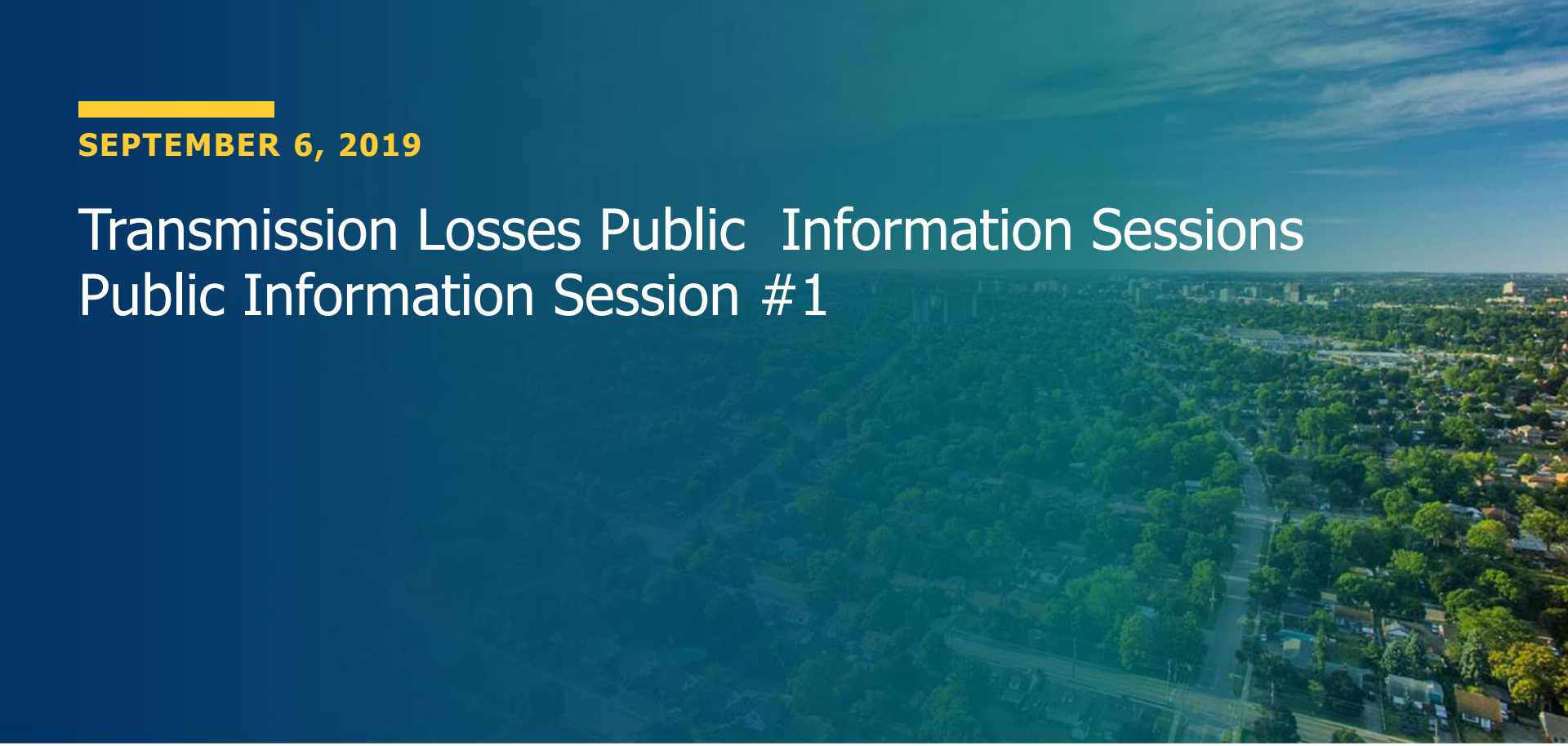

SEPTEMBER 6, 2019

# Transmission Losses Public Information Sessions
# Public Information Session #1

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# Agenda

1. Purpose
    - Background and Context
    - Information Sessions' Objectives
2. Division of Responsibilities Related to Transmission Losses
3. Transmission Losses 101
4. Next Steps

# 1. Purpose

# Past OEB Proceedings – Themes 1-2

Recent Revenue Requirement applications by IESO and Transmission Rate applications by Hydro One, have included details on the following transmission losses related topics/themes:

1. Division of responsibilities between the IESO and Hydro One on transmission losses
2. Consideration, evaluation and optimization of transmission losses in planning activities

# Past OEB Proceedings – Themes 3-5

3. Representations (or reporting) of transmission losses at the system level
4. Benchmarks to compare transmission losses in Ontario with other jurisdictions
5. Providing a better understanding of how transmission losses are generally managed in the sector

# OEB Decision and Order

As part of IESO's 2018 Revenue Requirement application, IESO filed a settlement proposal for the OEB's review and approval.

The settlement proposal reflected the agreement reached between IESO and participating intervenors.

# OEB Proposal Requirement

The proposal included the requirement to:

"engage with stakeholders regarding the IESO's transmission losses work/report including a discussion of the transmission losses processes used by National Grid UK, the recommendations of the Council of European Energy Regulators, and methodologies to assess the cost effectiveness of transmission loss reduction measures."

# OEB Settlement Proposal

The settlement proposal was accepted by the OEB.

The proposal is on the EB-2018-0143 Decision and Order Website.

# Planned Public Information Sessions

The IESO is planning to hold three sessions. To the extent the discussion warrants it, more sessions may be added.

# Session #1 – Ontario Context

(Today)

- Review the IESO and transmitter accountabilities for transmission planning  and losses
- Background on transmission losses

# Session #2 – Jurisdictional Scan

- Transmission losses processes used by National Grid (NG) UK
- Recommendations of the Council of European Energy Regulators (CEER)
- Methodologies to assess the cost effectiveness of transmission loss reduction  methods

# Session #3 - Planning

- The IESO will discuss:
  - How it considers transmission losses in planning for the Ontario system
  - How our work relates to the two reports discussed in Session 2
  - What we can improve
- Date and time to be confirmed

# 2. Division of  Responsibilities Related to Transmission Losses

# Operation of the System

- The IESO is responsible for day-to-day operation of the Ontario electricity system and market

# Planning and Design of the System

- The IESO is responsible for planning of the transmission system focusing on  system adequacy and reliability (system topology).

# Planning of the System

- Planning of the system is supported by transmitters and distributors, for example,  regional planning in Ontario follows the OEB-endorsed process which requires  the participation of the IESO, local transmitter and local distributors.

# Design of the System - Transmitters

- In addition to owning and maintaining transmission facilities, transmitters (such as Hydro One) are responsible for the detailed design of the transmission facilities, including developing equipment standards and selecting appropriate equipment.

# 3. Transmission Losses 101

# Losses in the Transmission System

- Transmission or Power losses are commonly defined as the difference between the amount of electricity entering the transmission system and the aggregated consumption registered at end-user meter points.

# Transmission losses in electrical systems are conventionally broken down into two categories:

- Technical losses
- Non-technical losses

# Technical Losses – inherent resistance

- Technical losses are the result of the inherent resistance of electrical conductors, which cause electrical energy to be transformed to heat and noise whenever current flows through them.

# Technical Losses – dissipation of heat

- The loss of energy stemming from the dissipation of heat in electrical networks (lines, cables, transformers and other elements of the grid) is usually referred to as 'physical (or ohmic) losses'. In the case of a transformer, losses include losses in the windings and the core.

# Transmission losses – Non-technical Losses

Non-technical losses comprise electricity that is delivered mostly for consumption but which is not paid for.

# Non-technical Losses – Main Causes

Non-technical Losses are mainly caused by:

- in-house consumption (also known as “hidden” losses)
- illegal abstraction of electricity (i.e., energy theft)
- non-metered supplies (such as public lighting)
- errors in metering, billing and data processing, etc.

# Non-technical Losses – Hidden causes

1. "Hidden" non-technical losses are typically associated to in-house consumption, but also to electricity consumed in order to cool transformers, and operate the control system.
2. Energy theft consists of tampering with meters and illegal connections.

This presentation will focus on technical losses only.

Reference documents on the CEER website

# Understanding Technical Losses – in Lines

In conductors, losses in the form of heat result from their inherent resistance and the amount of current flowing through them.

# Losses equation

Losses = Square of the current value (I2 where I being the current) X resistance of the conductor (R)

This means that when the current goes up by 10% through the conductor, the losses go up by 20%.

This also means that when the conductor resistance goes up by 10%, the losses also go up by 10%.

# Losses explained

This means that when the current goes up by 10% through the conductor, the losses go up by 20%.

This also means that when the conductor resistance goes up by 10%, the losses also go up by 10%.

# Transmission Line

# Transformer Winding Losses

In transformer windings, similar to conductors in transmission lines, losses in the form of heat result from their inherent resistance and the amount of current flowing through them.

Implications on losses as a result of winding resistance and current flowing through the winding is the same as discussed for transmission lines.

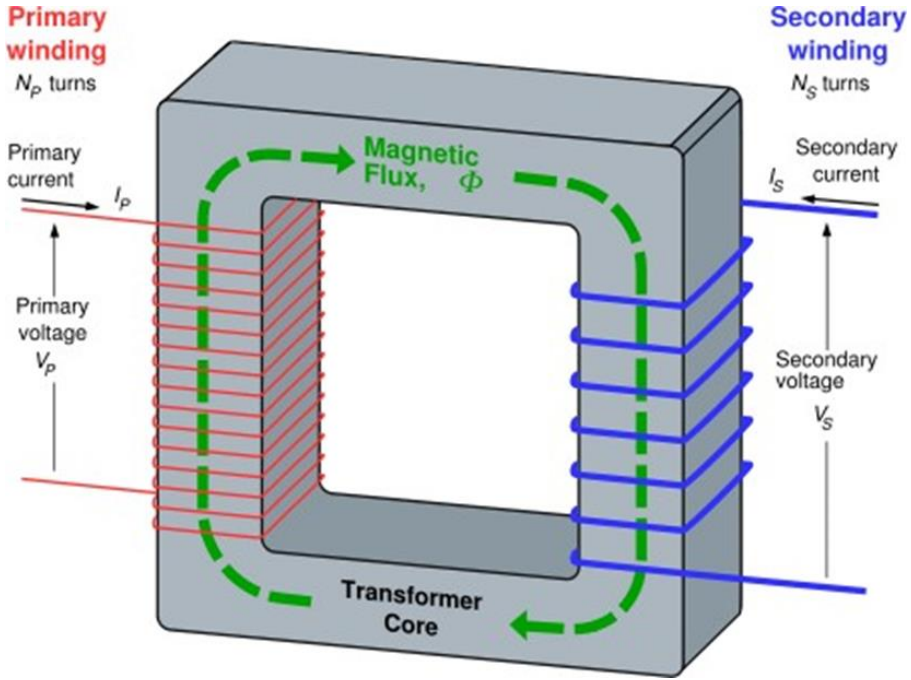
# Transformers Core Losses

In transformers, losses also occur in their core. Core losses are essentially constant, i.e., they do not change with current in the windings.

Core losses in transformers typically account for 0.5% of the transformer's  full load rating (i.e., 0.5 MVA in a 100 MVA transformer).

# Power Transformer

# Transformer Windings & Core - Diagram



# Factors Impacting Transmission Losses

Factor - Line voltage

How does it impact losses?

Higher voltage will result in lower current and hence less losses (for the same power transfer).

If a line is voltage upgraded, it will have lower losses.

# Factor - Line voltage – How does it impact losses?

Higher voltage will result in lower current and hence less losses (for the same power transfer).

If a line is voltage upgraded, it will have lower losses.

# Factor - Line voltage - Caveats

Increasing voltage to reduce losses will  impact line insulation, clearances, etc.  which in turn will add to cost and/or  other limitations

# Factor - Line loading or current – How does it impact losses?

As discussed earlier, higher (or lower) line loading or current, will result in more (or less) losses (recall losses are proportional to the square of current).

As load fluctuates, so do losses over a line.

# Factor - Line loading or current – Caveats

Keeping line loading lower will mean  having more facilities in service (than  required for reasons of need or  standards) which will add to cost

# Factor - Line resistance – How does it impact losses?

As discussed earlier, higher (or lower) conductor resistance will mean more (or less) losses.

This also means a longer line (which will have more resistance) will have higher losses.

# Factor - Line resistance – Caveat

Line resistance can be lowered by  increasing conductor size which may impact the line design and potentially  result in higher cost

# Further Considerations on Transmission Losses

Transmission system losses are not static but dynamic, and a continuously varying parameter.

# Transmission Losses – Detailed Analysis

A detailed analysis of losses including costing of losses for any project is a time-consuming endeavour and involves consideration of many factors.

Continually changing:

- Loads,
- Power flow over lines due to generation dispatch scenarios and output of renewables, and
- Demand and energy prices in the IESO market, etc.

# Transmission Losses – Assessment of Losses

The assessment of losses is therefore typically done on specific transmission projects where there is potential for significant loss reduction.

# Transmission Losses – Cost approach to projects

The approach on such projects is to assess losses and cost of losses for a select number of scenarios, which are established for each project, over the life of equipment.

# Reporting of Transmission Losses at IESO

The metrics for reporting transmission losses vary throughout the industry.

# Reporting – Annual Losses

Annual transmission losses as a percentage of annual energy demand, calculated as a ratio of the energy lost (i.e., total generation including imports less total loads including exports) to total energy generated or acquired (i.e., generation including imports).

# Reporting – System Peak Demand

Transmission losses at the time of system peak demand as a  percentage of system peak energy demand (peak hour).

Calculated using the same methodology as above except that it focuses only on  the peak hour.

# Reporting – Wholesale market cost of transmission system energy losses.

Calculated as the energy loss for each trading hour multiplied by the Hourly  Ontario Energy Price (HOEP) for that hour over the entire year

# Consideration of Losses in Transmission Planning

The primary consideration in the planning and design of Ontario's transmission system  (500 kV, 230 kV and 115 kV networks) is to ensure the adequacy and reliability of the system.

# Planning – Design Capacity

The system is, therefore, designed with sufficient capacity to supply the forecasted peak loads even with the loss of any one element, i.e., redundancy is built into the design. This redundancy of assets for meeting the reliability criteria however, also reduces the power flow levels over transmission assets which, in turn, reduces losses.

# Planning – Criteria and Standards

The transmission system design in Ontario is in accordance with the planning criteria and standards set out by:

- North American Electric Reliability Corporation (NERC)
- Northeast Power Coordinating Council (NPCC) and
- IESO's Ontario Resource Transmission Assessment Criteria (ORTAC)

# Planning – Factors considered

In system design, consideration is given to equipment design/standards, safety, customer  preference and cost effectiveness, including transmission losses.

# Planning – Mitigation

Transmission losses are mitigated through planning and design

# Planning – System Reinforcement

System reinforcement by building a new line or reconfiguration to also help reduce transmission losses, e.g., the Southwest GTA Reinforcement project which required constructing a new, double circuit 230 kV line to avoid overloading of the existing lines.

# Planning – Voltage Upgrade

Voltage upgrade option for new projects to meet capacity needs as part of area  plans, e.g., Barrie area conversion to 230 kV

# Planning – Conductor Selection

Normally, the conductor selection process to satisfy capacity requirements  results in the selection of a large conductor that has low losses.

# Planning – New Transformers

Requirement that the new transformers be designed to minimize losses (both winding and core losses) whether these transformers are used in new applications or in the replacement of the existing older units.

# Planning – Lifecycle Cost Approach

In managing assets such as transformers and lines, a lifecycle cost approach is utilized where all needs are balanced. Increased emphasis on one need may trigger other changes with additional costs outweighing the benefits. Balancing all needs with minimum cost is key to effective planning and design.

# 4. Next Steps

# Public  Information Sessions

Next public information session dates – to be confirmed

- Session #2 – Jurisdictional scan
- Session #3 – Bringing sessions #1 and #2 together

# Comments and Questions

Please submit any comments and/or questions on the material presented in this session to engagement@ieso.ca