BRONTE SUB-REGION INTEGRATED REGIONAL RESOURCE PLAN - APPENDICES

Part of the Burlington-Nanticoke Planning Region | June 30, 2016

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Bronte Sub-region IRRP

Appendix A: Demand Forecast

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A.1 Gross Demand Forecasts

Table A-1 below shows the gross peak demand per station, as provided by local distribution companies ("LDCs"). Where necessary, forecasts were adjusted to account for extreme weather conditions, defined by Hydro One Transmission as an electrical demand 6% above the median, or most likely, summer peak. Adjustments to extreme weather are done to ensure forecasts properly account for the risk of hotter than average conditions, which correlate to higher observed electrical demand associated with cooling loads.

Table A-1: Gross Forecast for Bronte IRRP, by Transformer Station, Select Years

	2016	2018	2020	2022	2024	2026	2028	2030	2032	2034
Bronte TS	133.3	142.2	148.4	154.5	158.7	161.3	163.6	165.9	168.1	169.9
Cumberland TS	123.0	125.6	129.2	131.9	135.4	139.0	142.1	145.3	147.5	148.7
Burlington DESN	154.7	158.0	162.5	166.0	170.3	174.9	178.8	182.9	185.7	187.2
Palermo TS	91.4	91.6	91.9	92.2	92.5	92.7	93.0	93.3	93.4	93.5
Trafalgar DESN	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0
Tremaine TS	89.2	97.2	99.3	101.0	102.9	105.0	106.8	108.7	110.1	111.0
Glenorchy MTS	50.3	73.5	109.9	130.1	104.1	111.7	117.9	124.1	130.3	133.7
Oakville #2 TS	126.1	128.2	130.1	132.2	134.5	136.9	139.4	142.2	145.3	148.6

Note that the gross demand is provided for the entire step-down station, even where some loads serve areas outside the study area. As a result, the sum of peak electrical demands presented for these stations is higher than for the total North West Greater Toronto Area ("NWGTA") study area. The IESO used the most recently available forecasts from neighbouring LDCs when additional forecast information was required.

The following sections describe the methodologies used by LDCs to prepare the gross demand forecasts used in the IRRP.

A.1.1 Burlington Hydro

Burlington Hydro Inc.'s ("BHI" or "Burlington Hydro") service territory is congruent with the City of Burlington. The area south of the QEW is urban and the population density is high; the area along the QEW is occupied by large loads, such as warehouses and manufacturers; and the area to the north of Dundas Street is rural and sparsely populated. The overwhelming majority of the population growth has been achieved through redevelopment of the downtown core with high rise condominiums that has also given rise to both increased commercial infrastructure (e.g., shops and services) and increased institutional loads (e.g., schools, community centres). The larger loads situated in the city have not experienced growth.

BHI is supplied from five Hydro One owned transformer stations (“TS”); they are:

- Bronte TS (shared with Oakville Hydro)
- Burlington TS
- Cumberland TS
- Palermo TS
- Tremaine TS (shared with Milton Hydro)

Since Tremaine TS was commissioned in 2013 BHI has been constructing, commissioning and loading feeders emanating from the station. Consequently, loading on the other 4 TSs are being rebalanced on an ongoing basis in order to respect Hydro One’s Customers Assigned Capacity as specified in the Connection and Cost Recovery Agreement (“CCRA”). BHI’s feeders emanating from Tremaine TS are not expected to be completed until 2018 at the earliest. Palermo TS presents unique concerns with respect to its ability to bring distributed generation to market.

The City of Burlington is situated in the Region of Halton that forecasts a range of economic and demographic factors over a long-term period including a forecast of the growth in occupied units in the City of Burlington. BHI relied on the region’s forecast to quantify residential load growth and assumed that commercial and institutional loads would change by the same proportion. BHI also assumed that industrial loads would not change. BHI relied on its historic proportions of residential, commercial and institutional, and, industrial loads to estimate a utility wide growth factor. This growth factor was applied to BHI’s peak day metered demand to forecast the net peak on an annual basis. It is important to note that BHI’s metered historic peak day demand data has not been weather normalized or adjusted for any exogenous factors.

A.1.2 Oakville Hydro

Oakville Hydro bases load forecasting on the most recent *Best Planning Estimates of Population, Occupied Dwelling Units and Employment* report issued by the Region of Halton. Residential growth is derived by the forecast estimates of occupied dwellings. Non-residential growth (commercial, retail, industrial and institutional) is derived by the employment figures contained within the planning report.

The Town of Oakville is also consulted to determine the geographic areas of new development, as well as any specific information from development planning and economic development avenues. The planning figures are converted to load in kW using variables according to density, load per occupied dwelling, dwelling type, load per employee, and load per area for non-residential developments, etc. The load forecast is adjusted based on recent historical trends and any known large load (e.g., a new Hospital or Data Centre).

Based on the geographic area of the forecast load, or known future loads, the load estimate is assigned to the area of the respective TSs' service area:

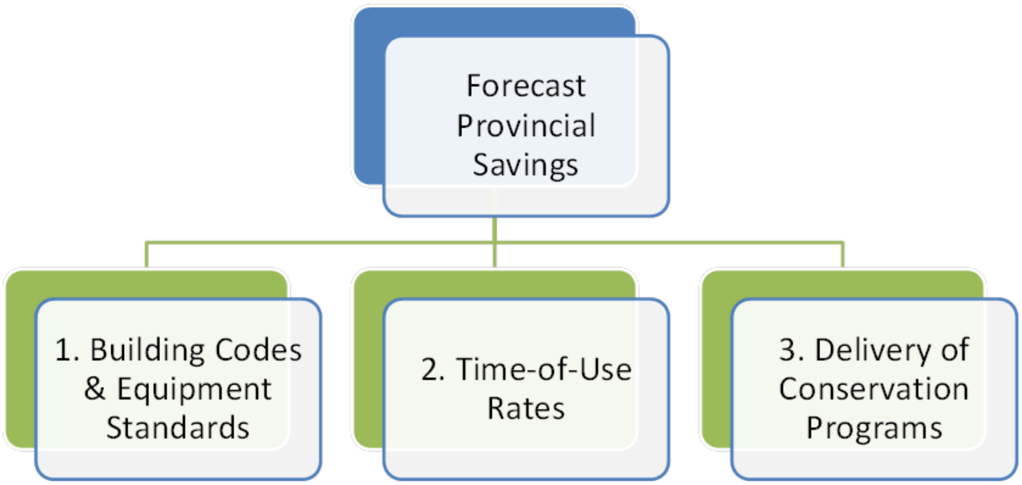
- Northwest – Palermo TS
- North Central – Glenorchy MTS
- Northeast – Trafalgar TS
- Southwest – Bronte TS
- Southeast – Oakville TS

A.2 Conservation Forecast in Regional Planning – Bronte IRRP

Conservation is the first resource to be considered in planning, approval and procurement processes. It plays a key role in maximizing the utilization of existing infrastructure and maintaining reliable supply by keeping demand within equipment capability. Conservation is achieved through a mix of program-related activities, rate structures, and mandated efficiencies from building codes and equipment standards. These approaches complement each other to maximize results. The conservation savings forecast for Bronte Sub-region have been applied to the gross peak-demand forecast, along with distributed generation resources, to determine the net peak demand for the sub-region.

In December 2013 the Ministry of Energy released a revised Long-Term Energy Plan ("LTEP") that outlined a provincial conservation target of 30 terawatt-hours ("TWh") of energy savings by 2032. The expected peak demand savings of these targets were estimated for the Bronte Sub-region. To estimate the impact of the conservation savings in the region, the forecast provincial savings were divided into three main categories:

Figure A-2: Provincial Conservation Savings, by Category



1. *Savings due to Building Codes & Equipment Standards*
2. *Savings due to Time of Use Rate structures*
3. *Savings due to the delivery of Conservation Programs*

To provide a more regional specific forecast, the impact of the savings for each category were allocated according to the residential, commercial and industrial forecast gross demand. The IESO worked together with the LDCs to determine an agreeable methodology to estimate the demand into the three customer classes. This provides a better resolution of the forecast conservation, as the conservation potential estimates vary by sector due to different energy consumption characteristics and applicable measures.

For the Bronte Sub-region, LDCs were asked to provide the breakdown of their gross demand forecast and provide the breakdown of load by customer class ("sector") forecast at each TS based on their knowledge of local customers and their loads. For TSs that an LDC cannot provide gross load segmentation for, the IESO and the LDCs worked together using best available information and assumptions to derive sectoral gross demand. For example, LDC information found in the Ontario Energy Board's ("OEB") Yearbook of Electricity Distributors was used to help estimate the breakdown of load. Once by sector gross demand at each TS is available, the next step is to estimate peak demand savings of each conservation category, time-of-use rate, codes and standards, and conservation programs. The estimates for each of the three savings groups are done separately due to their unique characteristics and data availability.

The table below shows the final estimated conservation reductions applied to the gross demand to create the planning forecast. Note that only the impacts from Burlington Hydro and Oakville Hydro customers are included (as opposed to total conservation within the Bronte sub-region, including from other LDCs).

Table A-2: Peak Demand MW Savings by TS from 2013 LTEP Conservation Targets, Select Years

Year	2016	2018	2020	2022	2024	2026	2028	2030	2032
Bronte TS	1.8	3.6	6.6	8.3	10.2	12.5	14.9	17.5	18.6
Cumberland TS	1.0	2.8	5.2	6.6	8.5	10.7	11.9	12.4	13.1
Burlington DESN	1.3	3.5	6.6	8.3	10.7	13.4	15.0	15.7	16.5
Palermo TS	1.0	1.9	3.5	4.2	5.1	6.0	7.1	8.2	8.6
Trafalgar DESN	1.2	2.3	4.0	4.9	5.8	6.9	8.1	9.6	10.0
Tremaine TS	0.5	1.3	2.4	3.1	4.0	5.1	5.7	6.0	6.4
Glenorchy MTS	0.8	1.5	2.7	3.9	5.4	7.5	9.9	12.8	14.3
Oakville #2 TS	1.5	2.9	5.2	6.4	7.5	8.9	10.4	12.3	12.9
TOTAL	9.1	19.8	36.2	45.7	57.3	70.9	83.1	94.5	100.4

Estimating Savings from Building Codes and Equipment Standards

Ontario Building codes and equipment standards set minimum efficiency level through regulations. Under IESO's current analysis, building codes and equipment standards are forecast to contribute a saving of about 10 TWh by 2032 in Ontario. To estimate the impact on the region, the associated peak demand savings are estimated and compared with gross peak demand forecast and savings percentages are developed for each sector.

Figure A-3: Building Codes and Equipment Standards, by Sector

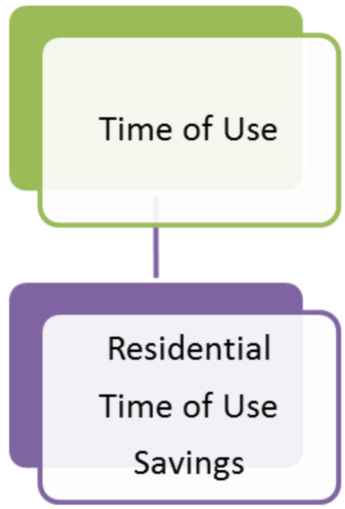
**Savings are projected for Residential & Commercial sectors only*

By 2032, the residential sector will see about 6.8% savings through standards and commercial sector will see about 6.5% savings through codes. The annual percentages were applied to the by sector demand forecast at each TS to develop an estimate of peak demand impacts from codes and standards.

Savings from Time-of-Use Rates

Almost all residential customers in Ontario have smart meters installed and are on Time-of-Use ("TOU") rates, as well as small commercial customers whose loads are less than 50 kW are also on TOU rates. Using results from the TOU impact evaluation completed in 2014, an average peak demand impact of -0.68% was assumed for residential customers who switched to TOU rates. This means a peak reduction of 0.68% across residential customers in the province, and is assumed to be consistent for residential customers in the Bronte Sub-region. It is assumed that the same impact will continue and peak savings will increase as residential sector demand grows. The percentage was applied to the incremental residential load of each TS in the study and peak reduction was estimated. The same impact evaluation found that the peak impact of TOU rates on small commercial customers is minimal. Commercial sector TOU impact is already embedded in the base year and no incremental savings are considered in the forecast.

Figure A-4: Time of Use by Sector

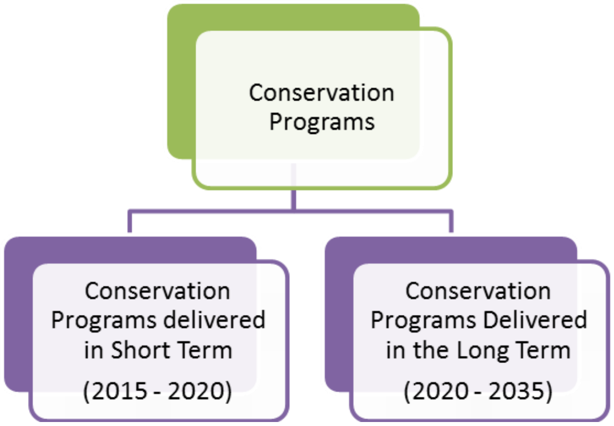


**No incremental savings are assumed for commercial sector*

Savings from the Delivery of Conservation Programs

Conservation programs across the province are forecast to reduce about 20 TWh of energy consumption by 2032. For the short term (2015 – 2020), all LDCs have conservation and demand management ("CDM") plans in place, which includes detailed savings projections through energy efficiency, conservation behind the meter generation, and indicate how their conservation efforts will integrate with regional planning. As per the Minister's direction for the Conservation First Framework ("CFF"), the IESO is to encourage LDCs to incent measures with persisting savings, peak demand reductions and that address local system needs. It is expected that LDCs will meet their CFF conservation targets and provide the estimated benefit that was forecast. The estimated peak impact can be found within the CDM plans, these savings values are directly used in the demand and conservation forecast for the region. For the long term (2021–2035), the achievable potential was estimated in a study in 2014 but the future programs will be designed later. The provincial forecast savings allocated to the region and TSs according to their respective load.

Figure A-5: Conservation Programs, by Timeline



Savings from Programs Delivered in the Short Term

CDM plans that were provided by each of the participating LDCs for the CFF contained information that was used to estimate the conservation savings to be considered for short-term program savings. The peak demand savings from conservation programs delivered in the short term include all persisting savings till 2035 due to the expected delivery of programs from 2015 to 2020. As a part of the plan, each LDC submitted Cost Effectiveness Calculators that contains estimated energy and demand savings associated with the delivery of programs from 2015–2020.

For LDCs that only have a portion of their total service territory associated with this IRRP, only a portion of their expected savings is estimated to occur in this sub-region. To determine this, the amount of conservation savings in the region is assumed to be proportional to the amount of the LDC's energy within the sub-region, i.e., if 60% of the LDC's energy is served in this sub-region, and then 60% of the expected conservation savings for that LDC is estimated to occur within this sub-region. When the total amount of peak demand savings for the sub-region is estimated, it is further allocated to the TS according to the share of residential, commercial, and industrial gross demand at each TS. For savings due to behind-the-meter generation projects, savings are applied to the TS to which the project is expected to connect.

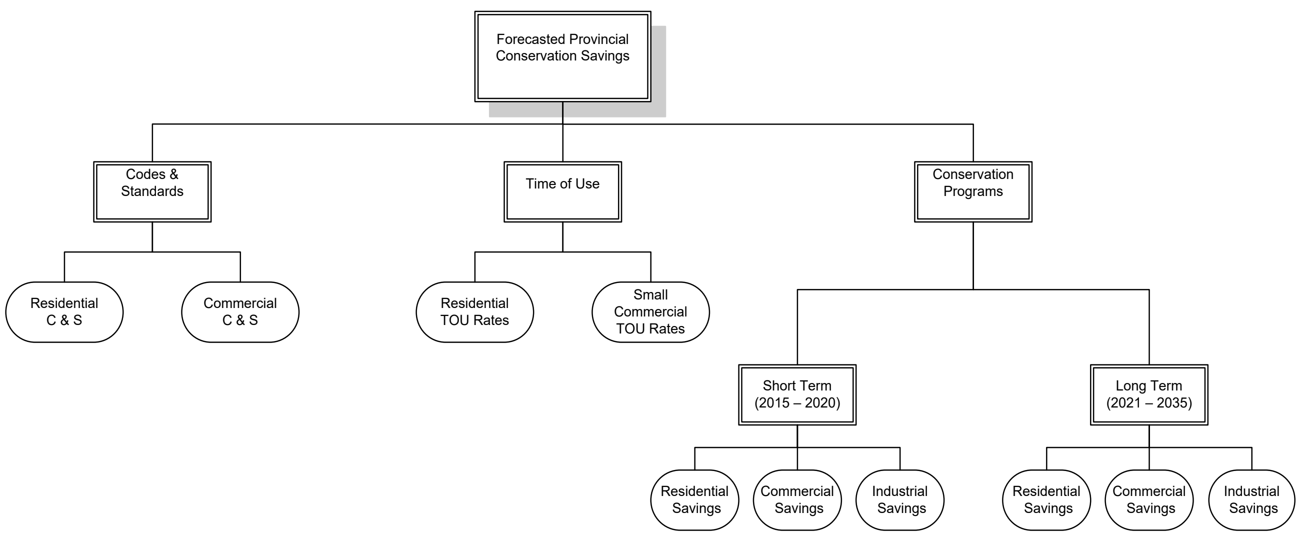
Savings from Programs Delivered in the Long Term

Savings from programs beyond the CFF were broken down to three sectors as well based on the IESO data and analysis. Energy savings were converted to peak reductions from the hourly profile for each sector. These peak reductions were compared with the respective gross peak to derive percentage saving of each year. These percentages were applied to the forecast demand at each TS to develop an estimate of MW peak demand impacts.

In addition to distribution connected customers, planned conservation savings from transmission connected customers were also considered. These customers are eligible for the Industrial Accelerator Program ("IAP") and their peak demand savings were analyzed on a case by case basis. For any transmission connected customers in the study region that have applied for IAP, their expected peak savings were included in the conservation forecast.

As described above, peak demand savings were estimated by sector for each conservation category. They were summed for each TS in the Bronte Sub-region. The analyses were done under normal weather conditions and can be adjusted to reflect extreme weather conditions. The resulting conservation savings, along with distribution generation resources were then applied to the gross demand to determine the net peak demand for further planning analyses.

Figure A-5: Forecast Conservation Savings, Summary



A.3 Distributed Generation Assumptions

The following table shows the expected peak demand impact of distributed generation ("DG") contracts active as of September 2015, but which had not reached commercial operation. These contributions were subtracted from the gross demand forecasts on a station by station basis.

Table A-3: Incremental DG for Bronte IRRP, by Station, Select Years

	2016	2018	2020	2022	2024	2026	2028	2030	2032	2034
Bronte TS	0.8	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Cumberland TS	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Burlington DESN	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Palermo TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trafalgar DESN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tremaine TS	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Glenorchy MTS	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Oakville #2 TS	0.1	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Because LDCs provided gross demand forecasts which aligned with actual observed peak demand, the impact of existing DG projects was already included in the forecasts. As a result, only projects which were not yet in-service as of the base year of the forecast were accounted for.

The IESO relied on existing contract information to identify projects within the study area which held valid contracts, but which were not yet in-service. This yielded 26 contracts, all for Solar PV projects, with a total of 7.9 MW installed capacity. In order to account for the expected contribution of intermittent generation sources during peak conditions, the IESO 18-month outlook was used to select an appropriate capacity contribution[1]. This yielded a value of 34% for solar during summer months.

Additionally, it was assumed that all projects would enter service on their Maximum Commercial Operation Date ("MCOD"), which led to slightly staggered in-service dates.

A.4 Planning Forecast, by Station

After accounting for the impacts of conservation and DG, the planning level forecasts applied for this IRRP are as follows:

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[1] http://www.ieso.ca/Pages/Participate/Reliability-Requirements/Forecasts-%26-18-Month-Outlooks.aspx

Table A-4: Net Forecast for Bronte IRRP, by Station, Select Years

	2016	2018	2020	2022	2024	2026	2028	2030	2032	2034
Bronte TS	130.7	137.5	140.8	145.1	147.4	147.6	147.6	147.4	148.4	150.6
Cumberland TS	121.5	122.3	123.5	124.9	126.4	127.8	129.6	132.4	133.9	135.1
Burlington DESN	153.2	154.3	155.8	157.6	159.5	161.4	163.7	167.1	169.0	170.6
Palermo TS	90.8	90.7	90.4	90.3	90.1	90.0	89.8	89.9	89.7	89.8
Trafalgar DESN	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0
Tremaine TS	85.3	95.9	96.8	97.8	98.8	99.8	101.0	102.6	103.6	104.5
Glenorchy MTS	46.9	67.1	97.7	114.5	87.9	91.7	93.3	94.1	98.0	101.9
Oakville #2 TS	124.2	124.5	123.5	124.1	124.7	125.2	125.5	125.7	127.3	130.7

Note that these numbers account for total demand (including DG and CDM) by station, which may include additional customers than Burlington Hydro and Oakville Hydro.

Bronte Sub-region IRRP

Appendix B: Needs Assessment

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B.1 ORTAC Criteria

In Ontario, the assessment of electricity supply capacity and restoration needs is carried out by applying the standards as set out in the IESO's Ontario Resource and Transmission Assessment Criteria ("ORTAC").[2]

ORTAC includes criteria related to assessment of the bulk transmission system, as well as the assessment of local or regional reliability requirements. The latter criteria are of relevance to this study and guided the technical studies performed in assessing the electricity system needs in the Bronte Sub-region. They can be broadly categorized as addressing two distinct aspects of reliability: (1) providing supply capacity, and (2) limiting the impact of supply interruptions.

With respect to supply capacity, ORATC required that the system be designed to provide continuous supply to a local area under specific transmission and generation outage scenarios, and to minimize the impact to customers under major outage scenarios (such as the simultaneous loss of two transmission elements on the same tower line). The ORTAC criteria governing supply capacity as applicable to the Bronte Sub-region is presented in Table B-1.

Table B-1: ORTAC Supply Capacity Criteria for Systems with Local Generation

Pre-contingency	Contingency[1]	Thermal Rating	Maximum Permissible Load Rejection
All transmission elements in-service, No local generation	N-0	Continuous	None
	N-1	LTE[2]	None
	N-2	LTE[2]	150 MW

1. N-0 refers to all elements in-service; N-1 refers to one element (a circuit or transformer) out of service; N-2 refers to two elements out of service (for example, loss of two adjacent circuits on same tower, breaker failure or overlapping transformer outage),N-G refers to local generation not available (for example, out of service due to planned maintenance).
2. LTE: Long-term emergency rating. 50-hr rating for circuits, 10-day rating for transformers.

With respect to supply interruptions, ORTAC requires that the transmission system be designed to minimize the impact to customers of major outages, such as a contingency on a double-circuit

[2] http://www.ieso.ca/imoweb/pubs/marketadmin/imo_req_0041_transmissionassessmentcriteria.pdf

tower line resulting in the loss of both circuits, in two ways: by limiting the amount of customer load affected; and by restoring power to affected load within a reasonable timeframe. Specifically, ORTAC requires that no more than 600 MW of load be interrupted in the event of a major outage involving two elements. Further, load lost during a major outage is to be restored within the following timeframes:

- All load lost in excess of 250 MW must be restored within 30 minutes;
- All load lost in excess of 150 MW must be restored within 4 hours; and
- All load lost must be restored within 8 hours.

For the load loss and restoration criteria, ORTAC includes provisions whereby a request for exemption may be made to the IESO.

B.2 System Load Flow Base Case Setup and Assumptions

The system studies for this IRRP were conducted using PSS/E Power System Simulation software. The reference PSS/E case was adapted from the 2014 summer base case that was produced by the IESO for West GTA analysis. Summer ambient conditions of 35°C and 0-4 km/hr wind for overhead transmission circuits were assumed in this study. For transformers, summer 10-day LTRs (MVA) are respected under post-contingency conditions. For circuits, summer LTE Planning (Amp) ratings are used.

The base case was developed with the following assumptions in place:

- Westbound flows along the Flow East Towards Toronto (FETT) interface were maintained at 5000 MW.
- Pickering NGS out of service.
- Two autotransformers added to Milton SS to account for expected future bulk system configuration. Halton TS and future Halton TS #2 assumed to be supplied directly from 230 kV bus. New 2 circuit 230 kV line connecting Meadowvale TS to Hurontario SS, supplied from Milton TS, and separate from existing T38/39B.
- All local cap banks (including Lorne Park TS, Oakville TS, Bronte TS, Burlington TS) assumed in-service, except where specified for specific tests.

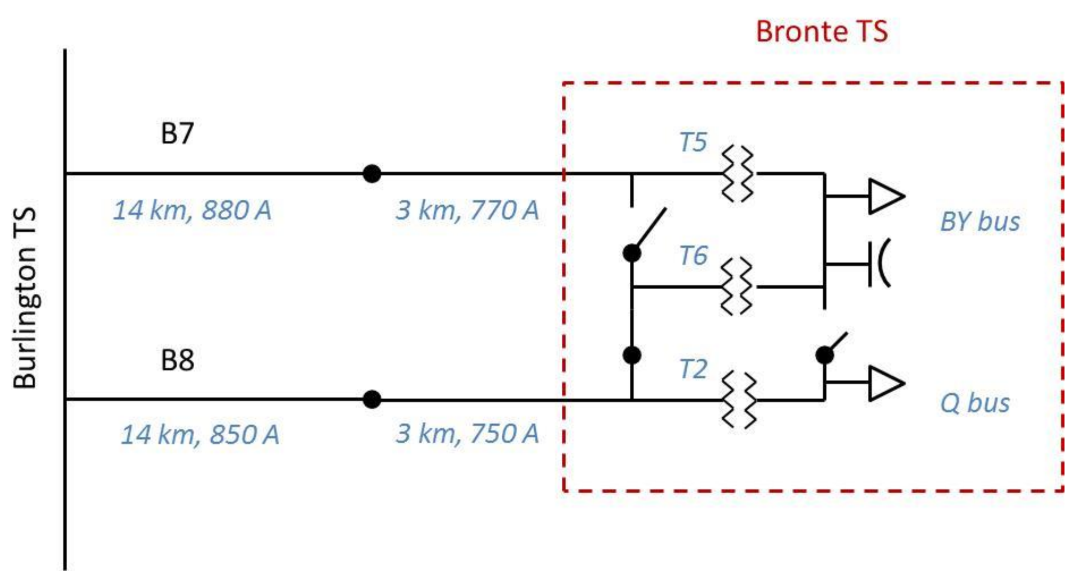
B.3 Bronte TS Needs

The following sections provide a more detailed description of limiting needs affecting maximum permitted loading at Bronte TS; Thermal limits of B7/B8 and post contingency voltage drop

B.3.1 Bronte TS – Thermal Limits of B7/B8

Bronte TS is served by two 115 kV circuits (B7 and B8) which emanate from Burlington TS and end at Bronte TS. Under normal operation, B7 serves the T5 transformer and B8 the T6 and T2 transformers. A simplified representation of this arrangement is shown in Figure B-1 below:

Figure B-1: Bronte TS Supply and Layout



Under ORTAC, each circuit must be capable of supplying total peak load for Bronte TS, without the need to curtail (reject) load, following the sudden loss of the companion circuit. The ability of each circuit to carry load is determined by their Long Term Emergency ("LTE") rating, which for circuits is measured in Amps ("A"). While 14 km of B7 and B8 is rated at 880 A and 850 A, respectively, there is a 3 km section only rated at 770 A and 750 A. As a result, the total current carried by B8 following the loss of B7 cannot exceed 750 A. Note that the loss of B8 is not as constraining of a contingency, as an additional 20 A are permitted to serve the same Bronte TS load.

The equivalent load in MW which corresponds to 750 A can vary depending on other system conditions, including customer power factor and system voltage. Based on the assumptions used in this analysis, the 750 A B8 limit following the loss of B7 was reached when total Bronte TS load exceeded approximately 135 MW. For this need, the limit is not sensitive to the loading balance between the BY and Q buses.

Under the net forecast, total Bronte TS load exceeds 135 MW beginning in year 2018, however this limit has already been exceeded during the 2012 and 2013 summer peaks. In both of these instances, B7 and B8 circuits were both in-service, and as a result operated within their thermal limits. Had one of the lines experienced a sudden fault during these times, system operators would have required the immediate transfer of load away from the station or load shedding to keep the remaining circuit below its LTE. Actual LTE at the time of the fault would be based on actual weather conditions, including temperature, sunlight, and wind.

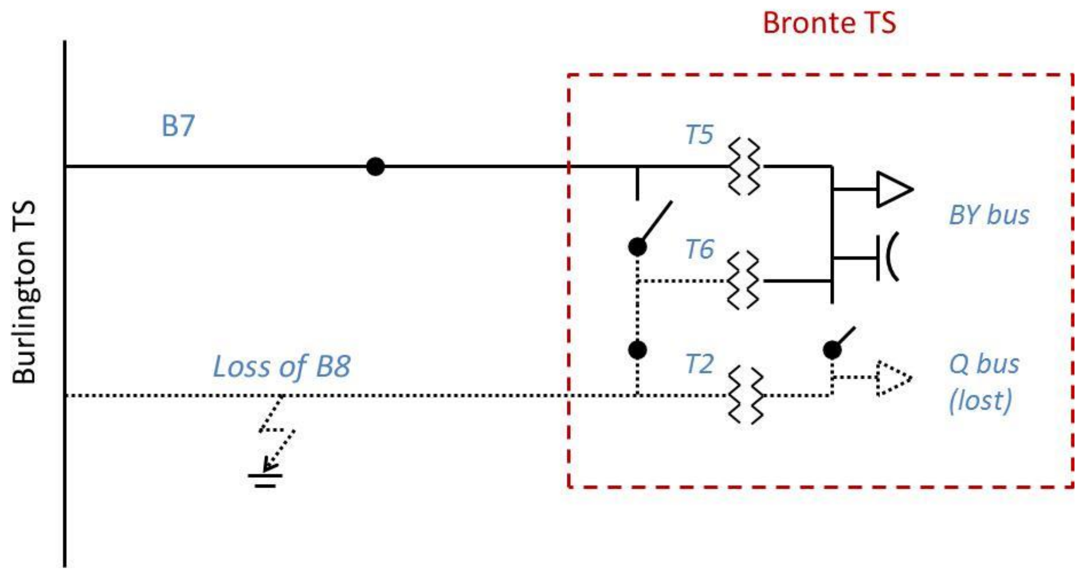
Although the sudden loss of circuit is a relatively rare event, ORTAC requires that the system be capable of supplying all peak load in the event of this type of contingency.

B.3.2 Bronte TS – Post Contingency Voltage Drop

Immediately following the loss of any one system element, voltage on the distribution side of a step-down station is required under ORTAC to drop no more than 10%. The risk of a large sudden voltage drop is greater with radially supplied loads, and increases the more load is being supplied, particularly as the thermal limit of the station transformers is approached. All these characteristics are in place at Bronte TS, making it particularly vulnerable to this type of need.

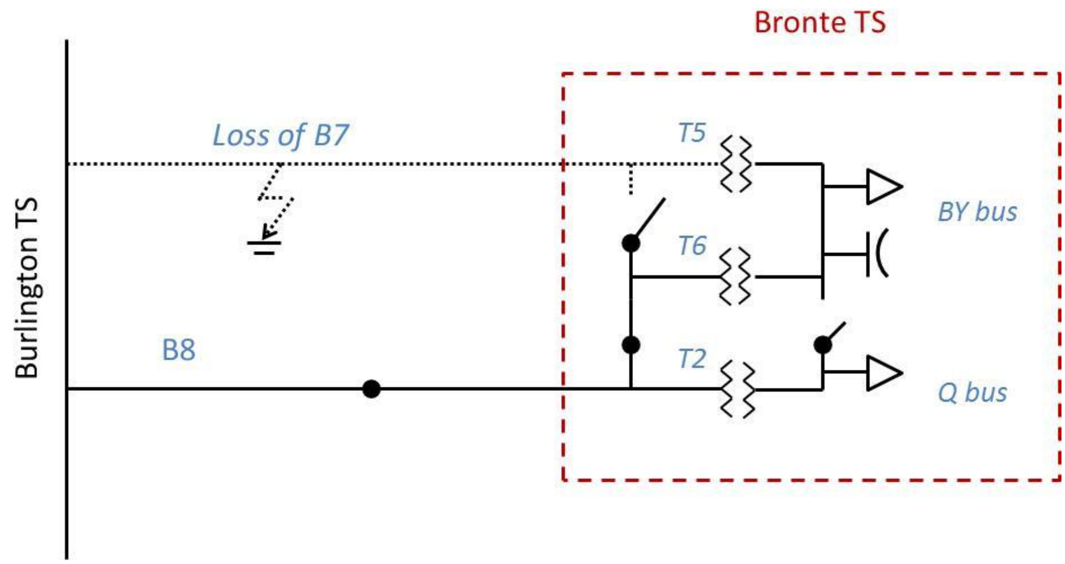
Due to the configuration of the station, a loss of circuit B8 causes an initial rejection of load served by the Q bus (by configuration, shown in Figure B-1. This makes the instantaneous voltage drop much less severe, as less demand is served by the remaining facilities. Load can be restored through operator action, but by this time sufficient action will have been taken to address the initial instantaneous voltage drop.

Figure B-2: Loss of B8 Supply, Q Bus Load Lost by Configuration



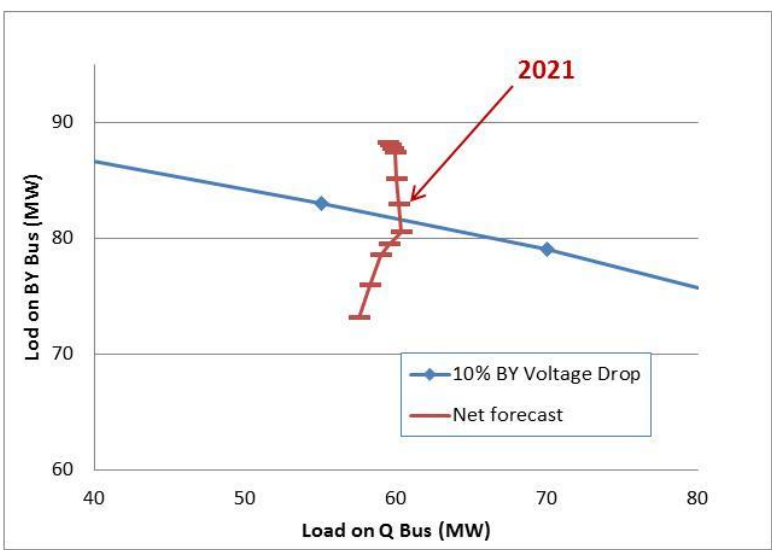
Following the loss of circuit B7, all Bronte TS load is served by the T2 and T6 transformers and sudden voltage drop becomes a constraining need. Note that this is the same contingency which was found to be more limiting when considering thermal limits of the supplying B7 and B8 circuits, as described in Section B.3.1.

Figure B-3: Loss of B7 Supply, no Load Lost



Under this contingency, the need is sensitive to the distribution of load between the two buses (BY and Q). This means that the maximum allowable station capacity varies depending on where the load is assigned. Of the two distribution side buses, BY is slightly more sensitive to sudden voltage drops. The graph below shows the loading conditions that produce a 10% voltage drop on the BY bus following the loss of B7:

Figure B-4: Loading Profile for Bronte TS, Loss of B7 Contingency, Voltage Drop Constraint



The area underneath the blue line represents "operable" loading profiles. This means combination of BY and Q bus loading which will not cause a voltage drop of over 10% on the

BY bus following the loss of B7. The red line shows the expected growth forecast, broken down by bus. The intersection of the two lines (the point where the station will be at risk of a 10% post contingency voltage drop) occurs in 2021.

Note that the net forecast line shows that demand on the Q bus is expected to remain relatively stable, while most growth is served by the BY bus. Maximum station load varies depending on share of load between the two buses, but under the expected profile it is reached when BY load reaches approximately 80 MW, with maximum station load at 149 MW.