***Hydro One Networks Inc. Transmission Interrogatory #001***

***Reference:***
ED Evidence, Page 5.

***Interrogatory:***

Preamble:

Inclusion of transmission system modeling of transmission losses can be used on a daily basis to optimize the configuration of the transmission system.

Interrogatory:

a) Please describe what daily reconfigurations of the transmission system would be informed from modeling the transmission losses on a daily basis and how would that materially reduce losses.

***Response:***

a) Examples of daily reconfigurations of the transmission system that would be informed from modeling transmission losses include:
    i. increasing operating voltage above nominal voltage to reduce the current flow on transmission lines assuming safe and reliable power system operation; and
    ii. During low load periods, disconnecting additional transformers to reduce core losses assuming safe and reliable power system operation.

***Hydro One Networks Inc. Transmission Interrogatory #002***

***Reference:***

ED Evidence, Pages 6 to 7.

***Interrogatory:***

Preamble:

A second option to reduce transmission conductor losses is to replace the conductor with materials that have extremely low resistance, sometimes referred to as superconductors. Superconductors achieve low resistance by cooling the material below a specific threshold temperature, while achieving substantially higher power transfer capability at the same voltage level and size as conventional materials. The need to cool the superconductor means that the use is primarily restricted to underground applications where cooling capabilities are easier to apply compared to overhead transmission lines. The superconductor materials are expensive compared to conventional conductor materials limiting the application to specific circumstances.

Interrogatory:

a) What specific circumstances would superconductors be applicable for the purpose of reducing conductor losses?
b) Has there been an application of superconductors for the primary purpose of reducing losses in North America?
c) If so, please identify where and what jurisdiction this has been applied and what might be the approximate investment level for these projects?
d) What is the typical per km cost ratio of a superconductor compared to a conventional ACSR conductor to transfer the same power level?

***Response:***

a) A specific circumstance where superconductors may be applicable to reduce transmission system losses is a densely populated urban area where right of ways are hard to find and/or secure. Decreasing the electrical resistance and increasing the power transfer capability can reduce transmission losses, especially if the superconductor reduces the current flow on other transmission lines serving the area.
b) A definitive answer to this question is outside the scope of the evidence. In addition, a comprehensive assessment of applications of superconductors across all of North America is not feasible in the time available. Although, Mr. Lusney is not aware of example of an application of superconductors for the primary purpose of reducing losses in North America, he has not specifically assessed applications of superconductors across North America.
c) See 2 b.

d) See 2 b. As noted at page 7 of the evidence: “The superconductor materials are expensive compared to conventional conductor materials limiting the application to specific circumstances.” Determining a per km cost for the same power transfer would require a complicated assessment involving the consideration of many different variables. Furthermore, work is always being done on new materials which could impact the economics and applicability of superconductors in the future.

***Hydro One Networks Inc. Transmission Interrogatory #003***

***Reference:***
ED Evidence, Page 7.

***Interrogatory:***

Preamble:

A third option for reducing transmission conductor losses is to reduce the flow of reactive power on the transmission conductor. Reactive power is the result of current and voltage not being in phase and leads to total current on a line being greater than what is required to deliver the required power to a load. Reactive power compensation can be used to remove reactive power and reduce the additional transmission system losses. Reactive power compensation can be provided by a Flexible Alternating Current Transmission System (FACTS). FACTS is defined by the IEEE as "a power electronic based system and other static equipment that provide control of one or more AC transmission system parameters to enhance controllability and increase power transfer capability". FACTS can provide Shunt Compensation or Series Compensation.

Interrogatory:

a) Is the primary purpose of most FACTS devices to improve power transfer capability, or to reduce conductor losses?
b) If the primary purpose is to improve power transfer capability, would that not result in higher current flows and higher losses?
c) If the primary purpose is to reduce conductor losses, please identify some examples of FACTS installations in North America for this purpose. Please also identify the type of FACTS device and an estimate of the facility cost and the forecasted level of loss savings.

***Response:***

a) FACTS devices serve a wide range of purposes including increasing power system reliability, power flow control, voltage regulation, improving power transfer capability, transient and dynamic stability improvements, and interconnection of renewable and distributed energy resources. The primary purpose of FACTS depends on the need identified and justified by the transmission system owner that the FACTS is attempting to address.
b) If a transmission owner determines the primary purpose of installing a FACTS device was to improve power transfer capability at a specific part of a power system, higher current flows and higher losses on the line may be one of the drawbacks in determining the cost-benefit of the investment. The increased power transfer capability through reactive power compensation from the FACTS may also reduce losses throughout the system by reducing the amount of generation required to serve load centers since more "real power" is delivered. Real power refers to the amount of current and voltage phases that are in sync when reaching an electrical load. When the current phase and the voltage

phase are perfectly in sync, the power factor is considered to be 1. Less generation production can also reduce current flow on other transmission assets which may reduce losses further. Implementation of FACTS devices requires a transmission owner to determine the primary purpose and assess the cost-benefit based on a variety of factors including impacts on transmission losses throughout the transmission system. Other factors include reliability, safety, stability and community support.

c) See 3 a. The focus of the evidence was transmission losses, options to reduce losses and an overview of regulation options. Assessing primary purposes of FACTS device deployment is considered out of scope.

***Hydro One Networks Inc. Transmission Interrogatory #004***

***Reference:***
ED Evidence, Page 12.

***Interrogatory:***

Preamble:

The first component of transmission efficiency regulation is allocation of responsibility for procurement of losses. In some countries (e.g., Norway), the transmitter/network operator is responsible for procurement of energy to replace losses and those transmission loss costs are included in allowed revenue. Where the transmitter/network operator is responsible for procuring transmission losses, the energy is typically secured through real-time energy markets, bi-lateral agreements or through auctions/tenders for generation of firm energy.

Interrogatory:

a) Please confirm that the Norwegian transmitter/network operator is Statnett, and please confirm whether ED's understanding of Statnett is consistent with the following statement taken from Statnett's website:

   Statnett is first of all responsible for all high voltage electricity transmission and distribution in Norway … Statnett is also appointed the role as Norway's Transmission System Operator (TSO) with an overall responsibility of coordinating the operation of the country's electric power system, maintaining correct balance between supply and demand at all times. In doing so Statnett also regulates all electric power exchange with other national grid systems abroad, primarily involving those of the other Nordic grid system operators.

***Response:***

a) Confirmed

***Hydro One Networks Inc. Transmission Interrogatory #005***

***Reference:***
ED Evidence, Page 12.

***Interrogatory:***

Preamble:

An example of transmission loss regulation is the transmission license of National Grid Electricity Transmission (NGET), a transmission company located in the United Kingdom (UK), which requires a report on transmission losses within its transmission system. NGET is required to publish an annual transmission losses report and to publish a strategy on how NGET will address the level of transmission losses on its transmission system.

Interrogatory:

a) Does NGET perform the integrated system operations function, including the balancing of generation and load, in addition to performing the functions of a transmission owner?
b) If so, how are these functions different from the integrated system operation functions performed by the IESO in Ontario?
c) Given the differences in the functions and operations of NGET and Statnett versus Hydro One, please explain why examples of where transmitter/network operator responsibility is shared is relevant to Ontario transmission owners.

***Response:***

a) Yes
b) The focus of the evidence was transmission losses, options to reduce losses and an overview of regulation options. Assessing the comparative functions of integrated system operators is considered out of scope.
c) The NGET licence obligations that relate to transmission losses provide an example of transmission losses regulation for a transmission owner. NGET considers and manages transmission losses as a part of its roles and functions as a transmission company. For example, as stated in the evidence, NGET considers transmission losses through investment planning and accounts for losses in equipment specifications and procurement processes (see page 13 for more details and examples). These are examples of loss reduction activities that Hydro One could undertake.

   The example is relevant to Ontario transmission owners to demonstrate an implemented transmission licence obligation and resulting strategy to consider and mitigate transmission losses. The NGET example demonstrates three key aspects for transmission owners:
   i. The establishment of a strategy for considering and mitigating transmission losses in a transmission system;

ii. A demonstration how transmission loss mitigation has been integrated into a transmission owner's planning process including expansion, reinforcement and replacement of transmission assets; and
iii. An approach to annual reporting of transmission system losses.