Ontario Power Authority
Toronto, Ontario

Northern York Region Electricity Supply Study
Submission to the Ontario Energy Board
September 30, 2005

Exhibit C
Capability of Existing System and Gap Analysis
Northern York Region

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1 INTRODUCTION

This exhibit provides an analysis that defines the gaps in the existing electricity supply infrastructure in Northern York Region, and forecasts the larger gaps that will exist in the future if action is not taken. Defining the magnitude, nature and timing of these gaps is a necessary step toward the identification of options, and the selection of alternatives used to close the gaps.

This exhibit uses information from three sources:

- Existing and past equipment load levels in Northern York Region
- Computer models to determine the capabilities of the local supply infrastructure
- Load forecasts from Exhibit B "Load Forecasts and CDM Options".

The goal of accurately defining the gaps is to identify the risks that the gaps present to the reliable supply of electricity to customers, and to allow for the accurate assessment of options designed to close the gaps.

In general there are three types of gaps:

- Bulk Supply
- Transformation, and
- Distribution

Bulk Supply gaps are gaps in the ability to deliver bulk electricity to the customer loads. This is generally because of a shortage of local or system generation capacity, or a shortage of the transmission line capacity needed to deliver "system" generation to the load.

Transformation and Distribution gaps are gaps in local step down transformer capacity and the required low voltage feeders to get the power to customers. These are usually dealt with together, as the means of closing the gaps are closely linked.

In both cases the gaps are defined by planning standards and practices that provide either direction or guidance in determining the amount of risk that should be assumed in the supply infrastructure. The purpose of these standards and practices is partially to ensure that the power system integrity is maintained, but mostly to ensure that electricity customers are offered an acceptable degree of reliability and security of supply.

This document accurately defines the gaps and their timing but does not propose or evaluate solutions. The options for solutions appear in other exhibits:

- Exhibit B – Load Forecast and CDM Options
- Exhibit D – Transmission (for bulk supply) Options
- Exhibit E – Transformation and Distribution Options
- Exhibit F – Generation Options

Those exhibits and others draw upon the information in this exhibit to define the parameters that they must meet to contribute to an overall solution. The options are ultimately combined into an overall integrated solution that meets the changing needs over time using an optimal mix of available options. Each exhibit that identifies options also screens them and recommends a subset of the best ones for integration into the overall solution.

The overall integrated solution is presented in the main document of the September 30, 2005 submission to the Ontario Energy Board.

2 BACKGROUND INFORMATION

The Ontario Power Authority (OPA) retained Hatch Acres and Maxlin Inc. to review the York Region load growth and study the adequacy of the electrical supply system to meet the area demand requirements over the next ten years. It became evident at an early stage of the study that only Northern York Region is significantly constrained in electrical supply as its demand is supplied by only one 230/44 kV Transformer Station (Armitage TS) located in southern Newmarket. Although the needs are not as urgent the southern portion of York Region is experiencing very high load growth, and there will be a need to ensure that capacity is available there to meet the growing needs. The OPA will address the southern portion of York Region in a future study.

Northern York Region is comprised of Newmarket, Aurora, East Gwillimbury, King, Georgina, Whitchurch-Stouffville in York Region and Bradford in south Simcoe. Four local distributing companies serve these townships: namely, Newmarket Hydro, Aurora Hydro, Barrie Hydro and Hydro One Distribution. Figure C-1 gives an overview of the portion of Northern York Region that approximately corresponds to the service area of Armitage TS.

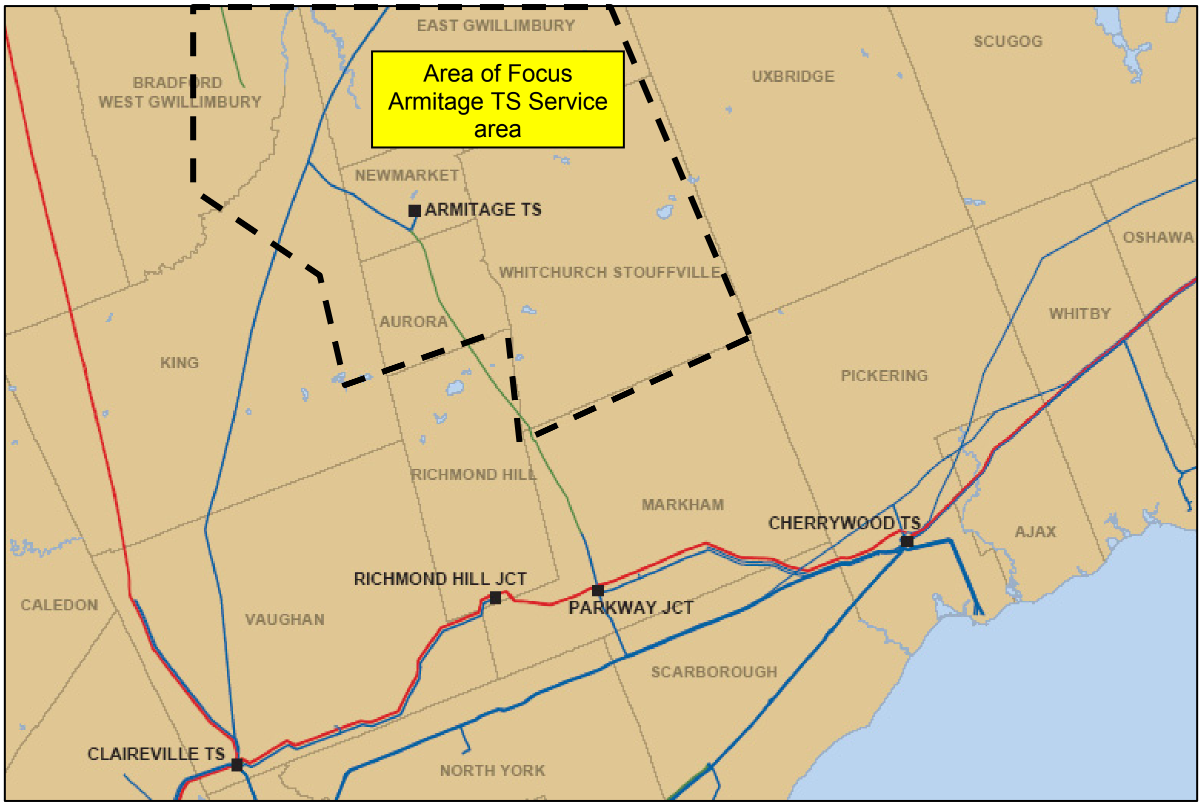


Figure C-1 Area of Focus for Northern York Region Supply Study

3 PLANNING CONSIDERATIONS

A reliable bulk transmission system delivering electricity to a major load center such as Northern York Region should meet the following performance requirements, all of which are included in the OPA planning considerations:

1. With all elements of the supply infrastructure in service to supply the area load, the equipment must operate within its normal limits. The voltages on the transmission and distribution lines must be within acceptable ranges.

2. With all transmission elements in service pre-contingency, the loss of a transmission element, which would also result in the loss of the connected transformers, should not result in the interruption of area load. All the remaining elements must be within their applicable ratings and the voltages on the transmission and distribution lines must be within the acceptable ranges.

   This requirement is in conformance with the IESO's Supply Deliverability Guidelines, which state in part:

> *For loads between 250 MW and 500 MW: With all transmission elements in service pre-contingency, any single element contingency should not result in an interruption of supply to a load level greater than 250 MW.*

Additionally, in an area with local generation, it is customary to assume that for technical or commercial reasons the largest generator in the area is unavailable in determining the supply need for the area.

3. A diverse bulk supply source, either in the form of local generation or alternate high voltage transmission line transporting generation into the area, is available to supply as much area load as possible in the event of the loss of the existing main bulk supply facilities.

   For a major load centre such as Northern York Region, it is important to include supply security or diversity as part of the planning considerations. This is consistent with IESO's Supply Deliverability Guidelines, which state in part:

   > *With all transmission elements in service, for any double circuit contingency that results in a supply interruption of between 250 MW and 500 MW, all load should be restored by switching operations within a typical period of 30 minutes*

4. The distribution feeders must be capable of delivering electricity reliably to the customers within the acceptable voltage range with minimum electrical losses. Where practical, customer loads can be connected to adjacent feeders to minimize prolonged interruption in the event of planned or unplanned outage of a feeder.

These principles are considered to be good utility practice and are adopted by utilities worldwide.

4 DEMAND FORECAST FOR ARMITAGE TS SUPPLY AREA

Armitage TS serves four distributors: Aurora Hydro, Newmarket Hydro, Barrie Hydro and Hydro One's LDC. Barrie Hydro's load is embedded within the Hydro One distribution system, and is included with the Hydro One load in this document. The peak load at Armitage TS provides the most significant value for forecasting since it is the amount of electricity that system must be capable of reliably delivering to the connected customers. Table C-1 gives the historical and future peak demand values for Armitage TS. These values are based on the information obtained from Hydro One, the Independent Electricity System Operator and a demand forecast assembled by Hatch Acres. The study area is summer peaking so the forecasts and analysis focus on summer loads. Areas of high load growth outside of Newmarket and Aurora are shown in Figure C-2.

Three sets of data are provided. The "base" forecast of slightly over 3% on average aggregates all LDC forecasts to predict future Armitage TS loading. The "CDM Reduction" forecast introduces a reduction in the base forecast to recognize the goal of a 5% reduction in peak demand by 2007, per the Province's existing conservation and demand management initiative. The "extreme weather" forecast projects loads that are higher than the base forecast, include CDM and take into account the effects of hot weather. The basis for all three sets of data can be found in Exhibit B, the Load Forecast and CDM Options Exhibit.

Table C-1 Actual and Forecast Peak Demand in MW for Armitage TS Supply Area.

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Mar. 2004 Base Forecast	351	357.9	369.8	382.1	394.9	408.0	421.6	434.7	448.2	462.2	476.5	491.3	506.6	516.2
CDM reduction (5%)	351	357.9	369.8	382.1	394.9	387.6	400.5	413.0	425.8	439.1	452.7	466.7	481.3	490.4
Extreme Weather		400	414.2	428.0	442.3	434.1	448.6	462.5	476.9	491.8	507.0	522.7	539.0	549.2

The Armitage area load growth from 2005 to 2015 is projected to be approximately 140 MW under the base forecast. The base forecast is used because it falls between the CDM reduction and extreme weather forecasts and represents the most likely outcome given all of the uncertainties.

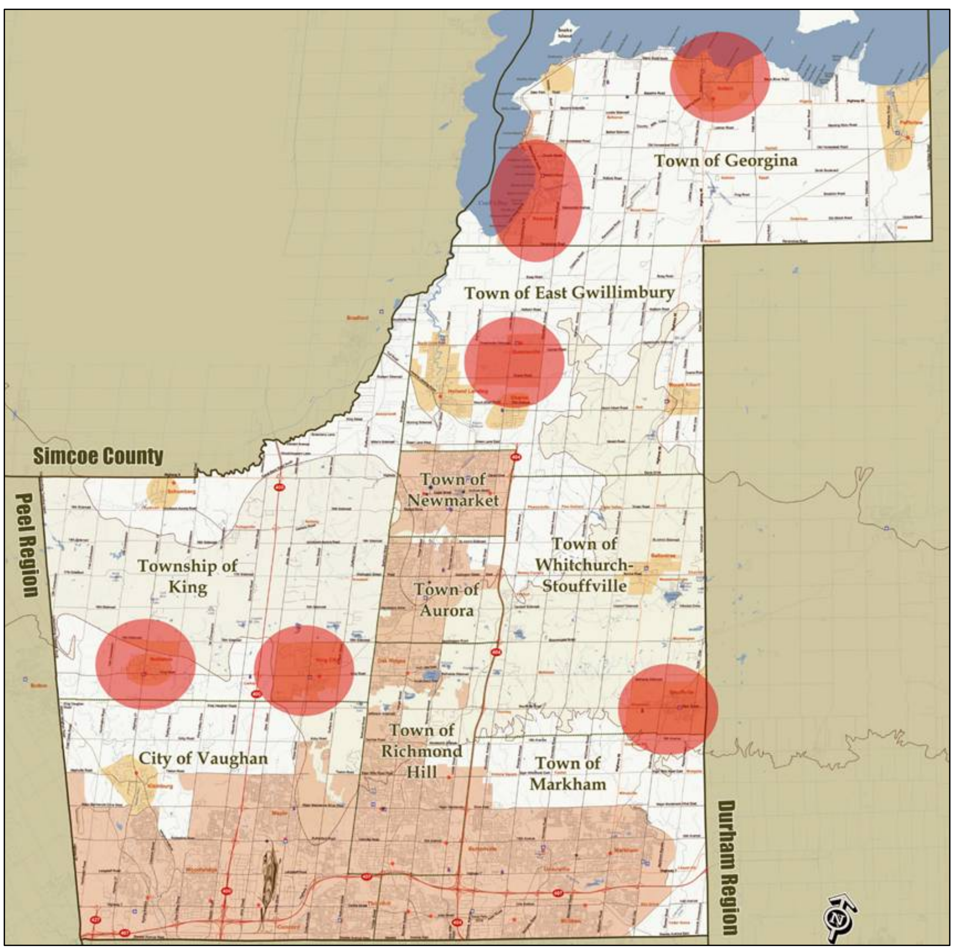


Figure C-2 Areas of High Load Growth Outside of Newmarket and Aurora

5 SYSTEM ADEQUACY ASSESSMENT

As shown in Figure C-3, the 230 kV transmission corridor that runs northeast from Claireville TS in Vaughan to Minden TS in central Ontario, consists of a double-circuit 230 kV line B82V and B83V (55 km) to Brown Hill TS supplying Armitage TS and Brown Hill TS. From there, the double-circuit line M80B and M81B (106 km), supplies loads at Beaverton TS and Lindsay TS along the corridor to Minden TS. These lines have been in service for many decades and originally brought hydroelectric power to the Toronto area from the north. The role of the lines has changed significantly, and they now have a primary function of moving power from the south up to Northern York Region. Figure C-3 shows that the 230 kV connection to Minden and hydroelectric resources in the north has become a weak supply for the Northern York Region. This is because of the great distance from Minden to Armitage TS and the tapped loads along the way in the more northerly areas that absorb the power carried from the north.

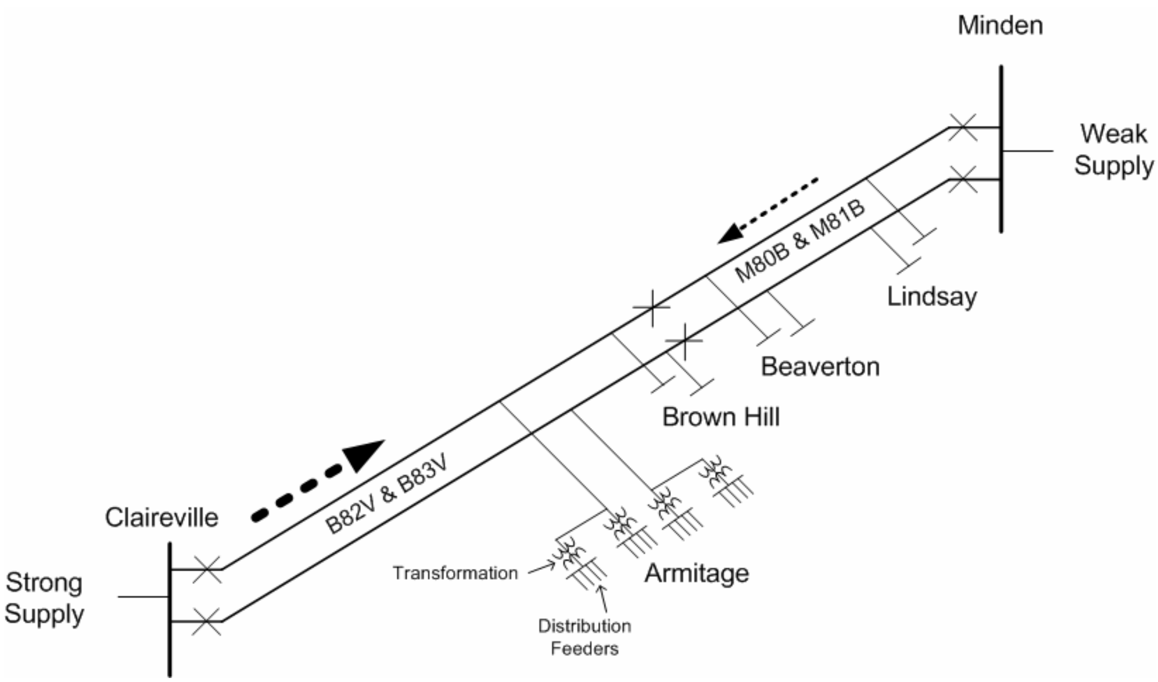


Figure C-3 Claireville – Minden Transmission Corridor with 230 kV lines B82V/B83V and M80B/M81B and Holland Junction Tap Supplying Armitage TS

Armitage TS, located in Newmarket, consists of four 230/44 kV transformers connected as two separate transformer stations on the same site. Sixteen 44 kV distribution feeders, eight per station, emanate from Armitage TS and serve a vast supply area. Armitage TS is located on a very congested site. A simplified schematic of Armitage TS follows as Figure C-4. A photograph of the station follows as Figure C-5.

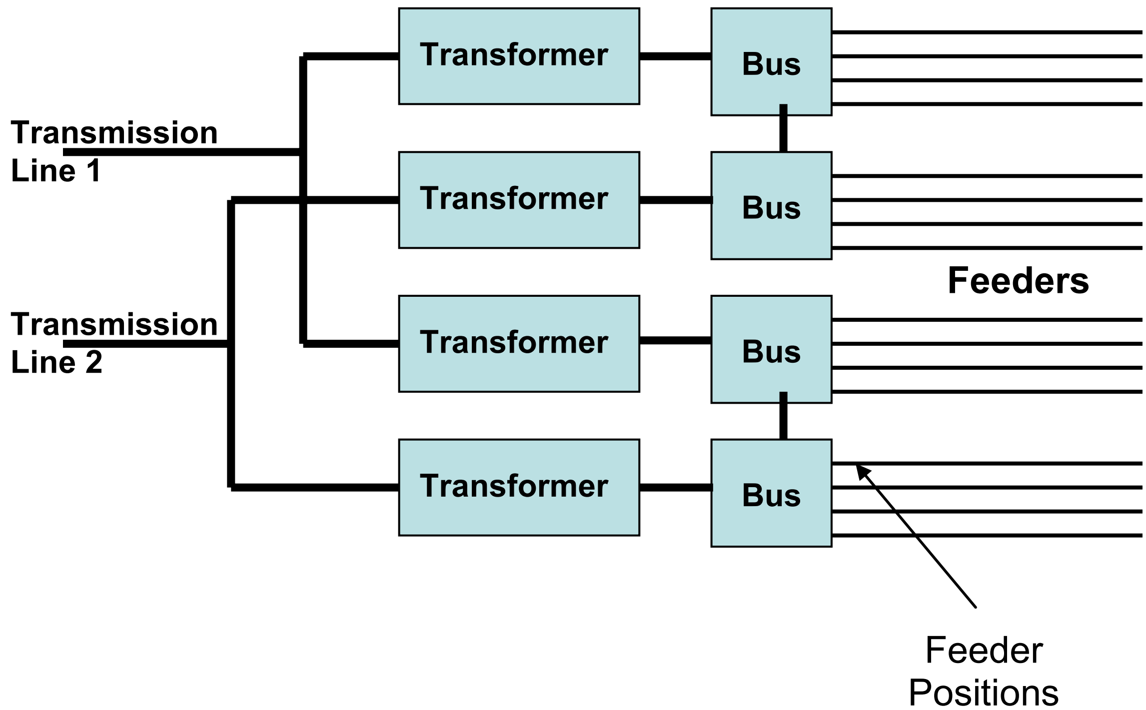


Figure C-4 Schematic of Armitage TS Supply Network

Figure C-5 Photograph of Armitage TS

There is a small generating station, the Keele Valley NUG, connected to one of Armitage TS 44 kV feeders. It has a maximum output of about 30 MW and contributes that power to the study area when in operation.

The ability to supply the existing load supplied by Armitage TS and future growing loads is limited by three related bottlenecks in the existing electrical supply system for Northern York Region. The first bottleneck is the physical ability to run additional feeder lines to service new growth areas. The Armitage TS site and local roadside pole line routes are highly congested. The second bottleneck is transformation capacity. This is based on the maximum load limitations of the power transformers used to step high voltages down to distribution voltage levels. The final bottleneck is a limitation on the overall bulk electricity supply to the local area. Each bottleneck is explained in more detail in the following sections.

5.1 Distribution System Constraints

Distribution feeder lines run from the transformer station to houses, buildings, and factories in the area supplying them with power. Ideally, these feeders need to be as short as possible to reduce losses, and each has a limited load-meeting capability. Figure C-4 (above) shows a simplified schematic of Armitage TS with sixteen outgoing 44 kV distribution feeders. Six of these feeders are allocated to Newmarket Hydro, three to Aurora Hydro and seven to Hydro One's LDC, and all are fully utilized to supply their customer demand in the area. Presently, Hydro One's LDC requires one new feeder, Aurora Hydro requires two, and Newmarket Hydro needs one to effectively serve their existing loads. Space limitations and feeder egress constraints do not allow any expansion at the Armitage TS site. Hence, no spare feeders are available to meet new demands. It is projected that at least eight new distribution feeders will be required over the next 10 years.

The distribution problem at Armitage TS is called "egress congestion". Presently, Armitage TS is at capacity and unable to meet the existing need for four new feeders or any future feeder requirements. Service is presently being provided through a non-optimal feeder configuration, but this solution is not sustainable and will become increasingly problematic as the need for new feeders increases. Sub-optimal feeder configurations result in greater electrical losses, reduced reliability and ultimately an inability to serve new loads.

New feeders are urgently needed to remedy the current situation in which load growth in the past few years has already been over-taxing the existing 16 feeders coming out of Armitage TS.

5.2 Transformation Constraints

The transformation bottleneck is based on the limited capability to take high voltage transmission power and step down the voltage to distribution levels. At present, there are two transformer stations at Armitage TS connected to two incoming lines. Each station is designed is to allow for its full load meeting capability even in the event that one incoming line or one transformer fails. Therefore the overall transformation capability at Armitage TS must be based on the assumption that two transformers (one from each of the two stations on the site) are out of service resulting from loss of an incoming line. Accordingly, the effective 230/44 kV transformation capacity at Armitage TS is limited by the 10-day limited time rating of 317 MW at 0.9 power factor. Exceeding this load increases the risk of equipment damage due to thermal overload.

Armitage TS Transformers

The transformers at Armitage TS have been subjected to the risk of overloading since 2002. Figure C-6 shows the gap between the firm transformation capacity and the historical loading as well as the forecast load for the Armitage TS serving Northern York Region. As shown, the summer peaks of 2002 to 2005 were all in excess of the 317 MW planning limit of Armitage transformers. Further, it is evident that the planning limit was exceeded even after taking into account the contribution to the area supply provided by the Keele Valley generation.

There are two reasons why this overloading has not yet resulted in power interruptions in Northern York Region. First, the system is designed to allow for a single contingency to occur at any time, but unless this contingency occurs during one of the periods where the transformer capability is exceeded, there is no service interruption. As the load continues to grow in Northern York Region, the periods in which the transformers are overloaded and the levels of overload will continue to grow as well. This will significantly increase the exposure to the risk of service interruption. The second reason why this has not resulted in service interruptions is that transformers are capable of running beyond their normal capacity for very short periods of time. Doing so however, puts considerable stress on the transformers and shortens their useful life, and is therefore undesirable for normal operation except for emergencies.

This necessitates an immediate reinforcement of the existing transformation capacity within Northern York Region in locked-step with new feeders.

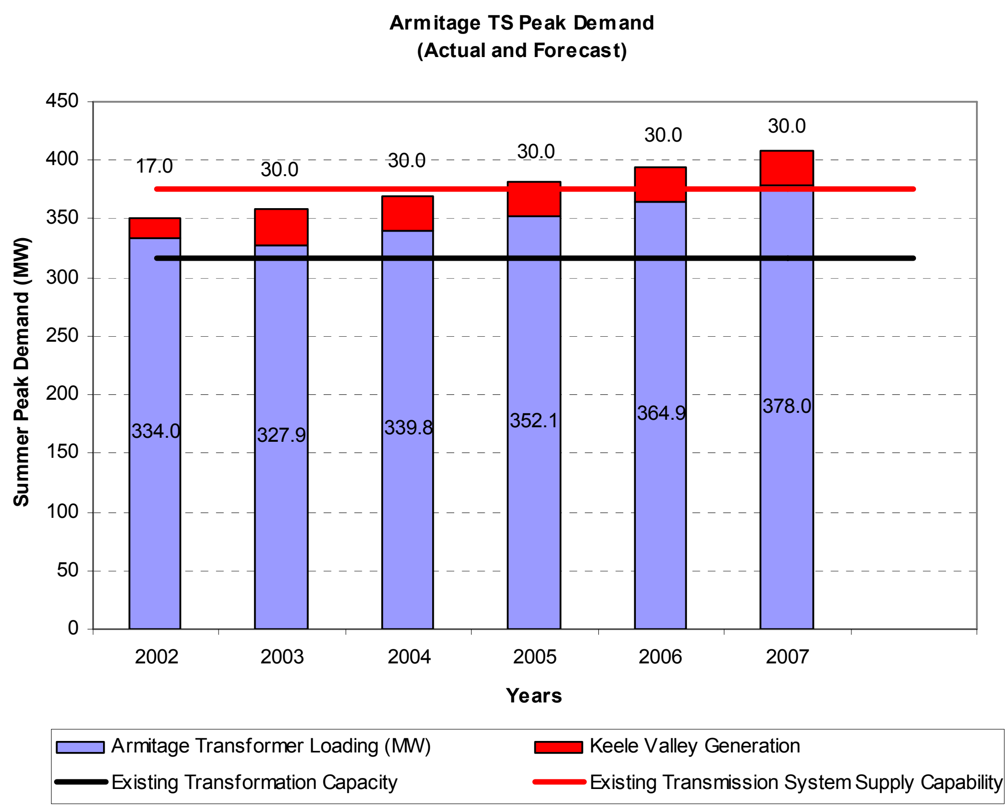


Figure C-6 Armitage TS Peak Demand (MW)

5.3 Transmission Network Supply Constraints

The existing transmission supply network limits the amount of power available to service Northern York Region. Presently, all of the supply comes from the two circuits that run from Claireville TS in Vaughan northeast towards Minden. At Holland Junction in King Township, an eight-kilometer tap line runs from these two circuits southeast to Armitage TS. Figure C-3 (above) shows this line running from Claireville TS to Armitage TS.

The transmission system is designed such that it must be capable of serving an entire connected load with one circuit out of service. There are number of reasons why circuits fail, such as lightning strikes, tree contacts, equipment failures, etc. As well, station equipment and lines need outages periodically so that routine maintenance or repairs can be carried out. It is important that supply is not interrupted every time such an incident or outage occurs. Therefore the supply bottleneck is based on the event that one of the circuits is out of service, meaning that when each circuit is running at half its capability, the line (both circuits together) is at its capacity to deal with these incidents. In such a case if a circuit was to fail then the total load would exceed the capability of the remaining circuit and an appropriate amount of load would have to be disconnected near instantly and automatically to avoid an interruption of the entire load.

In this particular case, the transmission capability of the two 230 kV circuits B82V and B83V is limited by two constraints:

The first constraint is the risk of voltage collapse, which is forecast to occur in 2008 if provincial Conservation and Demand Management (CDM) initiatives are effective, or 2006 if they are not. This voltage collapse constraint on B82V and B83V circuits limits their capability to reliably supply the area load to about 375 MW. This has been confirmed from the load flow simulations and the corresponding Power-Voltage (PV) curve is shown in Figure C-6. This curve shows the high voltage (nominal 230 kV) and low voltage (nominal 44 kV) and how the voltage goes down as the load goes up.

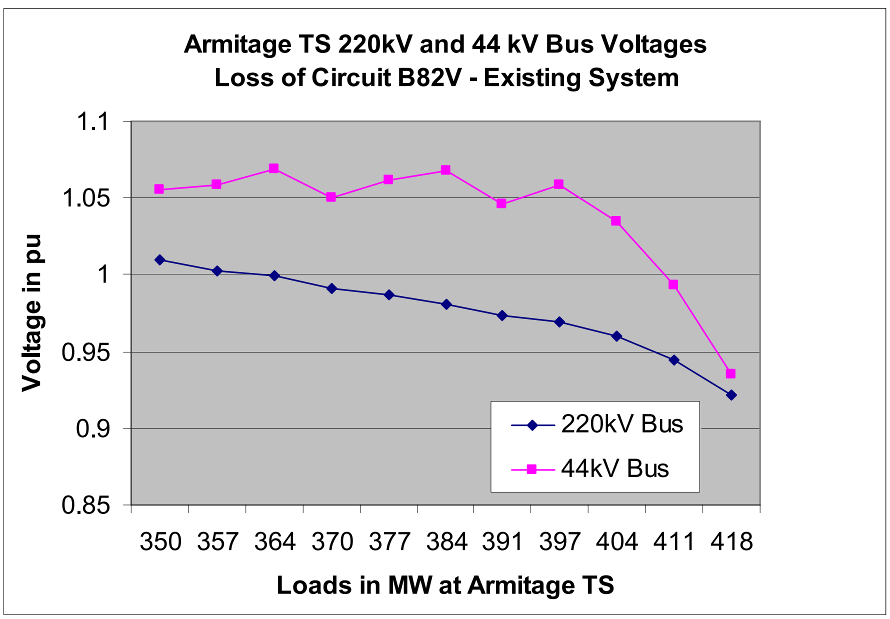


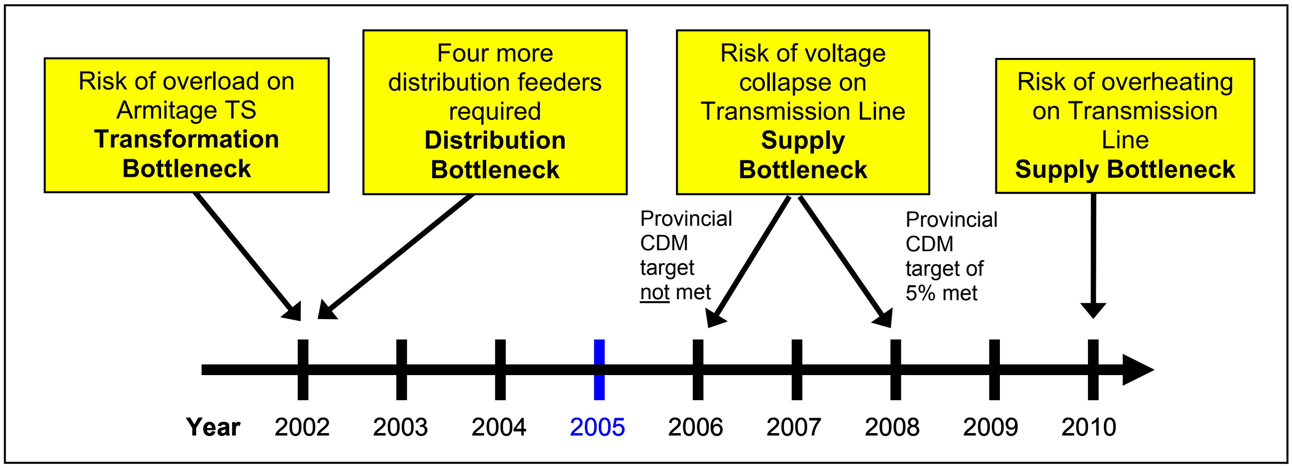
Figure C-6 Power-Voltage (PV) Curve for the Armitage TS Existing Supply System

The consequence of exceeding a 375MW peak load at Armitage TS is that should one circuit be forced out of service during the peak load period, a voltage collapse and local blackout of all Northern York Region would occur. This would however be avoided by reducing the peak load in anticipation of problems with one of the circuits through rotational load shedding or other means. Load would have to be reduced for several hours each day during summer months.

The second constraint is thermal and applies to the 8.5 km line section between Holland Junction and Armitage TS. That line section is only capable of supplying a load of 470 MW And is just adequate to meet the 2011 forecast Armitage TS load.

5.4 Gap Timeline

Figure C-7 shows a timeline of each of the bottlenecks at Armitage TS. Note that the transformation and distribution bottlenecks have already been encountered, and with no action the supply bottleneck will be exacerbated with continuing load growth.



FigureC-7: Timeline of Bottlenecks to Armitage TS Service Area

6 FUNCTIONAL REQUIREMENTS FOR CLOSING GAPS

The following sections provide planning and design considerations in the selection and evaluation of solutions designed to close the identified Northern York Region supply gaps.

6.1 Distribution System Gaps

Distribution feeders deliver power to areas of new development and to areas of continuing load growth in existing communities. They are provided in response to specific needs and specific locations so new feeders that are built will likely be underutilized for the initiate period while the load in the area they serve grows. Approximately eight feeders are required to distribute the power from one transformer station. The requirements for Northern York Region are typical:

- This is a 44 kV supply area and any new supplies will have to be 44 kV to enable effective and efficient integration of new supply facilities with existing ones.

- More than eight feeders will likely be required over the ten year horizon partly to catch up with past inadequacies, and partly to enhance geographic coverage for new load growth areas as part of continuing urban development.

- Feeders should not be loaded beyond about 20 MW each to ensure emergency transfer capability and should not be more than about 20 km in length to contain losses and minimize service interruptions.

- A “Feeder Position” (circuit breakers and controls) is required for each feeder provided to serve new loads. These feeder positions are built into transformer stations.

- Where practical load transfer capability from one transformer station to another should be provided by the distribution network to improve load security and diversity of supply in Northern York Region.

- Existing and future Conservation and Demand Management will have some effect on feeder loading but will not eliminate the need for new feeders, especially those required to supply new areas of urban development.

- Generation connected to feeders will not significantly reduce the number of feeders required to serve existing and future loads.

For a more detailed description, please refer to Exhibit E: Transformation and Distribution Options.

6.2 Transformation Gaps

Transformation is provided by building “Transformer Stations”. In Ontario, transformer stations generally take power from two high voltage lines, contain two transformers each capable of carrying the entire station load, contain capacitor banks for voltage support and finally provide up to eight feeder positions for outgoing feeders. The current supply arrangements to supply Northern York Region are not typical because there is a very high dependence on Armitage TS, one site with two transformer stations connected to the one set of incoming circuits, and as such little diversity of supply. The requirements are noted:

- Transformation in the form of transformer stations must be provided as close to the centre of load growth areas as possible to allow the provision of short and direct feeders to the loads.

- Transformer station location should take into account interaction with adjacent transformer stations of similar voltages and attempt to form networks with those stations as backup supply in emergencies.

- Adjacent stations in southern York Region are incompatible with those in Northern York Region due to the different distribution voltage classes, 28 kV in the south and

44 kV in the north. As such there is limited scope in cross-utilization of any spare transformer and feeder capacity or back-up capability.

- One 150 MW transformer station (based on Hydro One's standard design) is required as soon as possible in Northern York Region. A second transformer station will be required near the end of the ten year horizon. Both stations must be in close proximity to the loads they serve to obtain reliability and loss reduction at appropriate levels.

- Transformer stations should be equipped with low voltage shunt capacitor banks or other devices to support the voltage to the maximum extent possible. These devices must be designed to be effective without creating power quality (switching transients) problems.

- Conservation and Demand Management will have the effect of reducing transformer loading.

- 44 kV Generation can be used to close the gap provided that the generation capacity is firm, the feeder connections have sufficient redundancy to support the firm generation capacity, and that it can be implemented in time.

For a more detailed description, please refer to Exhibit F: Transformation and Distribution Options.

6.3 Bulk Electricity Supply Gaps

Bulk electricity supply consists of: (a) local generation, or (b) system generation accompanied by transmission system reinforcement to deliver that generation into Northern York Region. In either case it is the generation in sufficient quantity that closes the bulk electricity supply gap. The requirements are noted:

- Conservation and Demand Management can be used to offset the requirement for some portion of the bulk electricity supply. All Conservation and Demand Management demand reduction must be in place pre-contingency as voltage collapse can be near instantaneous, following the loss of a critical circuit.

- Local generation connected at 44 kV should provide at least 60 MW of firm capacity (i.e. with the largest unit out of service) and be connected to the distribution network in a manner that the connections do not degrade the firm capacity. 44 kV connected generation is unlikely to provide an adequate solution by itself.

- Local generation connected at 230 kV should provide at least 140 MW of firm capacity and be connected to the transmission circuit B82V and B83V in a manner that all generation remains available should a 230kV circuit fail or be unavailable for other reasons.

- Local generation connected at 230kV should be connected somewhere between Brown Hill TS, Armitage TS and Holland Junction to provide maximum benefit, and can tie to the B82V/B83V circuits using a maximum 15 km double-circuit 230 kV tap line.

- Local generation must run "pre-contingency". That means it must be running any time the load exceeds the single circuit capability of either the B83V or B83V circuits to respect either the voltage or thermal limits, in case one circuit trips off during that period.

- System generation installed outside Northern York Region can be transported into the area via a new transmission line with a new transformer station to feed some of the area load.

- Any bulk electricity supply solution should offer a maximum of security or diversity of load supply to provide as much load supply capability as possible following the loss of double circuit line from Claireville TS, with the provision of appropriate switching or isolation devices.

For a more detailed description, please refer to Exhibit D: Transmission Options, and Exhibit F: Generation Options.