Final Draft Report – revised February 1, 2010
Expedited System Impact Assessment
Hydro One Networks Inc.

1 GENERAL DESCRIPTION

Birmingham TS is a two DESN station radially supplied from Beach TS via the 115 kV circuits HL3 and HL4. It has an alternative supply via the 115 kV circuits B10 and B11 from Burlington TS.

Transformers T2 and T3 at Birmingham TS are scheduled to be replaced with new transformers in 2009. The existing configuration is shown in Figure 5.

2 PROPOSED MODIFICATION

A comparison of the technical specifications between the existing and the replacement transformers is given in the following two tables. T1 and T2 comprise a separate 110/14.2 kV station with distinct loads and are therefore assessed together.

Birmingham TS	**Existing T1 (NT50T1)**	**Existing T2 (NT50T2)**	**New T2**
Configuration	Three phase	Three phase	Three phase
Transformation (kV)	110/14.2/14.2	110/14.2/14.2	110/14.2/14.2
Winding Configuration	Delta/wye/wye	Delta/wye/wye	Delta/wye/wye
Thermal Rating	45 MVA ONAN 60 MVA ONAF 75 MVA OFAF	45 MVA ONAN 60 MVA ONAF 75 MVA OFAF	45 MVA ONAN 60 MVA ODAN 75 MVA ODAF
Continuous Thermal Rating (summer 30°C)	75MVA	75 MVA	75 MVA
15-MIN Thermal Rating (summer 30°C)	117.7 MVA	108.4 MVA	150 MVA
10-DAY Thermal Rating (summer 30°C)	84.8 MVA	84 MVA	102.6 MVA
Positive Sequence Impedance (H-X)	R = 0.45 % X = 11.24 % on 22.5 MVA base	R = Unknown X = 9.85 % on 22.5 MVA base	R = 0.196 % X = 9.279 % on 22.5 MVA base
Impedance to Ground	1.25 Ohms	1. 25 Ohms	1. 25 Ohms
Under-load tap-changer	13.8 ± 2.84 kV 32 Steps	13.8 ± 2.13 kV 24 Steps	14.2 ± 2.84 kV 32 Steps
Off-load tap-changer	N/A	Tap 1 115.5 kV Tap 2 112.75 kV Tap 3 110.0 kV Tap 4 107.25 kV Tap 5 104.5 kV	N/A
In service off-load tap position	N/A	N/A	N/A
Manufacturer	FP	Pion	Hyundai

Table 1 – Comparison of Existing and Replacement Transformers T1 and T2

Similarly, T3 is assessed with T4 since these two transformers also supply distinct loads.

Birmingham TS	**Existing T3 (NT50T3)**	**Existing T4 (NT50T4)**	**New T3**
Configuration	Three phase	Three phase	Three phase
Transformation (kV)	110/14.2/14.2	110/14.2/14.2	110/14.2/14.2
Winding Configuration	Delta/wye/wye	Delta/wye/wye	Delta/wye/wye
Thermal Rating	48 MVA ONAN 64 MVA ONAF 80 MVA ONAF	45 MVA ONAN 60 MVA ODAN 75MVA ODAF	45 MVA ONAN 60 MVA ODAN 75 MVA ODAF
Continuous Thermal Rating (summer 30°C)	80 MVA	88.7MVA	75 MVA
15-MIN Thermal Rating (summer 30°C)	110.2 MVA	110.2MVA	150 MVA
10-DAY Thermal Rating (summer 30°C)	85.8 MVA	101.8MVA	102.6 MVA
Positive Sequence Impedance (H-X)	R = 0.360 % X = 7.92 % on 20 MVA base	R = Unknown X = 9.61 % on 22.5 MVA base	R = 0.196 % X = 9.279 % on 22.5 MVA base
Impedance to Ground	7.5 Ohms	7.5 Ohms	7.5 Ohms
Under-load tap-changer	13.8 ± 1.42 kV 16 Steps	13.8 ± 2.84 kV 32 Steps	14.2 ± 2.84 kV 32 Steps
Off-load tap-changer	Tap 1 21.0 kV Tap 2 118.25 kV Tap 3 115.5 kV Tap 4 112.75 kV Tap 5 110.0 kV	N/A	N/A
In service off-load tap position	N/A	N/A	N/A
Manufacturer	CGE	Hyundai	Hyundai

Table 2 - Comparison of Existing and Replacement Transformers T3 and T4

3 ASSESSMENT

3.1 Replacement Transformers

The information provided by Hydro One Networks Inc. shows that the technical characteristics of the replacement transformers are similar to those of the existing ones. The positive sequence impedances of the new transformers are different than the original transformers' impedances but this does not represent a concern.

Both of the transformers being removed have an OLTC. The replacement transformers will have a ULTC providing a secondary voltage range as shown below. In both cases the replacement transformers will have a greater secondary voltage range than was possible with the OLTCs.

	Existing T1	**Existing T2 (to be removed)**	**Existing T3 (to be removed)**	**Existing T4**	**New T2/T3**
Under-load tap-changer (ULTC)	10.96 kV-16.64 kV	11.67 kV-15.93 kV	12.38 kV-15.22 kV	10.96 kV-16.64 kV	11.36 kV-17.04 kV

Table 3 – Secondary Voltage Ranges for Existing and the Replacement Transformers

3.2 Station 10-Day Summer Capabilities

The 10-DAY summer capabilities for each station (T1/T2 and T3/T4) are determined by the removing the transformer with the largest 10-DAY thermal rating from service. The 10-DAY summer ratings of the four transformers at Birmingham TS are listed in the two tables below.

For the T1/T2 station, the existing 10-DAY summer capability with T1 out of service is 84.0 MVA. With the replacement T2 installed, the T1/T2 10-DAY summer capability will be increased by 0.8 MVA to 84.8 MVA as shown in table 4 below.

Summer Ratings for Transformers T1 and T2		
Transformer	**10-DAY Thermal Rating (MVA) (summer 30°C)**	
	Prior to replacement of T2	**After replacement of T2**
T1	**O/S** (84.8)	84.8
T2	84.0	**O/S** (102.6)
T1/T2 Station Summer 10-DAY Capability **(with highest rated transformer out of service)**	**84.0**	**84.8**

Table 4 – 10-DAY Thermal ratings (summer) for transformers T1 and T2

For the T3/T4 station, the existing 10-DAY summer capability with T4 out of service is 85.8 MVA. With the replacement T3 installed, the T3/T4 10-DAY summer capability will be increased by 16 MVA to 101.8 MVA as shown in table 5 below.

Summer Ratings for Transformers T3 and T4		
Transformer	**10-DAY Thermal Rating (MVA) (summer 30°C)**	
	Prior to replacement of T3	**After replacement of T3**
T3	85.8	**O/S** (102.6)
T4	**O/S** (101.8)	101.8
T3/T4 Station Summer 10-DAY Capability (with highest rated transformer out of service)	**85.8**	**101.8**

Table 5 – 10-DAY Thermal ratings (summer) for transformers T3 and T4

3.3 LOAD PROJECTIONS

The peak load for the T1/T2 station at Birmingham TS was 42.7 MVA and occurred on April 10, 2008 at 03:00. Figure 1 shows the loading at the LV side of T1/T2.

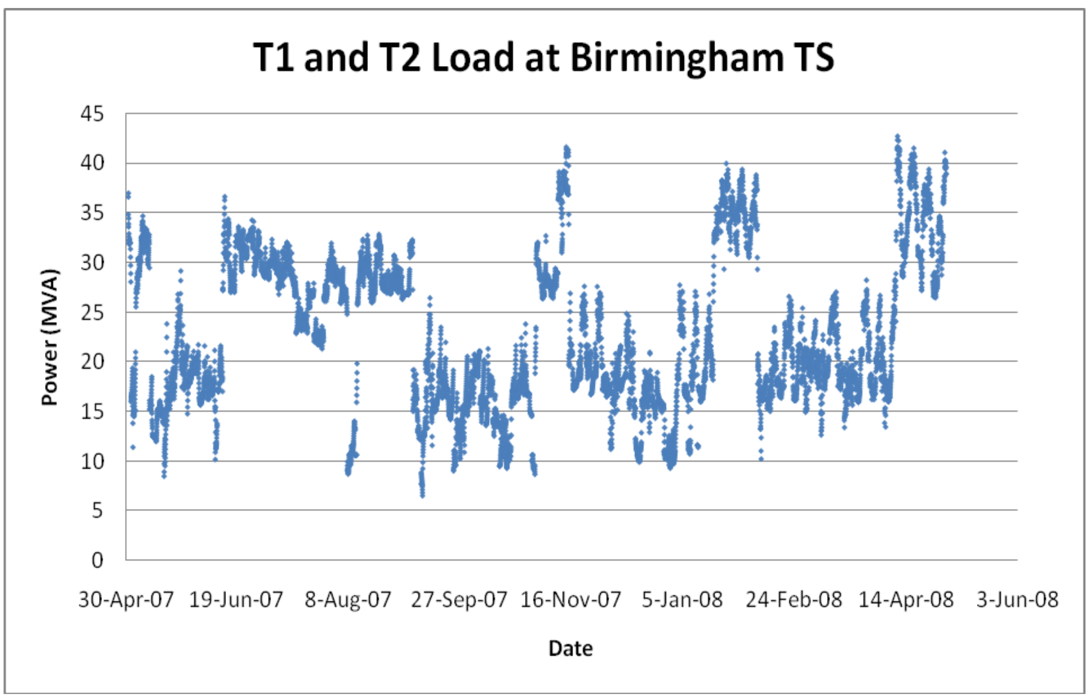

Figure 1 - Birmingham TS T1 and T2 Load

The peak load for the T3/T4 station was 64.3 MVA and occurred on September 13, 2007 at 04:00. Figure 2 shows the loading at the LV side of T3/T4.

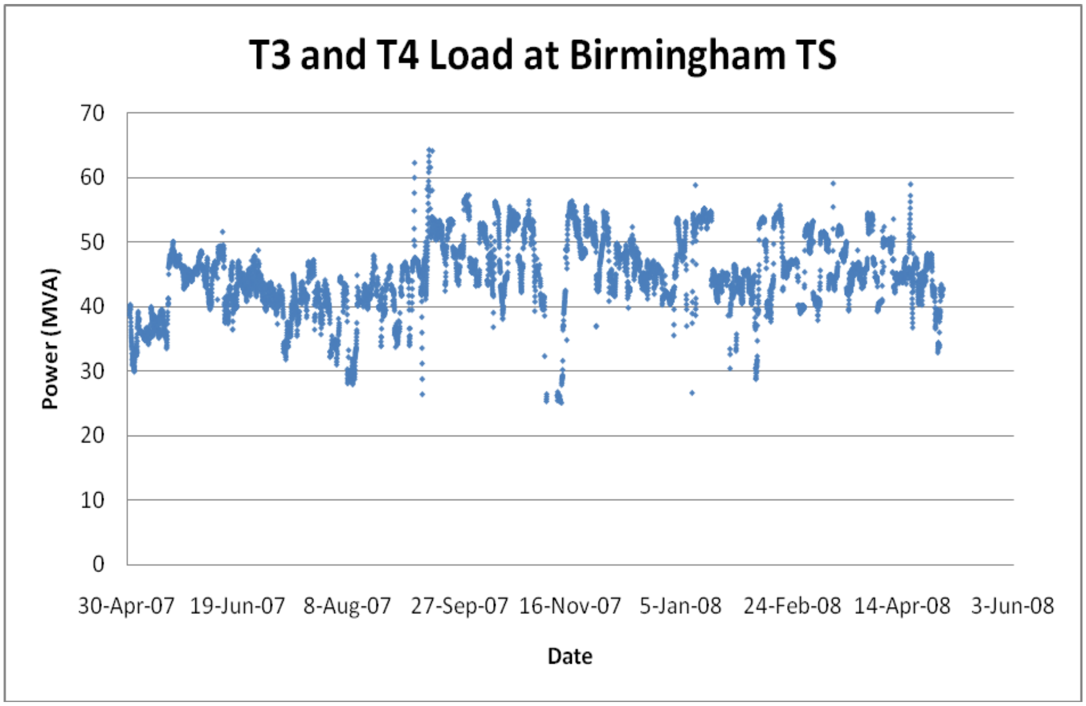

Figure 2 - Birmingham TS T3 and T4 Load

The peak loads on T1/T2 and on T3/T4 did not exceed the respective stations' 10-DAY summer capability.

With the current T1/T2 and T3/T4 station capabilities, there is a spare capacity of 41.3 MVA and 21.5 MVA, respectively, when compared to the 2008 peak loads at each of these stations. With projected loads as shown in Table 8 below, Birmingham TS is not expected to exceed its 10-day LTRs in the near future.

Birmingham TS Projected Peak Load Growth (assuming a 1% annual load growth)				
Year	T1/T2 Station		T3/T4 Station	
	Projected Peak Load	10-DAY summer capability	Projected Peak Load	10-DAY summer capability
2008	42.7 MVA (actual)		64.9 MVA (actual)	
2009	43.1 MVA	84.8 MVA	65.6 MVA	101.8 MVA
2010	43.6 MVA		66.2 MVA	
2011	44.0 MVA		66.9 MVA	
2012	44.4 MVA		67.6 MVA	
2013	44.9 MVA		68.3 MVA	
2014	45.3 MVA		68.9 MVA	
2015	45.8 MVA		69.6 MVA	

Table 6 – Birmingham TS Projected Load Growth

3.4 Line Taps

The HL3 and HL4 line taps from T2 and T3 have a summer continuous rating of 1030 A (205.2 MVA) and 1210 A (241 MVA), respectively, at 115 kV (35°C, 4 km/h wind speed). These lines are more than adequate to supply the near term load growth that would occur at Birmingham TS.

3.5 Power Factor

The Market Rules require operation at a power factor range of 0.9 lagging to 0.9 leading. Operational information from May 2007 through May 2008 was used to calculate the power factor at Birmingham TS at T1/T2 and T3/T4. Birmingham TS is not equipped with shunt capacitors.

Figure 3 illustrates the power factor at the LV side of T1/T2 and figure 4 shows the power factor at the LV side of T3/T4.

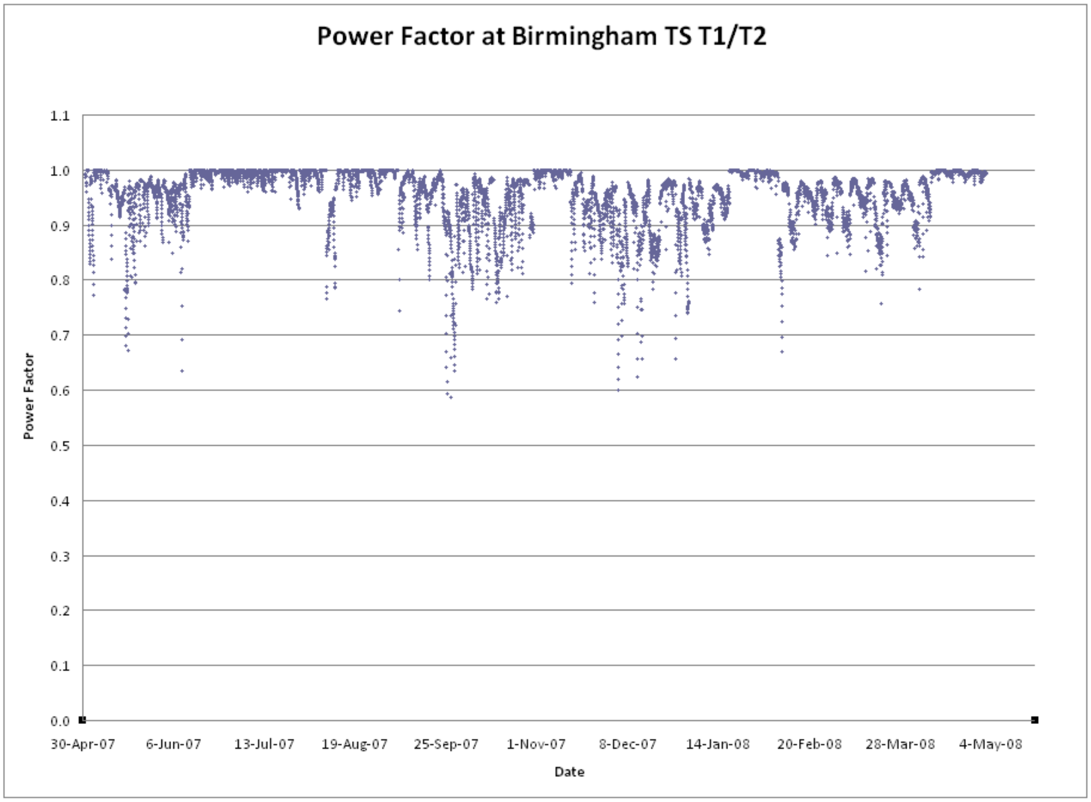

Figure 3 - Power Factor at Birmingham TS T1/T2

Between May 2007 and May 2008, the lowest power factor at Birmingham TS T1/T2 of 0.59 occurred on August 26, 2007 at 19:00. The power factor as calculated on the high side at that time was 0.58 lagging.

The actual values at the low voltage side were as follows:

Date	Time	T1 P (MW)	T1 Q (MVAR)	T2 P (MW)	T2 Q (MVAR)	P Total (MW)	Q Total (MVAR)	LV PF	HV pF (calculated)
September 26, 2007	19:00	-4.08	-3.27	-4.87	-9.08	-8.95	-12.36	0.59	0.58

Table 7 – Birmingham TS T1/T2 at Lowest Power Factor

A total of 9 MX of capacitors need to be added to Birmingham TS T1/T2 to satisfy market rules with respect to load power factor at heavy load conditions.

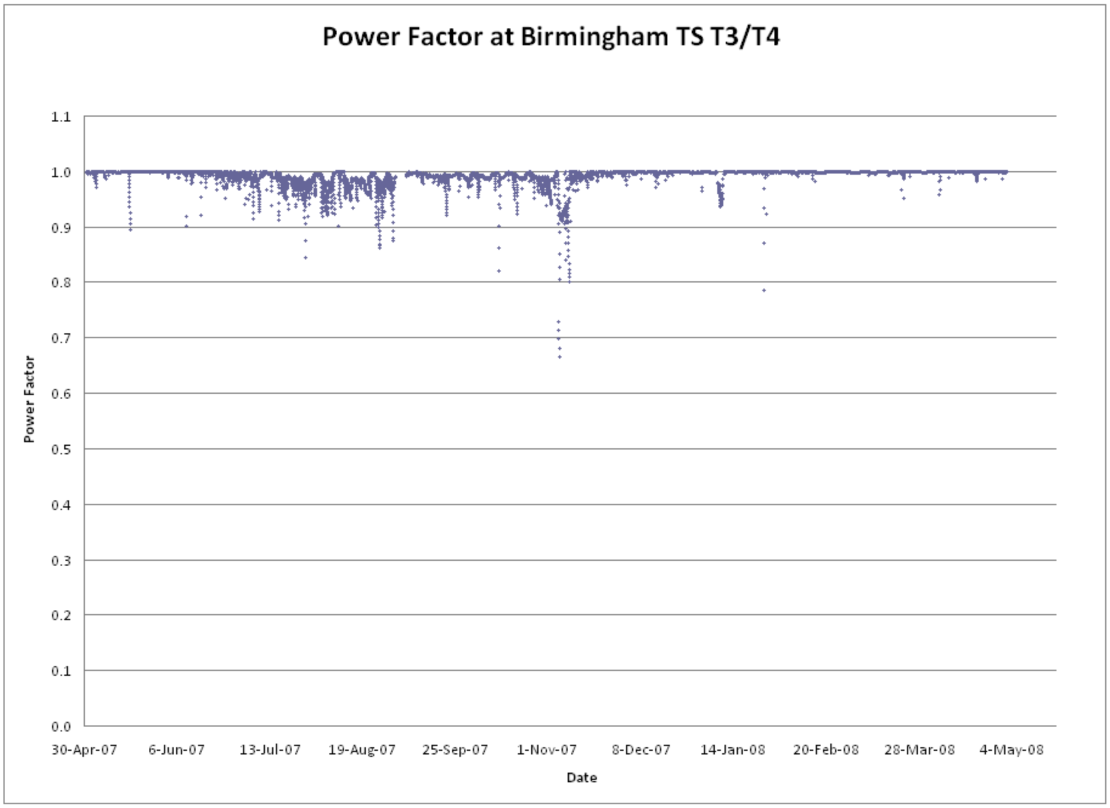

Figure 4 - Power Factor at Birmingham TS T3/T4

Between May 2007 and May 2008 the lowest power factor at Birmingham TS T3/T4 of 0.60 occurred on August 5, 2007 at 07:00. The power factor as calculated on the high side at that time was 0.57 lagging.

The actual values at the low voltage side were as follows:

Date	Time	T3 P (MW)	T3 Q (MVAR)	T4 P (MW)	T4 Q (MVAR)	P Total (MW)	Q Total (MVAR)	LV PF	HV pF (calculated)
November 5, 2007	11:00	-7.35	-9.70	-5.74	-4.97	-13.08	-14.67	0.666	0.656

Table 8 – Birmingham TS T3/T4 at Lowest Power Factor

A total of 9 MX of capacitors need to be added to Birmingham TS T3/T4 to satisfy market rules with respect to load power factor at heavy load conditions.

4 CONCLUSIONS

It can be concluded that the replacement of T2 and T3 transformers at Birmingham TS will not result in a material adverse effect on the reliability of the IESO-controlled grid because:

- the replacement will result in an increase of 0.8 MVA to 84.8 MVA in the T1/T2 summer 10-DAY capability, and an increase of 16 MVA to 101.8 MVA in the T3/T4 summer 10-DAY capability;
- the voltage range provided by the ULTC for the replacement of T2 and T3 is similar to the ULTC voltage range of the existing transformers;
- the positive sequence impedance for the replacement T2 is similar to the positive sequence impedance of the existing T2;

- The positive sequence impedance for the replacement T3 is greater than the positive sequence impedance of the existing T3 but similar to the positive sequence impedance of the existing T4; and
- The power factor on both T1/T2 and T3/T4 stations are below the market rules requirement of 0.9 lagging.

5 REQUIREMENTS

Hydro One must notify the IESO as soon as it becomes aware of any changes to the assumptions made in the connection assessment. The IESO will determine whether these changes require a re-assessment.

Hydro One is required to meet the requirements with respect to protection systems for the new transformers and coordination with the existing protection systems, as outlined in the Transmission System Code.

The Market rules (Chapter 4 section 7.4) require that transmitter shall provide the IESO on a continual basis with on-line monitored quantities as specified in Appendix 4.16. For this proposed project, the IESO will continue to require the operating quantities associated with the new transformer.

Power factor correction of 9 MX and 9 MX is required at T1/T2 and T3/T4, respectively.

6 NOTIFICATION OF APPROVAL

It is therefore recommended that a Notification of Approval of the Connection Proposal be issued subject to the implementation of the requirements listed in section 5.0.

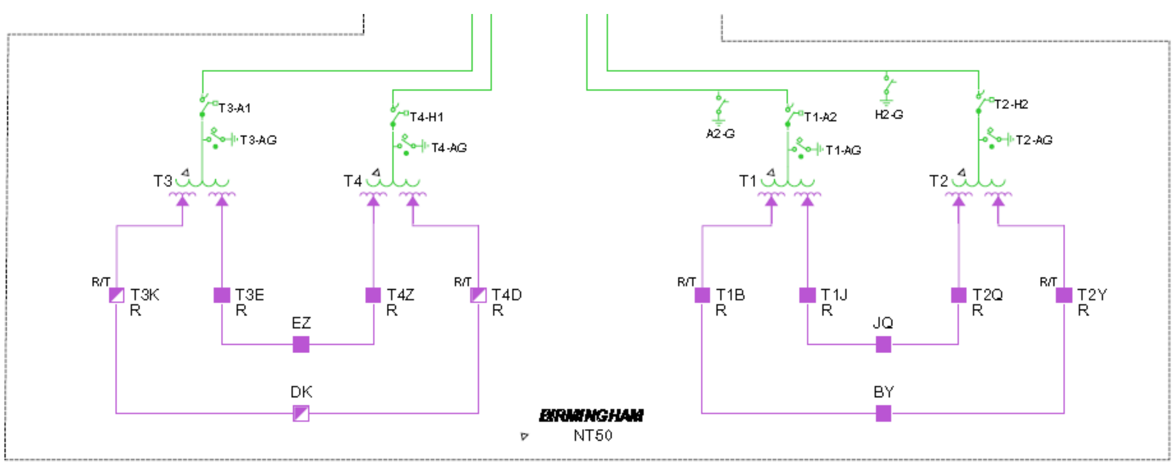

Figure 5 - Birmingham TS Station Operating Diagram