Q. Does Hydro have a standard bus configuration for its 230 kV and 138 kV? How are bus configurations (ring-bus, breaker and a half, relief bus, etc) determined on a case by case basis?

A. Hydro's existing stations' bus configurations reflect the evolution of the system and the standards applied at the time each station was established and therefore do not fit a standard configuration. For new stations or major station upgrades, Hydro will determine the configuration on a case-by-case basis as follows:

- A radial transmission line supplying a single customer would be configured as a simple load bus. For new stations at the 230 kV or 138 kV transmission system level, Hydro would likely configure the station with two power transformers sized such that either transformer could supply the full load with the other transformer out of service. Customers requesting only one transformer are made aware of the risk and potential for long outage times should there be a transformer failure as Hydro does not maintain uninstalled spare transformers at the 230 kV and 138 kV voltage classes. Dedicated high and low voltage circuit breakers for each transformer are recommended in this configuration, particularly if the customer's process is very sensitive to outages;
- The situation with two transmission lines (supply lines) connected to two load lines or transformers lends itself to a ring bus arrangement where the connections clockwise around the ring are line-load-line-load. This configuration ensures a connection between the supply (line) and load during a fault with a breaker fail. The future connection of the 230 kV transmission line between Granite Canal and Bottom Brook is configured as

a ring bus including termination points for the new 230 kV transmission line, the Granite Canal Generating Station, the 230 kV transmission line between Granite Canal and Upper Salmon and a 230 kV, 15 MVAR shunt reactor;

- The situation with three or four supply lines (i.e. generator connections) and three or four load (transmission) lines lends itself to the breaker-and-one-half bus arrangement, particularly if there is the same number of supply and load connections. The Holyrood Terminal Station is an example of this arrangement. On each of three legs or diameters there is a generator connection and a transmission line connection (Unit 1 with TL217, Unit 2 with TL242 and Unit 3 with TL218). The addition of the combustion turbine will result in a fourth breaker-and-one-half leg with the combustion turbine paired with the 230/138 kV transformers T6, T7 and T8. The re-build of the 230 kV portion of the Bottom Brook Terminal Station to accommodate the Maritime Link converter station is configured as a breaker-and-one-half arrangement with one 230 kV transmission line (TL209, TL211, TL233 and the new TL269 to Granite Canal) connected to separate legs and the four transformers (Bottom Brook T1 and T3, two Maritime Link converter transformers) likewise are connected to separate legs;
- In situations when the total number of terminations at a station exceeds eight, Hydro gives consideration to application of the breaker-and-one-third bus arrangement. The breaker-and-one-third is preferred when there are two supply (generator) lines for every load (transmission) line. In this case, two supply (generator) lines can be connected to the outside ends of the same leg with the transmission line connected to the leg between the supply lines. The Churchill Falls 735 kV switchyard is arranged in breaker-and-one-third with each of three legs containing two 230/735 kV transformers and a 735 kV transmission line (from top to bottom transformer, transmission line,

transformer). The station contains six 230/735 kV transformer terminations and three 735 kV transmission line terminations. The Muskrat Falls Terminal Station is planned as a breaker-and-one-third arrangement. The station consists of four 315 kV supply lines from the four generators and eight load terminations including two 315 kV transmission lines to Churchill Falls, two 315/138/25 kV transformers, two 315 kV supply lines for the HVdc converter transformers and two 315 kV supply lines for the HVdc converter station ac filters;

- Consideration is given to future termination requirements when developing a bus configuration for a new terminal station; and
- Decisions between ring bus, breaker-and-one-half and breaker-and-one-third consider not only the impact of a breaker failure and the split between supply and load terminations, but also the costs with respect to civil works and the optimal number of circuit breakers. For example: five elements to be terminated in a ring bus configuration would require five circuit breakers; and in a breaker-and-one-half configuration, eight circuit breakers would be required and the station layout would have space for one future termination point with the addition of one additional circuit breaker.