

2022 - 2025 System Losses Plan

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1. INTRODUCTION

Hydro Ottawa Limited ("Hydro Ottawa") operates in the City of Ottawa and the Village of Casselman. Hydro Ottawa was formed in November 2000 following the amalgamation of five municipally owned electric utilities (Gloucester Hydro, Goulbourn Hydro, Kanata Hydro, Nepean Hydro and Ottawa Hydro). Hydro Ottawa acquired the assets of Casselman Hydro Inc. in April 2002. Each utility owned and operated its distribution systems with different operational and planning philosophies. The combined distribution systems resulted in a distribution system with diverse characteristics to serve urban and rural customers.

Hydro Ottawa operates and maintains assets for six (6) different voltage levels: 4.16kV, 8.32kV, 12.43kV, 13.2kV, 27.6kV, and 44kV.

With a service territory comprised of 662 km² of rural area and 454 km² of an urban area, Hydro Ottawa's total footprint of 1,116 km² makes it the fifth physically largest in the province.

Hydro One Network Inc. ("Hydro One") and Hydro Ottawa-owned transmission stations supply Hydro Ottawa service territory. Additional details on Hydro Ottawa's system configuration are found in Hydro Ottawa's most recent Distribution System Plan as part of Hydro Ottawa's 2021-2025 rate application¹.

Energy losses in a distribution system include transformation losses at the transmission-connected stations, feeder line losses, distribution transformation losses, and secondary line losses. All of these components contribute to the energy losses of a distribution system. As part of the 2021-2025 Approved Settlement Agreement², Hydro Ottawa committed to endeavouring to maintain a five-year average total system loss below the target of 3.02%³ set by the Ontario Energy Board ("OEB") in EB-2005-0381 through cost-effective measures⁴. In addition, Hydro Ottawa committed to preparing a plan to reduce distribution system losses as much as possible through cost-effective measures and filing the plan with the OEB.

¹ Hydro Ottawa Limited, 2021-2025 Custom Incentive Rate-Setting Distribution Rate Application, EB-2019-0261 (February 10, 2020, Updated May 29, 2020).

² Hydro Ottawa Limited, 2021-2025 Custom Incentive Rate-Setting Approved Settlement, EB-2019-0261 (September 18, 2020).

³ 2019 annual loss percentage of 3.02% (five-year average was 3.09%)

⁴ Ontario Energy Board, *Decision with Reasons*, EB-2005-0381 (April 12, 2006).

2. SYSTEM LOSSES

The use of the term “system losses” refers to the difference between the invoiced electricity delivered to Hydro Ottawa by the Independent Electricity System Operator and Hydro One and the invoiced electricity delivered to Hydro Ottawa customers. The system losses are comprised of two types: technical and non-technical losses.

Technical losses: Technical energy losses on a distribution system are primarily due to heat dissipation and include transformation losses at the transmission-connected stations, distribution feeder line losses, distribution transformation losses, and secondary line losses.

Non-technical losses: Non-technical energy losses include theft of power, billing errors, metering inaccuracies and unmetered service loads. These losses are difficult to quantify and are mitigated through good utility practices and procedures.

As shown in Table A from 2017-2021, Hydro Ottawa’s percentage of distribution losses has remained lower than the Peer Group Average and Ontario Average. The Hydro Ottawa system losses are consistently lower than the peer group average and lower than the Ontario average.

Table A – Percentage of System Losses - Comparison of Ontario LDCs⁵

	2017	2018	2019	2020	2021
Hydro Ottawa	2.97%	3.22%	3.02%	3.14%	2.87%
Peer Group Average ⁶	3.37%	3.43%	3.45%	3.49%	3.37%
Ontario Average	3.82%	3.80%	3.95%	4.03%	3.88%

⁵ Hydro Ottawa has used the information provided in the OEB’s Yearbook of Electricity Distributors for 2017-2021 to compare the percentage of distribution system energy losses.

⁶ Peer group consists of the following Ontario electricity distributors; Alectra Utilities, Burlington Hydro Inc., Enwin Utilities Ltd., Hydro One Networks Inc., Kitchener-Wilmot Hydro Inc., London Hydro Inc., Oakville Hydro Distribution Inc., Synergy North Corporation (Thunder Bay Hydro Electricity Distribution Inc.), Toronto Hydro-Electric System Limited, Veridian Connections (Alectra as of 2019), and Waterloo North Hydro Inc.

3. REDUCING SYSTEM LOSSES

Hydro Ottawa worked with CIMA+ to review technical losses, specifically distribution line feeder losses on 10 selected feeders representing Hydro Ottawa feeders. The selection of 10 feeders offered a cross-sectional view of the Hydro Ottawa distribution system, where recommendations provided could be actionable across all feeders.

The study completed by CIMA+ resulted in four (4) recommendations provided in section 7 of their report. These recommendations were:

1. Any power factor correction efforts should include a more detailed analysis to determine the optimum size of shunt capacitors and a detailed review of the loads and load locations to determine the best location for the installations.
2. Load balancing to a 10% target should be an ongoing effort to minimize feeder losses. These efforts can be planned and implemented in stages, with a monitoring period to gauge the effects before moving more loads.
3. Unless a feeder has a large number of small conductors, the impacts of any reconductoring⁷ can be expected to be minimal and would not warrant this measure.
4. Voltage conversion⁸ for the sole purpose of reducing losses is likely to be more expensive. However, voltage conversion for any feeders nearing end-of-life replacement is recommended.

⁷ Reconductoring: To replace the conductor or cable on a distribution system to allow greater electric-current-carrying capability.

⁸ Voltage conversion: Usually, to increase distribution system voltage to allow greater electric-current-carrying capability by replacing distribution transformers and/or conductors.

4. HYDRO OTTAWA'S ACTION PLAN

Based on the CIMA+ study and recommendations, Hydro Ottawa proposes the following incremental and continued actions to mitigate system losses.

1. Power Factor Correction

In 2021, Hydro Ottawa completed a study at the Kanata Municipal Transmission Station (MTS) by deploying Sentient Energy's GEMS®+ENG0® solution. The primary objective was to measure the benefits of voltage support and capacity reduction, energy savings and technical loss reductions. Line losses were one of the technical losses measured due to implementing the technology.

The power factor correction implementation resulted in an annual line loss reduction of 20 MWh from June 2018 to May 2019, and 17.6 MWh from June 2019 to May 2020.

At Kanata MTS, residential customers consume 17%, and commercial and industrial consumers consume 83% of the station loading. Using the June 2018 to May 2019 reported reduction of line losses of 20,000 kWh, residential, commercial and industrial consumers would see a 0.01% decrease in their monthly consumption.

Based on the study completed at the Kanata MTS, it is not proposed to pursue standalone capital investments of Sentient Energy's GEMS®+ENG0® solution on the merits of line loss reductions only. Hydro Ottawa's future capital replacement programs will continue to look at equipment and opportunities to incorporate embedded power factor correction controls.

2. Load Balancing

After CIMA+'s recommendation regarding feeder imbalancing, Hydro Ottawa completed a study to review the system-wide feeder imbalance and put a phase-wise plan in place to undertake load-balancing efforts. Results published from a 2005 load unbalance paper from the 15th Power Systems Computation Conference concluded that *"High levels of load unbalance produced greater losses while the same demand is maintained*

at each unbalance scenario. This means that network reconfiguration considering load balancing is highly recommended to diminish overall system losses.”⁹

Based on CIMA+’s recommendation and the technical reference paper published, a criterion was established prioritizing highly loaded feeders with a >10 % imbalance. Of approximately 800 feeders in Hydro Ottawa’s system, 299 feeders met the requirements. Details are in Table B below.

Table B – Action plan for Load Balancing

% Feeder Loading	Number of feeders > 10% imbalance
>=60%	56
50%-60%	46
40%-50%	58
30%-40%	56
20%-30%	40
10%-20%	43
Total	299

Hydro Ottawa will determine the optimal feeder configuration to minimize imbalances on the first 56 feeders which are >60% loaded as well as phase imbalanced to >10%. Hydro Ottawa will complete an optimal feeder configuration analysis by Q2 2023 and will complete the system changes related to feeder balancing by the end of 2025. The load balancing will cost Hydro Ottawa approximately \$95,000 to complete on the first phase of 56 feeders.

Based on the analysis for feeder balancing, Hydro Ottawa estimates to save 7,700,000¹⁰ kWh in yearly losses once all balancing is completed.

⁹ Ochoa Ochoa, L. F., Ciric, R. M., Padilha-Feltrin, A., & Harrison, G. P. (2005). Evaluation of distribution system losses due to load unbalance. In 15th Power Systems Computation Conference PSCC 2005 (pp. 1-4).

¹⁰ Assumptions included load distribution per phase based on peak load distribution per phase, a single conductor resistance value, and constant system configurations.

3. Reconductoring

As recommended by CIMA+, there are more effective loss mitigation strategies than reconductoring on its own. As assets reach their end-of-life expectancy, Hydro Ottawa has completed reconductoring during projects such as the Limebank and Leitrim projects and the Fallowfield and Cambrian projects. Additionally, Hydro Ottawa has initiated an audit of conductor sizes information stored, and field checks will be completed to ensure up-to-date information. This would help make informed decisions on reconductoring when needed.

Hydro Ottawa will continue to complete reconducting projects when assets need additional capacity, when maintenance needs arise, or when they reach their intended end-of-life cycle. This is in line with CIMA+'s recommendation for reconductoring.

4. Voltage Conversion

CIMA+ indicated that voltage conversion for reducing losses alone would unlikely be economical; however, voltage conversion for end-of-life assets is recommended and would benefit system losses.

Voltage conversion projects allow Hydro Ottawa to serve more customers safely and reliably while accommodating growth. It provides better power quality and minimizes losses on Hydro Ottawa's distribution system. Voltage conversion projects can also be completed with reconductoring projects to ensure the conductor size can support the increased voltage.

Details of Hydro Ottawa's voltage conversion budget program can be found in Attachment 2-4-3(E): Material Investments of Hydro Ottawa's 2021-2025 Rate Application¹¹. This action is not incremental to the 2021-2025 Distribution System Plan but is highlighted as it is also a recommendation from the CIMA+ study.

¹¹ Hydro Ottawa Limited, 2021-2025 Custom Incentive Rate-Setting Distribution Rate Application, EB-2019-0261 (February 10, 2020, Updated May 29, 2020).

Projects, where voltage conversions are planned to address capacity constraints and aging infrastructure, are listed in Table C below.

Data for line loss reduction calculations for various projects were unavailable at the time the report was completed.

Table C – Voltage Conversion Projects

Project	Voltage Conversion	Status	Estimate Yearly Line Loss Reduction (kWh)
Richmond South	8kV to 28kV	Completed	Not Available
Fisher	4kV to 13kV	In-progress	8,000,000
Beaverbrook	12kV to 28kV	In-progress	140,000
South Nepean	8kV to 28kV	Planned	Not Available
Navan Road	8kV to 28kV	Planned	Not Available
Dagmar	4kV to 13kV	Planned	11,000,000

5. Unmetered Load Service

In addition to the CIMA+ recommendations, Hydro Ottawa has begun a review of all unmetered service loads. Unmetered service loads impact non-technical losses. The review began in Q3 of 2022 and is expected to be completed by 2024. It consists of reviewing all unmetered connected loads and their respective loading profile.

6. Project Optimization

Hydro Ottawa's investment decision-making process utilizes asset investment planning and management software tools to evaluate and optimize projects to create a plan that balances asset conditions, lifecycle cost, labour resources, risks and benefits. Hydro Ottawa uses value measures to define risks and benefits or opportunities. Potential risks include deficiencies to health and safety, system capacity, environment stewardship, compliance and increasing financial costs. Potential benefits include improving system reliability and program efficiencies, enabling distributed generation and reducing financial costs.

The financial costs include the reduction of distribution system losses. Part of the project evaluation will include the project's impact on reducing system losses. The scoring methodology used in the prioritization process will account for the impact of a project on system losses when applicable.

5. SYSTEM LOSS ENERGY SAVINGS

The average losses in Hydro Ottawa's original loss study was 3.17%¹² over the five-year period of 2001-2005: Hydro Ottawa reported annual losses of 3.14%¹³ in 2005¹⁴. As outlined in Table D & E, Hydro Ottawa's five year average loss percentage for 2017 to 2021 has consistently been below the 2005 loss factor percentage as presented in the original system losses reduction plan. In addition, since 2019, the five year average is trending positively towards the 2019 annual loss factor of 3.02%¹⁵. This demonstrates the projects Hydro Ottawa implemented in the past have efficiently reduced energy losses. In general, projects aim not only to reduce system loss but also to reduce overall energy demands on the system. When replacing end-of-life assets, Hydro Ottawa will continue to make future capital investments into equipment that reduces system losses. When these investments are energized, they should improve Hydro Ottawa's system losses for years to come.

¹² Hydro Ottawa Limited, 2021-2025 Custom Incentive Rate-Setting Distribution Rate Application, EB-2019-0261 Undertaking Responses Attachment JT 3.15(A), Table 2.1

¹³ 2005's % is an annual loss percentage.

¹⁴ Ontario Energy Board, *Decision with Reasons*, EB-2005-0381 (April 12, 2006).

¹⁵ Hydro Ottawa Limited, 2021-2025 Custom Incentive Rate-Setting Approved Settlement plan, EB-2019-0261 (September 18, 2020).

Table D – 2005 and 2017-2021 Electricity Purchases and Sales

	2005	2017	2018	2019	2020	2021
Electricity Purchases (kWh)	7,911,789,396	7,410,783,961	7,612,655,949	7,466,402,854	7,267,291,175	7,320,051,888
Electricity Sales (kWh)	7,663,197,036	7,190,875,162	7,367,818,383	7,240,881,408	7,039,448,672	7,109,738,445
Losses (kWh)	248,592,360	219,908,799	244,837,567	225,521,446	227,842,503	210,313,443
5 year average loss % ¹⁶	3.14%	2.91%	3.03%	3.09%	3.07%	3.04%

Table E – 2005 and 2017-2021 Electricity Purchases and Sales Including Wholesale Customers

	2005 ¹⁷	2017	2018	2019	2020	2021
Electricity Purchases (kWh)	7,911,789,396	7,445,895,024	7,646,355,171	7,500,328,010	7,300,770,509	7,353,013,964
Electricity Sales (kWh)	7,663,197,036	7,224,848,131	7,400,425,274	7,273,713,842	7,071,852,991	7,141,630,694
Losses (kWh)	248,592,360	221,046,894	245,929,897	226,614,169	228,917,518	211,383,270
5 year average loss % ¹⁸	3.14%	2.91%	3.03%	3.09%	3.07%	3.04%

¹⁶ 2005's % is an annual loss %.

¹⁷ Hydro Ottawa did not have Wholesale Metered customer(s) at this time.

¹⁸ 2005's % is an annual loss %.

6. CONCLUSION

Hydro Ottawa is committed to reducing technical and non-technical losses from its distribution system. The study completed by CIMA+ supported current efforts by Hydro Ottawa and identified load-balancing opportunities.

Hydro Ottawa will continue with its current efforts and implement a 10% target for load balancing in stages, with monitoring periods to gauge the effects before moving and balancing additional loads. In addition, Hydro Ottawa continues to work towards leveraging existing software to assess the impact of loss mitigation as a result of load-balancing efforts.

Hydro Ottawa will include "Improved System Losses" as a criterion for project evaluation. The added measure will add importance to a project providing benefits by reducing system losses.

Based on the recommendations from CIMA+, Hydro Ottawa plans to implement load balancing and continue planned work of reconducting and voltage conversion projects. Hydro Ottawa also plans to complete a review of unmetered load services by 2024.