.19	240.3	-0.84	244.6	0.95	244.4	0.87
Keith 115 kV	123.9	121.2	-2.16	121.9	-1.54	121.2	-2.14	122.0	-1.51	122.4	-1.15	122.5	-1.08	126.5	2.11	126.5	2.17	124.6	0.57	124.5	0.56
Crawford J3E 115 kV	122.2	118.6	-2.94	119.6	-2.09	118.7	-2.87	119.7	-2.03	119.9	-1.88	120.0	-1.78					123.2	0.84	123.2	0.84
Crawford J4E 115 kV	122.4	118.9	-2.93	119.9	-2.09	118.9	-2.86	120.0	-2.02	120.1	-1.88	120.3	-1.78					123.5	0.84	123.5	0.84
Essex 115 kV	121.3	116.8	-3.69	118.1	-2.63	117.0	-3.57	118.2	-2.53	118.2	-2.56	118.3	-2.44	113.0	-6.86	114.8	-5.36	122.6	1.10	122.6	1.11
Windsor Transalta 115 kV	121.4	116.8	-3.71	118.1	-2.65	117.0	-3.59	118.3	-2.54	118.2	-2.57	118.4	-2.45	113.0	-6.85	114.9	-5.35				
Walker Z1E 115 kV	121.3	116.7	-3.78	118.0	-2.69	116.8	-3.65	118.1	-2.59	118.1	-2.62	118.2	-2.50	113.0	-6.83	114.8	-5.33				
Walker Z7E 115 kV	121.2	116.6	-3.78	117.9	-2.69	116.7	-3.65	118.0	-2.59	118.0	-2.62	118.1	-2.50	112.9	-6.84	114.7	-5.33				
Ford Essex Z1E 115 kV	121.3	116.1	-4.34	117.6	-3.10	116.3	-4.18	117.7	-2.97	117.6	-3.06	117.8	-2.92	113.5	-6.50	115.2	-5.05				
Ford Essex Z7E 115 kV	121.3	116.1	-4.34	117.6	-3.10	116.2	-4.18	117.7	-2.97	117.6	-3.06	117.8	-2.92	113.4	-6.50	115.2	-5.05				
Lauzon 115 kV	121.4	115.8	-4.59	117.4	-3.29	116.0	-4.42	117.6	-3.14	117.4	-3.25	117.6	-3.11	113.7	-6.35	115.4	-4.92	124.7	2.71	124.3	2.40
Bell River K2Z 115 kV	120.8	115.1	-4.71	116.8	-3.33	115.3	-4.53	116.9	-3.18	116.8	-3.33	117.0	-3.15	112.9	-6.50	114.8	-4.98	124.2	2.84	123.8	2.52
Bell River K6Z 115 kV	120.0	114.2	-4.80	115.9	-3.39	114.5	-4.61	116.1	-3.24	115.9	-3.39	116.2	-3.21	112.2	-6.51	113.9	-5.07	124.0	3.34	123.6	3.02
Kingsville K2Z 115 kV	117.3	111.4	-5.04	113.0	-3.59	111.6	-4.84	113.2	-3.43	113.1	-3.56	113.3	-3.40	109.6	-6.54	110.9	-5.39	120.9	3.09	120.5	2.76
Kingsville K6Z 115 kV	117.4	111.5	-5.06	113.2	-3.58	111.7	-4.86	113.4	-3.42	113.2	-3.57	113.4	-3.38	109.7	-6.56	111.1	-5.36	121.4	3.41	121.0	3.07
Tilbury West 115 kV	118.1	112.2	-4.96	113.9	-3.54	112.5	-4.77	114.1	-3.38	114.0	-3.51	114.1	-3.35	110.2	-6.67	111.8	-5.31	121.6	2.97	121.2	2.64
Kent 115 kV	118.3	112.4	-4.96	114.1	-3.54	112.6	-4.77	114.3	-3.38	114.1	-3.50	114.3	-3.35	110.4	-6.66	112.0	-5.30	121.8	2.97	121.4	2.64

* Kingsville load was converted for this contingency Pre-ULTC

Table 35: Voltage assessment results with all elements in-service for double contingencies – Scenario S4 (continued)

Bus Name	Pre-Cont.	Chatham 230 DL23 BF: C23Z + Chatham D Bus				Chatham 230 DL21 BF: C21J + Chatham D Bus				Lauzon T1L7 BF: Z7E+C23Z			
		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	231.3	227.0	-1.87	228.0	-1.44	227.1	-1.81	227.6	-1.59	228.9	-1.01	229.8	-0.64
Malden C21J 230 kV	231.4	226.9	-1.97	227.9	-1.53					229.1	-1.02	230.0	-0.63
Malden C22J 230 kV	231.4	226.8	-1.97	227.8	-1.53	226.3	-2.20	226.8	-1.95	229.0	-1.03	229.9	-0.64
Leamington C21J 230 kV	233.5	227.1	-2.74	228.3	-2.23					231.2	-1.00	232.2	-0.54
Leamington C22J 230 kV	233.2	226.8	-2.75	228.0	-2.24	222.6	-4.56	223.5	-4.17	230.8	-1.01	231.9	-0.55
Lauzon C23Z 230 kV	228.7					222.8	-2.60	223.4	-2.32				
Lauzon C24Z 230 kV	228.5	209.3	-8.39	215.4	-5.73	222.5	-2.63	223.1	-2.35	211.4	-7.51	217.5	-4.80
Chatham 230 kV	242.3	234.5	-3.24	235.8	-2.71	235.9	-2.66	236.3	-2.49	240.7	-0.67	241.9	-0.16
Keith 115 kV	123.9	120.9	-2.42	121.7	-1.71	122.2	-1.35	122.4	-1.20	121.2	-2.10	122.1	-1.41
Crawford J3E 115 kV	122.2	118.0	-3.40	119.3	-2.40	120.3	-1.54	120.5	-1.36	118.4	-3.12	119.6	-2.13
Crawford J4E 115 kV	122.4	118.3	-3.39	119.5	-2.40	120.6	-1.54	120.8	-1.36	118.6	-3.12	119.8	-2.13
Essex 115 kV	121.3	116.0	-4.33	117.6	-3.07	119.2	-1.71	119.5	-1.51	116.3	-4.11	117.8	-2.84
Windsor Transalta 115 kV	121.4	116.1	-4.36	117.6	-3.09	119.3	-1.72	119.5	-1.52	116.3	-4.18	117.8	-2.90
Walker Z1E 115 kV	121.3	115.9	-4.44	117.4	-3.15	119.1	-1.74	119.4	-1.54	115.9	-4.43	117.5	-3.11
Walker Z7E 115 kV	121.2	115.8	-4.44	117.4	-3.15	119.1	-1.74	119.3	-1.54				
Ford Essex Z1E 115 kV	121.3	115.1	-5.11	116.9	-3.64	119.0	-1.92	119.3	-1.69	114.9	-5.33	116.9	-3.68
Ford Essex Z7E 115 kV	121.3	115.1	-5.12	116.9	-3.64	119.0	-1.92	119.3	-1.69				
Lauzon 115 kV	121.4	114.8	-5.42	116.7	-3.86	119.0	-1.99	119.3	-1.76	114.4	-5.73	116.6	-3.94
Bell River K2Z 115 kV	120.8	114.1	-5.56	116.1	-3.91	118.3	-2.04	118.6	-1.79	113.7	-5.88	116.0	-3.98
Bell River K6Z 115 kV	120.0	113.2	-5.66	115.2	-3.98	117.5	-2.08	117.8	-1.82	112.8	-5.99	115.1	-4.06
Kingsville K2Z 115 kV	117.3	110.3	-5.95	112.3	-4.23	114.7	-2.18	115.0	-1.93	109.9	-6.29	112.2	-4.31
Kingsville K6Z 115 kV	117.4	110.4	-5.97	112.5	-4.20	114.8	-2.19	115.1	-1.92	110.0	-6.31	112.4	-4.28
Tilbury West 115 kV	118.1	111.2	-5.85	113.2	-4.17	115.6	-2.15	115.9	-1.90	110.8	-6.19	113.1	-4.25
Kent 115 kV	118.3	111.3	-5.85	113.3	-4.16	115.7	-2.15	116.0	-1.90	110.9	-6.19	113.2	-4.24

Table 36: Voltage assessment results under outage conditions – Scenario S3

Bus Name	KEITH A Bus O/S	KEITH A Bus + C23Z				J3E O/S	J3E + C23Z				CHATHAM D Bus O/S	CHATHAM D BUS + CHATHAM K BUS				C21J Chatham end open	C21J Chatham end open + Keith C21J IBO			
	Pre-Cont.	Pre-ULTC		Post-ULTC		Pre-Cont.	* Pre-ULTC		Post-ULTC		Pre-Cont.	Pre-ULTC		Post-ULTC		Pre-Cont.	Post-ULTC		Pre-ULTC	
	kV	kV	%	kV	%	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	232.1	230.3	-0.78	231.0	-0.46	232.0	230.5	-0.63	230.5	-0.63	229.7	228.9	-0.36	229.2	-0.22	231.3	231.1	-0.09	231.1	-0.09
Malden C21J 230 kV	237.2	234.9	-0.95	236.1	-0.47	232.2	230.8	-0.63	230.7	-0.64	229.8	228.9	-0.36	229.3	-0.22	231.2	230.8	-0.21	230.7	-0.21
Malden C22J 230 kV	232.4	230.5	-0.81	231.3	-0.48	232.2	230.7	-0.63	230.7	-0.64	229.7	228.9	-0.36	229.2	-0.22	231.4	231.1	-0.13	231.1	-0.13
Leamington C21J 230 kV	239.3	237.2	-0.84	238.4	-0.37	235.8	234.6	-0.51	234.4	-0.59	231.8	230.8	-0.42	231.1	-0.30	232.0	231.5	-0.20	231.5	-0.20
Leamington C22J 230 kV	236.5	234.4	-0.88	235.4	-0.47	235.5	234.3	-0.52	234.1	-0.61	231.5	230.5	-0.42	230.8	-0.30	234.3	233.6	-0.31	233.6	-0.31
Lauzon C23Z 230 kV	230.8					228.7					225.9	216.7	-4.09	218.6	-3.24	230.5	230.4	-0.04	230.4	-0.04
Lauzon C24Z 230 kV	230.6	214.2	-7.10	219.8	-4.67	228.5	217.1	-4.99	215.5	-5.68	225.7	216.4	-4.12	218.3	-3.26	230.2	230.1	-0.04	230.1	-0.04
Chatham 230 kV	244.4	243.0	-0.58	244.2	-0.11	242.9	242.6	-0.11	242.2	-0.28	237.0					244.9	244.7	-0.07	244.7	-0.07
Keith 115 kV	123.8	121.1	-2.15	122.2	-1.29	123.9	122.3	-1.34	122.4	-1.22	122.9	121.3	-1.27	121.8	-0.91	123.7	123.6	-0.04	123.6	-0.04
Crawford J3E 115 kV	122.6	118.9	-3.03	120.3	-1.90						121.4	119.2	-1.80	119.8	-1.31	122.5	122.5	-0.04	122.5	-0.04
Crawford J4E 115 kV	122.9	119.2	-3.02	120.6	-1.90	121.8	118.5	-2.69	118.8	-2.46	121.6	119.5	-1.80	120.1	-1.31	122.8	122.7	-0.04	122.7	-0.04
Essex 115 kV	122.2	117.5	-3.86	119.2	-2.48	121.0	116.5	-3.69	116.6	-3.58	120.7	117.9	-2.33	118.6	-1.71	122.1	122.1	-0.04	122.1	-0.04
Windsor Transalta 115 kV	122.3	117.5	-3.88	119.2	-2.49	121.0	116.6	-3.70	116.7	-3.60	120.7	117.9	-2.35	118.7	-1.72	122.2	122.1	-0.04	122.1	-0.04
Walker Z1E 115 kV	122.2	117.4	-3.96	119.1	-2.54	121.0	116.4	-3.75	116.6	-3.65	120.7	117.8	-2.39	118.5	-1.76	122.1	122.1	-0.04	122.1	-0.04
Walker Z7E 115 kV	122.1	117.3	-3.96	119.0	-2.54	120.9	116.4	-3.75	116.5	-3.65	120.6	117.7	-2.39	118.5	-1.75	122.0	122.0	-0.04	122.0	-0.04
Ford Essex Z1E 115 kV	122.6	117.0	-4.56	119.0	-2.96	121.4	116.4	-4.14	116.4	-4.09	120.8	117.5	-2.79	118.3	-2.07	122.5	122.5	-0.04	122.5	-0.04
Ford Essex Z7E 115 kV	122.6	117.0	-4.57	119.0	-2.96	121.4	116.4	-4.14	116.4	-4.09	120.8	117.4	-2.79	118.3	-2.07	122.5	122.5	-0.04	122.5	-0.04
Lauzon 115 kV	122.8	116.9	-4.83	119.0	-3.14	121.6	116.4	-4.31	116.4	-4.28	120.9	117.3	-2.97	118.3	-2.20	122.7	122.7	-0.04	122.7	-0.04
Bell River K2Z 115 kV	122.2	116.1	-4.99	118.3	-3.20	120.9	115.5	-4.47	115.7	-4.34	120.2	116.5	-3.07	117.5	-2.24	122.1	122.0	-0.04	122.0	-0.04
Bell River K6Z 115 kV	121.2	114.7	-5.34	117.2	-3.29	120.0	114.1	-4.86	114.6	-4.49	119.2	115.2	-3.33	116.4	-2.31	121.1	121.0	-0.05	121.0	-0.05
Kingsville K2Z 115 kV	117.3	110.0	-6.22	113.2	-3.56	115.6	109.4	-5.43	110.0	-4.90	115.2	110.6	-3.99	112.3	-2.53	117.2	117.1	-0.05	117.1	-0.05
Kingsville K6Z 115 kV	117.4	110.0	-6.29	113.1	-3.58	116.2	109.3	-5.94	110.4	-4.94	115.2	110.5	-4.04	112.2	-2.54	117.2	117.2	-0.05	117.2	-0.05
Tilbury West 115 kV	118.9	112.2	-5.65	114.8	-3.45	117.4	111.5	-4.99	111.8	-4.73	116.8	112.7	-3.54	114.0	-2.44	118.8	118.7	-0.05	118.7	-0.05
Kent 115 kV	119.0	112.3	-5.64	114.9	-3.45	117.5	111.7	-4.99	112.0	-4.73	117.0	112.8	-3.54	114.1	-2.44	118.9	118.8	-0.05	118.8	-0.05

* Lauzon load was converted for this contingency Pre-ULTC

Table 37: Voltage assessment results under outage conditions – Scenario S4

Bus Name	KEITH A Bus O/S	KEITH A Bus + C23Z				J3E O/S	J3E + C23Z				CHATHAM D Bus O/S	CHATHAM D BUS + CHATHAM K BUS				C21J Chatham end open	C21J Chatham end open + Keith C21J IBO			
	Pre-Cont.	Pre-ULTC		Post-ULTC		Pre-Cont.	* Pre-ULTC		Post-ULTC		Pre-Cont.	Pre-ULTC		Post-ULTC		Pre-Cont.	Post-ULTC		Pre-ULTC	
	kV	kV	%	kV	%	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Keith 230 kV	231.4	230.1	-0.58	230.6	-0.35	231.3	230.2	-0.48	230.2	-0.45	229.0	228.3	-0.31	228.5	-0.22	230.2	229.6	-0.26	229.8	-0.16
Malden C21J 230 kV	234.3	232.7	-0.69	233.6	-0.30	231.4	230.3	-0.47	230.4	-0.44	228.9	228.2	-0.33	228.4	-0.23	230.0	221.3	-3.76	223.0	-3.02
Malden C22J 230 kV	231.6	230.2	-0.60	230.7	-0.36	231.3	230.2	-0.48	230.3	-0.45	228.8	228.1	-0.32	228.3	-0.22	230.2	229.2	-0.41	229.5	-0.30
Leamington C21J 230 kV	235.5	234.1	-0.60	235.0	-0.21	233.2	232.5	-0.33	232.4	-0.35	229.2	228.1	-0.49	228.3	-0.38	228.7	220.9	-3.39	222.6	-2.66
Leamington C22J 230 kV	233.8	232.3	-0.64	233.0	-0.31	232.9	232.1	-0.34	232.1	-0.37	228.9	227.8	-0.48	228.1	-0.38	231.2	228.6	-1.11	229.0	-0.96
Lauzon C23Z 230 kV	229.0					226.5					224.3	216.1	-3.66	217.5	-3.02	228.6	228.2	-0.18	228.3	-0.14
Lauzon C24Z 230 kV	228.8	214.4	-6.32	219.1	-4.27	226.3	216.2	-4.46	215.5	-4.79	224.1	215.8	-3.68	217.3	-3.03	228.4	228.0	-0.18	228.1	-0.13
Chatham 230 kV	243.1	242.3	-0.35	243.2	0.04	241.7	241.9	0.09	241.7	-0.01	236.0					244.0	243.4	-0.23	243.5	-0.20
Keith 115 kV	123.8	121.7	-1.75	122.4	-1.19	124.1	122.7	-1.14	122.8	-0.99	122.8	121.5	-1.07	121.8	-0.85	123.5	123.4	-0.13	123.4	-0.08
Crawford J3E 115 kV	122.2	119.1	-2.54	120.0	-1.77						121.0	119.1	-1.52	119.5	-1.21	122.0	121.8	-0.14	121.8	-0.09
Crawford J4E 115 kV	122.5	119.4	-2.54	120.3	-1.77	121.3	118.4	-2.35	118.8	-2.08	121.2	119.4	-1.52	119.8	-1.21	122.2	122.1	-0.14	122.1	-0.09
Essex 115 kV	121.4	117.4	-3.31	118.5	-2.34	119.7	115.8	-3.27	116.0	-3.12	119.9	117.5	-1.97	118.0	-1.57	121.2	121.0	-0.14	121.0	-0.10
Windsor Transalta 115 kV	121.4	117.4	-3.33	118.6	-2.36	119.8	115.9	-3.28	116.0	-3.13	119.9	117.5	-1.99	118.0	-1.58	121.2	121.0	-0.14	121.1	-0.10
Walker Z1E 115 kV	121.3	117.2	-3.39	118.4	-2.41	119.7	115.7	-3.33	115.9	-3.18	119.8	117.4	-2.03	117.9	-1.61	121.1	121.0	-0.15	121.0	-0.10
Walker Z7E 115 kV	121.2	117.1	-3.39	118.3	-2.40	119.6	115.6	-3.33	115.8	-3.18	119.7	117.3	-2.03	117.8	-1.61	121.0	120.9	-0.15	120.9	-0.10
Ford Essex Z1E 115 kV	121.4	116.7	-3.94	118.0	-2.81	119.9	115.4	-3.69	115.6	-3.59	119.7	116.8	-2.37	117.4	-1.89	121.3	121.1	-0.15	121.1	-0.11
Ford Essex Z7E 115 kV	121.4	116.6	-3.94	118.0	-2.81	119.8	115.4	-3.69	115.5	-3.59	119.7	116.8	-2.37	117.4	-1.89	121.2	121.0	-0.15	121.1	-0.11
Lauzon 115 kV	121.5	116.4	-4.18	117.9	-2.99	119.9	115.3	-3.85	115.4	-3.77	119.6	116.6	-2.52	117.2	-2.02	121.3	121.1	-0.16	121.2	-0.12
Bell River K2Z 115 kV	120.9	115.7	-4.29	117.2	-3.02	119.3	114.6	-3.97	114.8	-3.81	119.0	115.9	-2.60	116.6	-2.04	120.7	120.5	-0.16	120.6	-0.12
Bell River K6Z 115 kV	120.1	114.9	-4.37	116.4	-3.08	118.5	113.7	-4.04	113.9	-3.88	118.2	115.1	-2.65	115.8	-2.08	119.9	119.7	-0.17	119.8	-0.12
Kingsville K2Z 115 kV	117.4	112.0	-4.59	113.5	-3.27	115.7	110.8	-4.24	111.0	-4.13	115.4	112.2	-2.77	112.9	-2.21	117.2	117.0	-0.17	117.0	-0.13
Kingsville K6Z 115 kV	117.5	112.1	-4.60	113.7	-3.25	115.9	110.9	-4.26	111.1	-4.11	115.5	112.3	-2.79	113.0	-2.20	117.3	117.1	-0.17	117.2	-0.13
Tilbury West 115 kV	118.2	112.9	-4.52	114.4	-3.22	116.6	111.7	-4.17	111.8	-4.07	116.3	113.1	-2.72	113.7	-2.18	118.0	117.8	-0.17	117.9	-0.12
Kent 115 kV	118.4	113.0	-4.51	114.6	-3.22	116.7	111.9	-4.16	112.0	-4.07	116.4	113.3	-2.72	113.9	-2.18	118.2	118.0	-0.17	118.0	-0.12

* Lauzon load was converted for this contingency Pre-ULTC

Appendix C Protection Impact Assessment

Hydro One Networks Inc.
483 Bay Street
Toronto, Ontario
M5G 2P5

PROTECTION IMPACT ASSESSMENT

LIMINGTON TS

NEW 75/125MVA 215.5/27.6/27.6KV TRANSFORMER STATIONS

PCT – 517

Executive Summary

Date: November 19, 2013

Prepared by:

P&C Planning Group

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Disclaimer

This Protection Impact Assessment has been prepared solely for the IESO for the purpose of assisting the IESO in preparing the System Impact Assessment for the proposed connection of the proposed generation facility to the IESO–controlled grid. This report has not been prepared for any other purpose and should not be used or relied upon by any person, including the connection applicant, for any other purpose.

This Protection Impact Assessment was prepared based on information provided to the IESO and Hydro One by the connection applicant in the application to request a connection assessment at the time the assessment was carried out. It is intended to highlight significant impacts, if any, to affected transmission protections early in the project development process. The results of this Protection Impact Assessment are also subject to change to accommodate the requirements of the IESO and other regulatory or legal requirements. In addition, further issues or concerns may be identified by Hydro One during the detailed design phase that may require changes to equipment characteristics and/or configuration to ensure compliance with the Transmission System Code legal requirements, and any applicable reliability standards, or to accommodate any changes to the IESO-controlled grid that may have occurred in the meantime.

Hydro One shall not be liable to any third party, including the connection applicant, which uses the results of the Protection Impact Assessment under any circumstances, whether any of the said liability, loss or damages arises in contract, tort or otherwise.

Revision History

Revision	Date	Change
R0	November 19, 2013	Released

EXECUTIVE SUMMARY

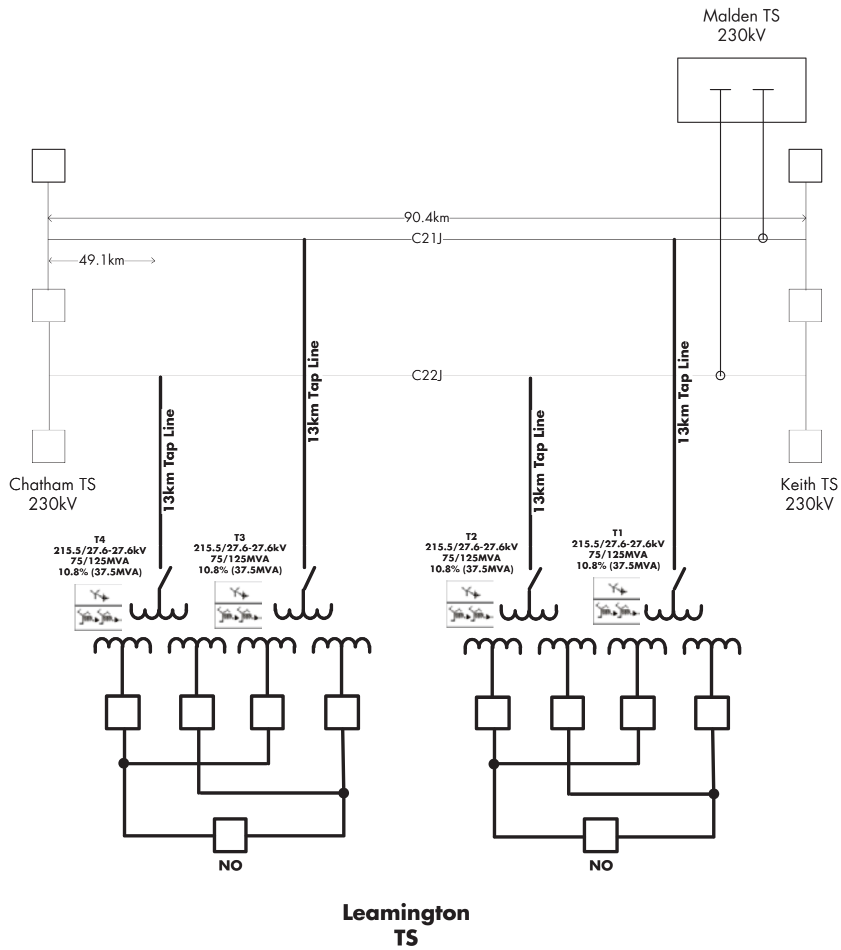

Figure #1 – Leamington TS on HONI Circuits C21J and C22J
(This figure is to be used for illustrative purpose only.)

The installation of the proposed DESN station connection is feasible as long as the proposed changes/additions are made.

PROTECTION HARDWARE

Existing protection "A" POTT and "B" POTT schemes of terminal stations have to be modified to receive the transfer trip signal from Leamington TS. Hardware addition may be required.

PROTECTION SETTING

Zone settings changes at both terminal stations are not required.

TELECOMMUNICATIONS

New dual communication links between Leamington TS and one of the terminal stations are required to send transfer trip signals. The cascading to the other terminal and other tapped facilities will be required.

Modifications in existing schemes at the selected terminal station are required to receive and cascade the transfer trip signals.

LEAMINGTON TS SITE

Standard transformer protections are required that are compliant with the requirements of Transmission System Code.

New communication links between Leamington TS and both terminal stations are required.

CUSTOMER IMPACT ASSESSMENT

483 Bay Street
Toronto, Ontario
M5G 2P5

CUSTOMER IMPACT ASSESSMENT

SUPPLY TO ESSEX COUNTY TRANSMISSION REINFORCEMENT PROJECT

Plan/Project # : **AR 17503**

Revision: **Draft**

Date: **May 9, 2014**

Issued by: **Transmission System Development Department**
Network Development & Regional Planning Division
Hydro One Networks Inc.

Prepared by:

Hamid Hamadanizadeh
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Transmission System Development

Reviewed by:

Ibrahim El Nahas, P.Eng.
Manager - Transmission Planning
Transmission System Development

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DISCLAIMER

This Customer Impact Assessment was prepared based on preliminary information available about the proposed *Supply to Essex County Transmission Reinforcement Project*, consisting of construction of a 230/27.6-27.6 kV, 75/125 MVA transformer station in the Town of Leamington and construction of a connecting 13 km, double-circuit, 230 kV overhead transmission line between the new station and the existing 230 kV transmission lines. This report is intended to highlight significant impacts, if any, to affected transmission customers early in the project development process and thus allow an opportunity for these parties to bring forward any concerns that they may have, including those needed for the review of the connection and for any possible application for Leave to Construct. Subsequent changes to the required modifications or the implementation plan may affect the impacts of the proposed connection identified in this Customer Impact Assessment. The results of this Customer Impact Assessment and the estimate of the outage requirements are subject to change to accommodate the requirements of the IESO and other regulatory or municipal authority requirements. The fault levels computed as part of this Customer Impact Assessment are meant to assess current conditions in the study horizon and are not intended to be for the purposes of sizing equipment or making other project design decisions. Many other factors beyond the existing fault levels go into project design decisions.

Hydro One Networks Inc. shall not be liable, whether in contract, tort or any other theory of liability, to any person who uses the results of the Customer Impact Assessment under any circumstances whatsoever for any damages arising out of such use unless such liability is created under some other contractual obligation between Hydro One Networks Inc. and such person.

EXECUTIVE SUMMARY

Hydro One is planning the reinforcement of the supply to Essex County to address the supply capacity needs in the Windsor – Essex region, minimize the impact of outages, and ensure compliance with IESO's Ontario Resource and Transmission Assessment Criteria. These needs were identified in a planning study carried out by the Ontario Power Authority with input from Hydro One, the IESO and the Local Distribution Companies in the region. This Customer Impact Assessment (CIA) is concerned with the potential impact of this plan on the area customers.

The plan consists of:

- Construction of a 230/27.6-27.6 kV, 75/100/125 MVA DESN station in the Town of Leamington
- Construction of a connecting 13 km, double-circuit, 230 kV overhead transmission line from the Leamington station to the existing Chatham-Keith circuits C21J and C22J.
- Installation of Optic Ground Wire (OPGW) on the towers of the new line and existing C21J/C23Z towers (near Leamington Junction).

An assessment of voltage performance and loading capability of the transmission facilities in the area has been carried out and documented in an IESO System Impact Assessment (**SIA**) Draft Report of the proposed transmission reinforcement, "Leamington TS - Supply to Essex County Transmission Reinforcement Project", CAA ID 2013-507, May 9, 2014. The report concludes that with the allowed operation measures (use of Windsor SPS) voltage performance of all connection points remains within the Market Rules requirements and the thermal loading of the facilities remains within their ratings. The thermal overloads that require the use of operating measures are less significant with the incorporation of this project compared to the existing situation (without this project).

The following potential impacts on existing customers in the area are reviewed is this CIA:

- Short circuit impact
- Impact on customer power supply reliability.

The findings of this CIA are as follows:

1. The plan has no significant impact on Short-Circuit Levels in the area since it does not introduce additional sources of short circuit current. The distributed generators that are expected to connect to the low-voltage side of the new Leamington station are those that were previously planned to connect to the Kingsville station.

2. The plan does not result in deterioration of the area's customer power supply reliability. The new 13 km line tap to the existing Chatham-Keith circuits will marginally increase their exposure to faults; however, this will not result in increased disruptions to customers in normal conditions.

3. The plan will result in reduced frequency and amount of armed load rejection that would be required in the event of 230 kV supply interruption to Lauzon TS.

CUSTOMER IMPACT ASSESSMENT
SOUTH-ESSEX COUNTY TRANSMISSION REINFORCEMENT

1.0 INTRODUCTION

1.1 Background

The Ontario Power Authority (**OPA**) conducted a planning study for the Windsor - Essex region, with input from Hydro One Networks Inc (**Hydro One**), the Independent Electricity System Operator (**IESO**) and area Local Distribution Companies, to assess the supply adequacy and security in the region. The study identified the need to increase supply capacity in the region, minimize the impact of outages, and ensure compliance with IESO's Ontario Resource and Transmission Assessment Criteria (ORTAC). A map of the region is shown in Figure 1.

This Customer Impact Assessment (**CIA**) examines the impact of the recommended plan which consists of:

- **Leamington DESN Station**
  A new 230/27.6-27.6 kV, 75/100/125 MVA DESN transformer station will be built in the Town of Leamington. Six feeders will initially be provided at the station, and some load will be transferred to the new station from Kingsville TS.

- **Leamington DESN Connection Line**
  This new Leamington station will be supplied by a new 13 km 230 kV double-circuit overhead line which will be tapped from the existing Chatham to Keith circuits C21J and C22J at about 20 km east of Sandwich Junction.

A schematic diagram of the existing and proposed facilities is shown in Figure 2.

As part of the Connection Assessment and Approval (**CAA**) process, the IESO has carried out System Impact Assessment (**SIA**) of the proposed transmission reinforcement and has documented the findings in the draft SIA report CAA ID 2013-507, "Leamington TS - Supply to Essex County Transmission Reinforcement Project", dated May 9, 2014.

Hydro One has carried out this CIA to assess the impact that the proposed transmission reinforcement may have on facilities owned by load and generation customers in the Windsor - Essex area. This is in accordance with the requirements of the Ontario Energy Board Transmission System Code.

1.2 Customer List

Table 1 lists all transmission customers in the Windsor-Essex area.

Table 1: Transmission Customers in Area

No.	*Station*	*Supply Circuits*	*Connected Customer*
1	Keith TS	230 kV C21J, C22J, J5D 115 kV J3E, J4E, J1B, J2N	• Brighton Beach Power LP • West Windsor Power • Enwin Powerlines Ltd. • Essex Power Corp. • Hydro one Networks Inc.
2	Lauzon TS	230 kV C23Z, 24Z	• Enwin Powerlines Ltd. • Hydro One Networks Inc.
3	Malden TS	230 kV C21J, C22J	• Enwin Powerlines Ltd. • Essex Power Corp. • Hydro One Networks Inc.
4	Essex TS	115 kV J3E, J4E Z1E, Z7E	• Enwin Powerlines Ltd.
5	Crawford TS	115 kV J3E, J4E	• Enwin Powerlines Ltd.
6	Chrysler MTS, General Motors MTS, Ford Annex MTS, Ford Windsor MTS	115 kV E8F, E9F	• Enwin Powerlines Ltd.
7	Walker TS	115 kV Z1E, Z7E	• Enwin Powerlines Ltd.
8	Walker MTS #2	115 kV Z1E, Z7E	• Enwin Powerlines Ltd.
9	Ford Essex CTS	115 kV Z1E, Z7E	• Enwin Powerlines Ltd.
10	Windsor TransAlta CGS	115 kV Z1E	• TransAlta Energy Corporation
11	Belle River TS	115 kV K2Z, K6Z	• Hydro One Networks Inc.
12	Kingsville TS	115 kV K2Z, K6Z	• E.L.K. Energy Inc. • Essex Power Corp. • Hydro One Networks Inc.
13	Tilbury TS	115 kV K2Z	• Hydro One Networks Inc.
14	Tilbury West DS	115 kV K2Z	• Hydro One Networks Inc.
15	Comber WFCGS	230 kV C23Z, C24Z	• Comber Wind LP
16	Port Alma #1 WFCGS	230 kV C23Z, C24Z	• Kruger Energy Port Alma LP
17	Port Alma #2 WFCGS	230 kV C23Z, C24Z	• Kruger Energy Port Alma LP
18	Dillon WFCGS	230 kV C23Z	• Raleigh Wind Power Partnership
19	Gosfield WFCGS	115 kV K2Z	• Gosfield Wind LP
20	Pte-Aux Roches WFCGS	115 kV K6Z	• Pte-Aux Roches Wind Inc.
21	East Windsor CGS	115 kV E8F and E9F	• East Windsor Cogeneration LP

2.0 Customer Impact Assessment Scope

The purpose of this CIA is to assess the potential impacts of the proposed new transmission facilities on the existing connected load and generation customers in the Windsor Essex area. This is in accordance with the requirements of the Ontario Energy Board Transmission System Code.

A review of the following potential impacts on existing customers is conducted in this CIA:

- Short circuit impact at the connection point
- Impact on customer power supply reliability

3.0 SHORT-CIRCUIT STUDY ANALYSIS

The proposed transmission reinforcement has no significant impact on Short-Circuit Levels in the area since,

a) It does not create new or reinforced connection to the existing sources of short circuit current, i.e., it does not change the “Fault Impedance” in the area.

b) It does not add new sources of short circuit current. The distributed generators that are expected to connect to the low-voltage side of the new Leamington station are those that were previously planned to connect to the Kingsville station.

The impact of potential new generation that may apply in the future to connect to Leamington station or its connecting lines will be assessed at that time.

4.0 SUPPLY RELIABILITY TO CUSTOMERS

With the incorporation of the proposed plan, up to 95 MW of load will be transferred from Kingsville TS, which is supplied from the 115 kV transmission in the Windsor-Essex area, to the new Leamington TS, which will be supplied from the 230 kV transmission. The loads transferred will be primarily from within, and east of, the Town of Leamington. This transfer will alleviate concerns of thermal overload of the Kingsville TS supply circuits K2Z and K6Z following the loss of either supply circuit, and therefore eliminate the need for special operating measures at Kingsville TS such as opening of the bus tie breaker in the summer months when the station load exceeds line capability. It will also alleviate low voltage concerns at Kingsville TS for which the Windsor Area SPS is currently used to reject load at the station.

With the establishment of Leamington TS, loads in, and to the east of the Town of Leamington will be closer to the supply station. This will improve the reliability for these loads by reducing their exposure to supply interruptions caused by faults in the distribution system.

The transfer of load to Leamington TS will ease the loading on the Windsor-Essex 115 kV transmission facilities, which would require load rejection in the event of 230 kV supply interruption to Lauzon TS. With reduced loading on the 115 kV circuits, the frequency and the amount of arming of load rejections in the area to protect the system for double-circuit faults on the Chatham-Lauzon circuits will be reduced.

The new 13 km Leamington DESN tap lines will marginally increase the exposure of the existing 90 km circuits C21J and C22J to faults. However, under normal conditions, this will not deteriorate the reliability of supply for the customers since the system is always operated such that the loss of these two lines will not violate the system reliability requirements.

As a result of the above observations, it is expected that the plan will not result in deterioration of the area’s customer power supply reliability.

The IESO SIA report concludes that the projects do not adversely affect the reliability of the grid. It further concludes that with the use of operating measures, thermal loading of transmission facilities remain within their capabilities, and that voltage performance at customer connection points meets Market Rules requirements. This project will result in improvement of the system performance compared to the existing system.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This CIA report describes the impact of the proposed South-Essex County Transmission Reinforcement on the customers in the area.

The short-circuit levels at customer transmission connection points will not be materially affected as a result of this transmission reinforcement.

The proposed transmission reinforcement has no material adverse reliability impact on existing customers in the area.

The voltage assessment as reported in the SIA document shows that voltage performance remains within the Planning Criteria for all the scenarios studied.

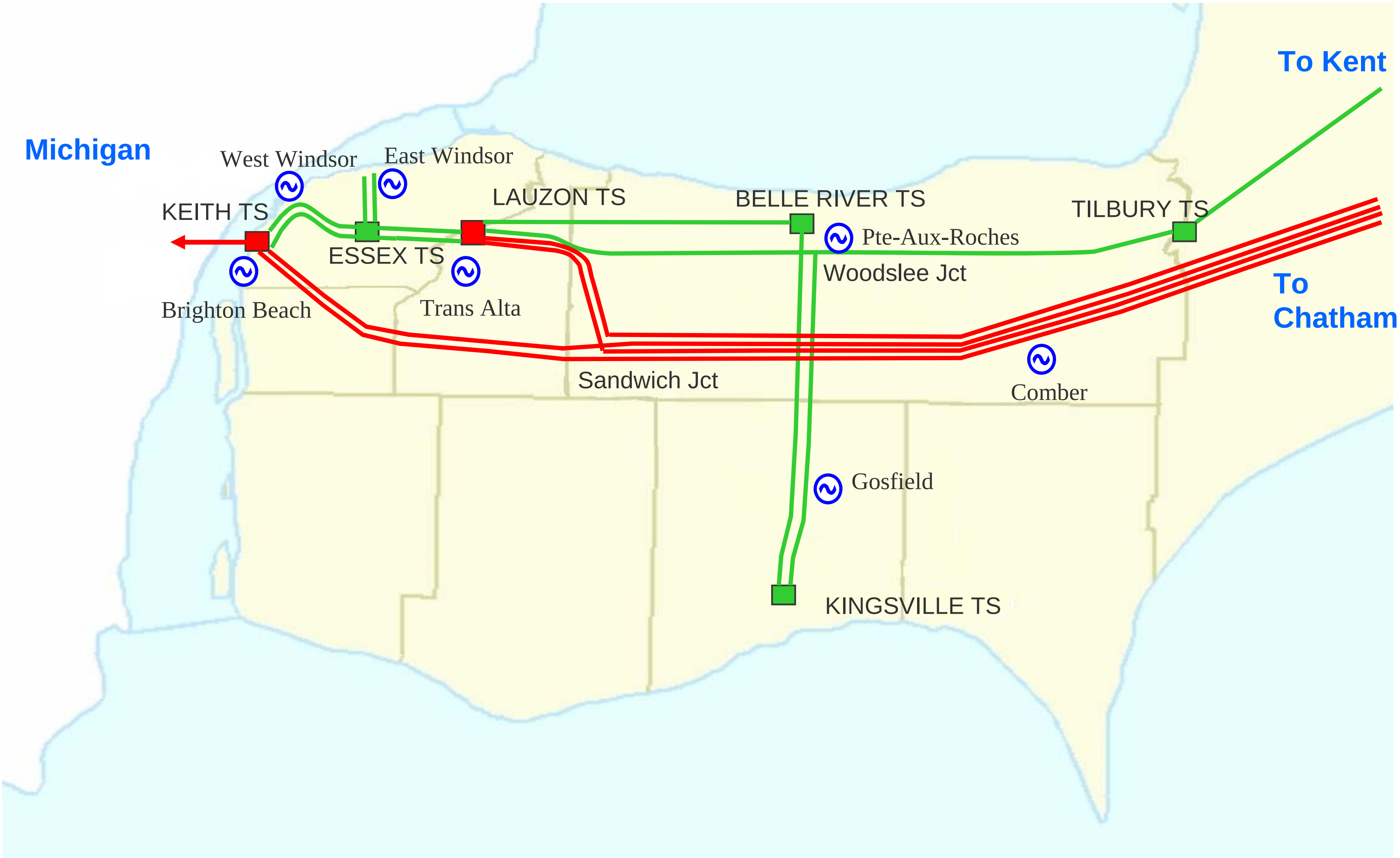

Figure 1: Map of Windsor – Essex Area: Existing Facilities

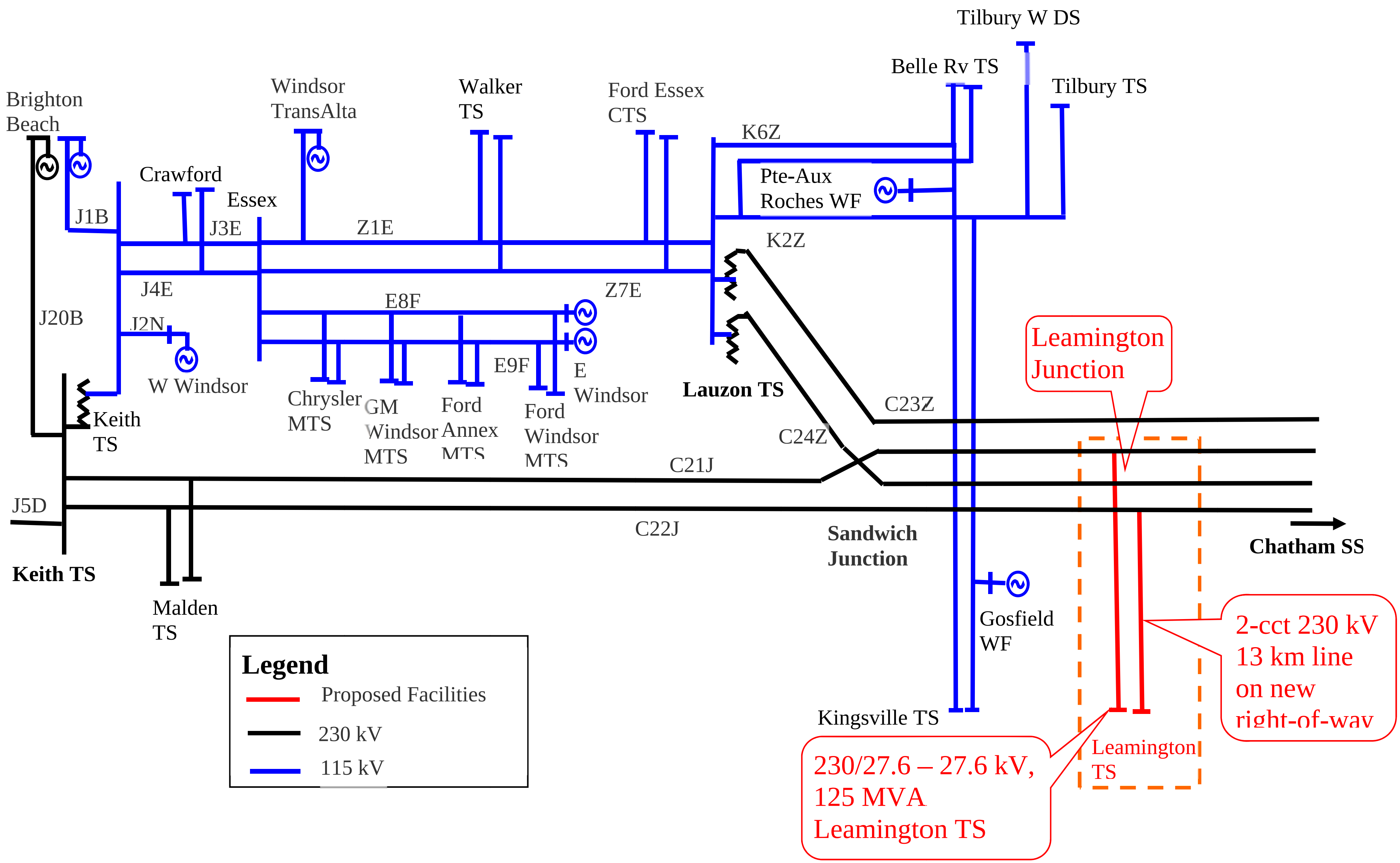

Figure 2: Schematic Diagram of Existing and Proposed Transmission Facilities