SEPTEMBER 24, 2025

Demand Research Technical Papers Webinar

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Welcome and Introduction

- Today's session will be recorded and available for viewing online following the session
- All documents associated with this session can be found on the Technical Papers engagement page

Participation

- For questions and comments click on the “raise hand” icon (hand symbol) at the top of the application window. This will indicate to the host you would like to speak
- To unmute audio, click on the microphone icon at the top of the application window
- Audio should be muted when not asking a question

Territory Acknowledgement

The IESO acknowledges the land we are delivering today's webinar from is the traditional territory of many nations including the Mississaugas of the Credit, the Anishnabeg, the Chippewa, the Haudenosaunee and the Wendat peoples and is now home to many diverse First Nations, Inuit and Métis peoples. We also acknowledge that Toronto is covered by Treaty 13 with the Mississaugas of the Credit First Nation.

As we have attendees from across Ontario, the IESO would also like to acknowledge all of the traditional territories across the province, which includes those of the Algonquin, Anishnawbe, Cree, Oji-Cree, Huron-Wendat, Haudenosaunee and Métis peoples.

Agenda

- Technical Paper 1: Extracting Insights and Trends from Residential and Small Commercial Electricity Data
- Technical Paper 2: Large Step Loads
- Technical Paper 3: Insights on Space Heating Electrification and its Implication on Ontario Electricity System Planning
- Technical Paper 4: Scenario Analysis of Electric Vehicle Adoption and Charging Demands

About the IESO

Operate Ontario's province-wide electricity system on a 24/7 basis

Support innovation and emerging technologies

Oversee the electricity market, driving competition to maintain affordability

Work closely with communities to explore sustainable options

Plan for Ontario's future energy needs

Enable province-wide energy conservation

Technical Paper 1: Extracting Insights and Trends from Residential and Small Commercial Electricity Data

Anthony Ionno, MSc, MA

Lead Data Scientist – Operational Models and Forecasts

Overview

- Background and Purpose
- Dataset Description
- Results
- Future Work and Next Steps

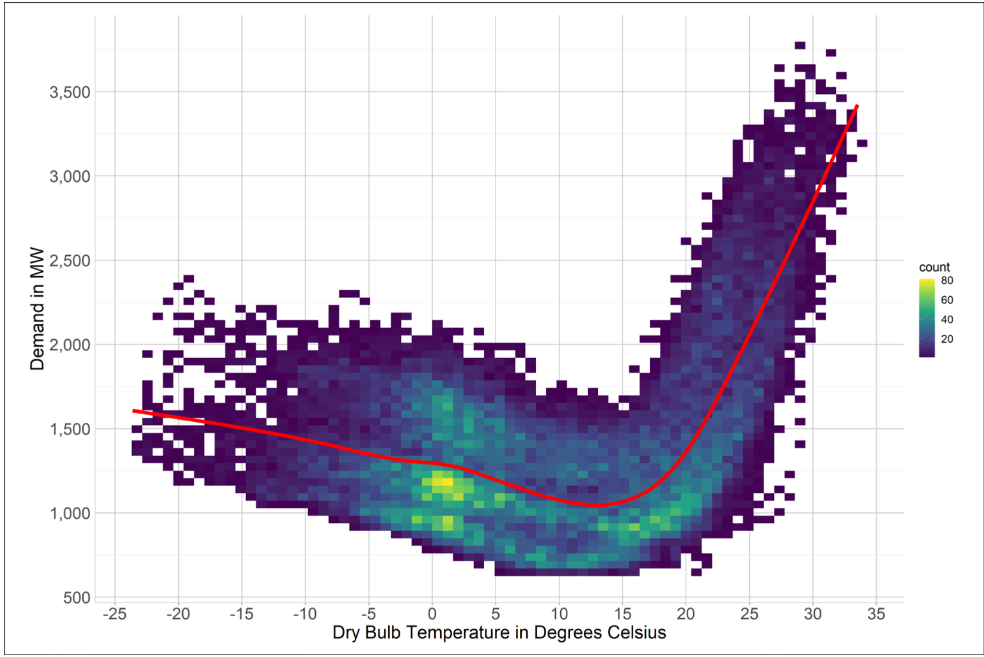
Background

- Ontario is one of the few jurisdictions in the world where a full-scale smart-meter roll out was mandated by the provincial government in 2004
- The IESO is responsible for handling what is now one of the largest smart-meter databases in the world, the Meter Data Management Repository (MDM/R),
- The MDM/R contains hourly electricity data on residential and small commercial consumers that is managed by the Smart Metering Entity (SME)

Purpose

- **Production of energy statistics** to aid in the understanding of historical residential and small commercial consumer electricity consumption and demand behaviour
- **Production of a series of hourly electricity demand machine learning models** to capture and isolate the effect of weather on residential and small commercial demand, which will help improve demand forecast processes and models
- **Production of geographical visualizations** to better enable geo-targeting for demand management activities such as energy conservation and demand response programs

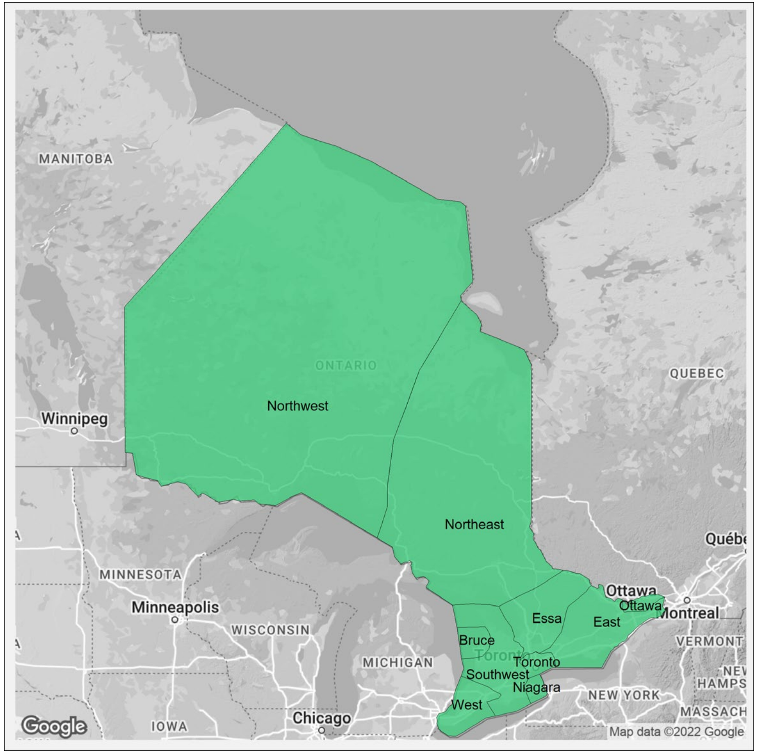
Figure 0.1: Heatmap of Residential Demand and Dry bulb Temperature for Toronto Electrical Zone



Dataset Description

- Hourly electricity consumption data for residential and small commercial consumers at the forward sortation level
- Dataset spans January 1, 2018 to November 30, 2021
- Contains commodity and distribution rate class metadata
- Analysis is aggregated to the IESO electrical zone level in most cases

Figure 0.2: Map of Ontario Subdivided by IESO Electrical Zone



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Results Overview

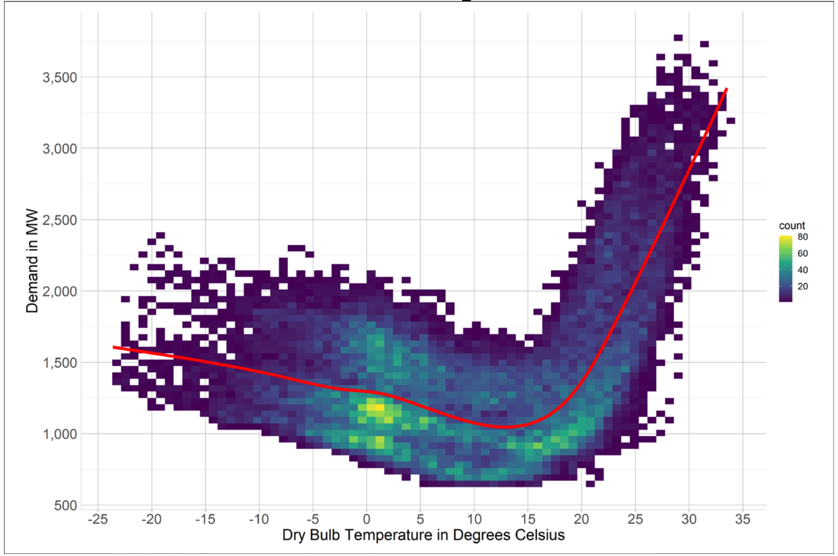
- Weather Sensitivity Analysis
- Geospatial Analysis

This presentation covers some but not all the analyses within the paper

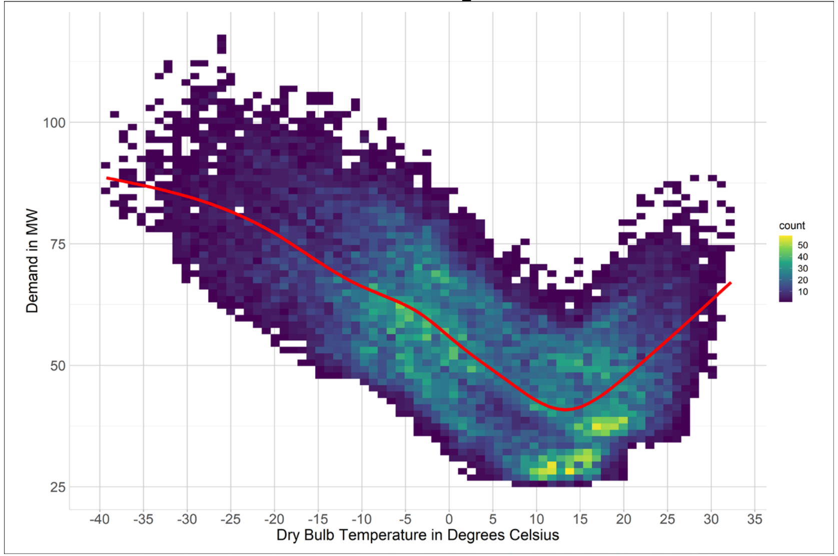
Weather Sensitivity Analysis

Weather Sensitivity Analysis (1 of 6)

Residential – Toronto IESO Electrical Zone Only

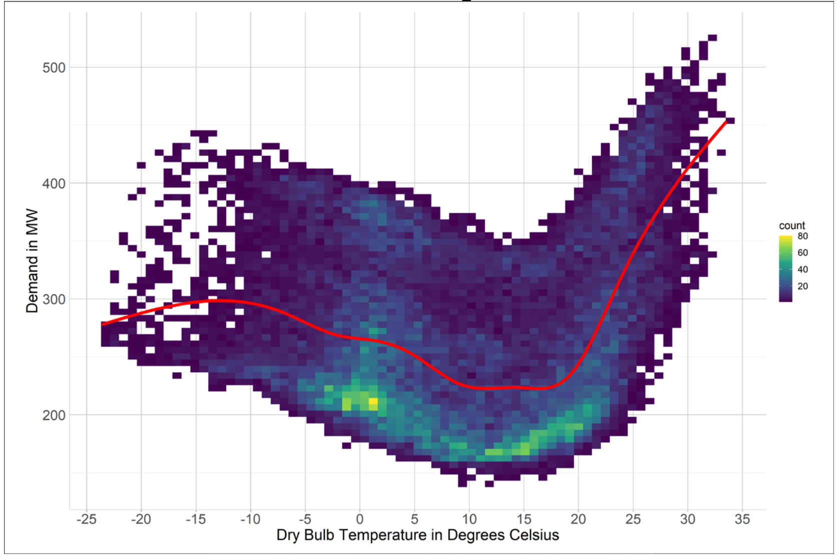


Residential – Northwest IESO Electrical Zone Only

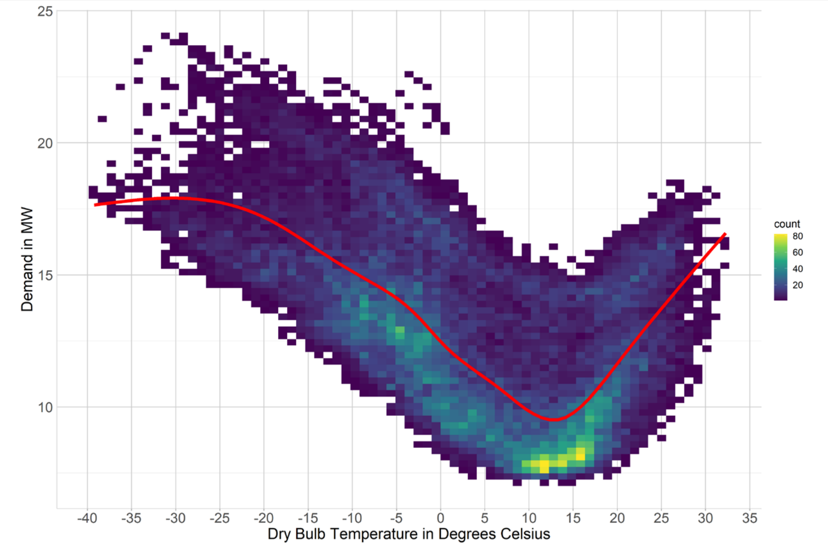


Weather Sensitivity Analysis (2 of 6)

Small Comm. – Toronto IESO Electrical Zone Only

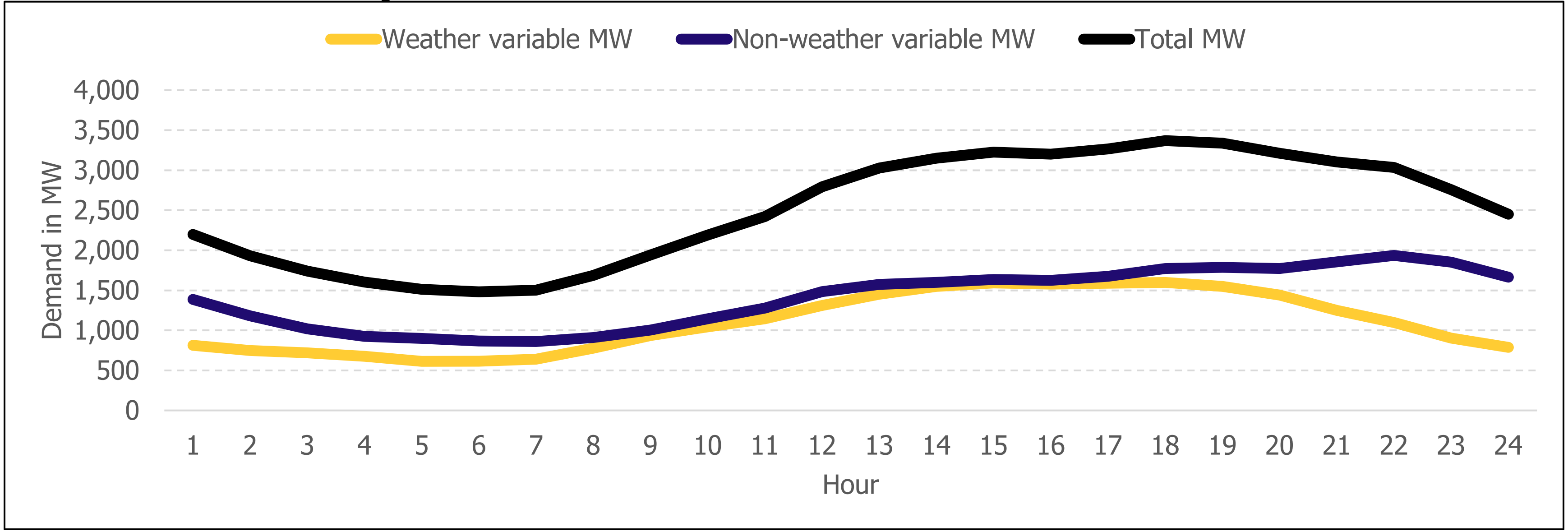


Small Comm. – Northwest IESO Electrical Zone Only



Weather Sensitivity Analysis (3 of 6)

Residential breakdown of hourly demand for July 20, 2019 – hottest 2019 Summer day in Toronto



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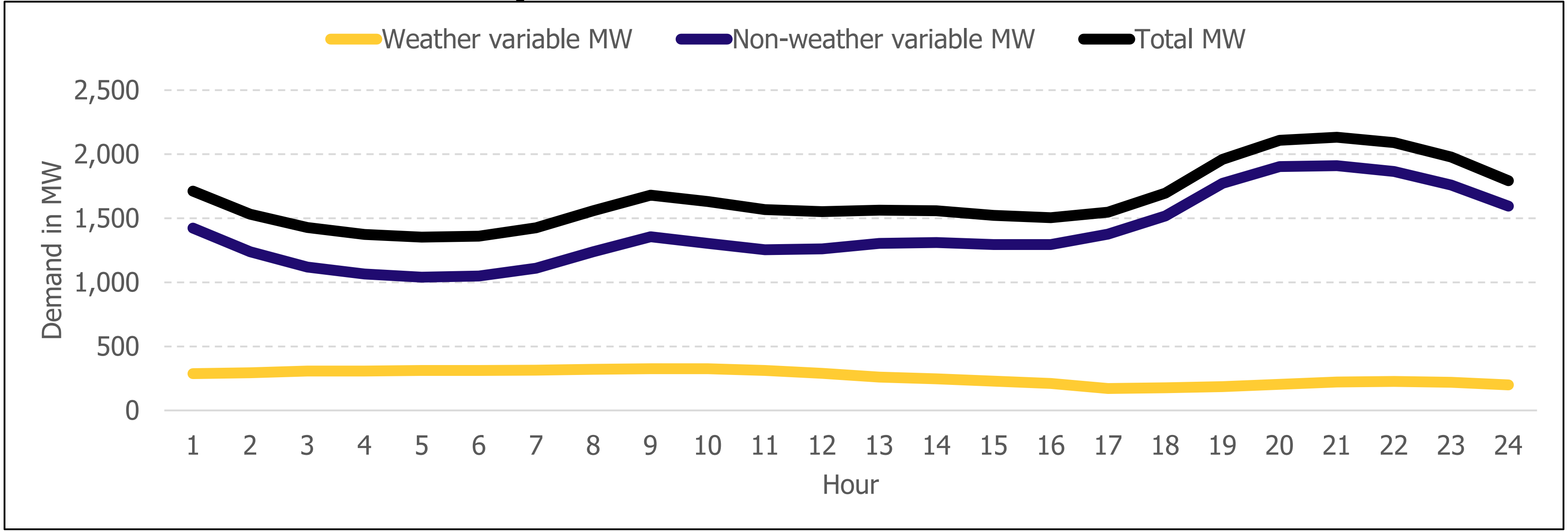
Weather Sensitivity Analysis (4 of 6)

Residential breakdown of hourly demand for January 21, 2019 – coldest 2019 Winter day in Toronto



Weather Sensitivity Analysis (5 of 6)

Average Contribution of Weather Variables to Hourly Residential Demand Prediction, Broken Down by Season, Time-of-day, and IESO Electrical Zone

Electrical Zone	Winter				Spring				Summer				Fall			
	Morn	Aft	Eve	Night	Morn	Aft	Eve	Night	Morn	Aft	Eve	Night	Morn	Aft	Eve	Night
East	12%	10%	8%	12%	11%	11%	9%	13%	14%	13%	11%	15%	12%	13%	10%	16%
Essa	11%	9%	7%	11%	10%	11%	8%	11%	15%	14%	12%	15%	12%	12%	9%	15%
Niagara	6%	5%	5%	7%	13%	13%	13%	17%	20%	24%	20%	19%	15%	14%	13%	19%
Northeast	16%	14%	12%	16%	12%	12%	10%	13%	22%	15%	13%	23%	15%	14%	11%	18%
Northwest	16%	14%	11%	15%	11%	11%	9%	12%	22%	13%	11%	21%	12%	11%	9%	14%
Ottawa	9%	7%	5%	8%	10%	11%	9%	13%	15%	17%	14%	15%	12%	12%	10%	16%
Southwest	6%	5%	4%	6%	10%	11%	10%	12%	15%	19%	15%	15%	12%	12%	10%	15%
Toronto	6%	5%	5%	7%	14%	13%	13%	18%	22%	27%	20%	18%	16%	14%	13%	21%
West	6%	6%	5%	7%	12%	13%	13%	17%	19%	24%	18%	16%	15%	14%	12%	18%
Avg.	9%	7%	6%	9%	10%	11%	9%	13%	16%	16%	13%	16%	12%	11%	10%	15%

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Weather Sensitivity Analysis (6 of 6)

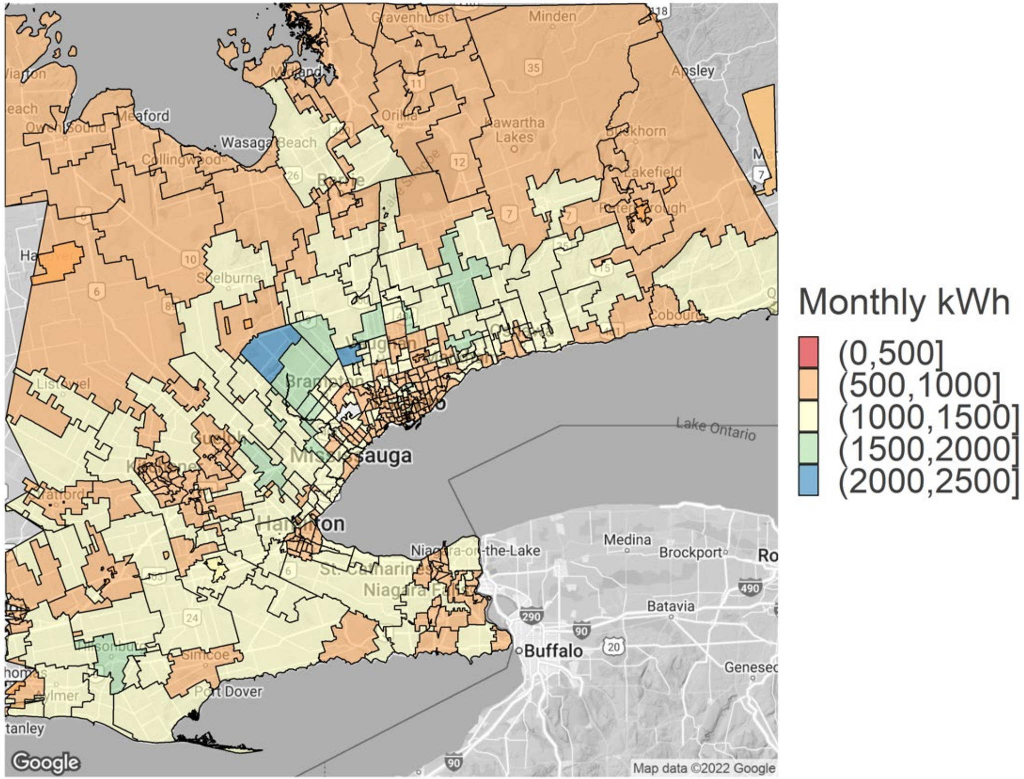
Average Contribution of Weather Variables to Hourly Small Commercial Demand Prediction, Broken Down by Season, Time-of-day, and IESO Electrical Zone

Electrical Zone	Winter				Spring				Summer				Fall			
	Morn	Aft	Eve	Night	Morn	Aft	Eve	Night	Morn	Aft	Eve	Night	Morn	Aft	Eve	Night
East	7%	6%	6%	8%	7%	7%	9%	9%	7%	8%	7%	9%	8%	7%	9%	11%
Essa	7%	6%	5%	7%	6%	6%	7%	7%	7%	7%	6%	9%	7%	6%	8%	9%
Niagara	5%	4%	5%	6%	8%	7%	10%	11%	9%	12%	9%	10%	8%	6%	9%	12%
Northeast	12%	13%	10%	11%	9%	8%	11%	12%	12%	5%	11%	23%	10%	7%	14%	17%
Northwest	14%	14%	12%	14%	9%	8%	11%	12%	15%	5%	13%	24%	11%	8%	13%	16%
Ottawa	7%	5%	5%	7%	7%	7%	8%	8%	7%	8%	6%	8%	8%	7%	8%	10%
Southwest	5%	5%	4%	5%	6%	6%	9%	9%	8%	10%	7%	9%	6%	5%	8%	11%
Toronto	4%	4%	3%	5%	6%	7%	8%	6%	7%	9%	7%	7%	7%	6%	7%	8%
West	4%	4%	4%	5%	7%	7%	10%	9%	9%	13%	9%	7%	7%	7%	9%	10%
Avg.	6%	6%	5%	7%	7%	6%	8%	8%	8%	8%	8%	10%	7%	6%	9%	10%

Geospatial Analysis

Geospatial Analysis (1 of 3)

Average Residential Monthly Energy in kWh, Broken down by Forward Sortation Area



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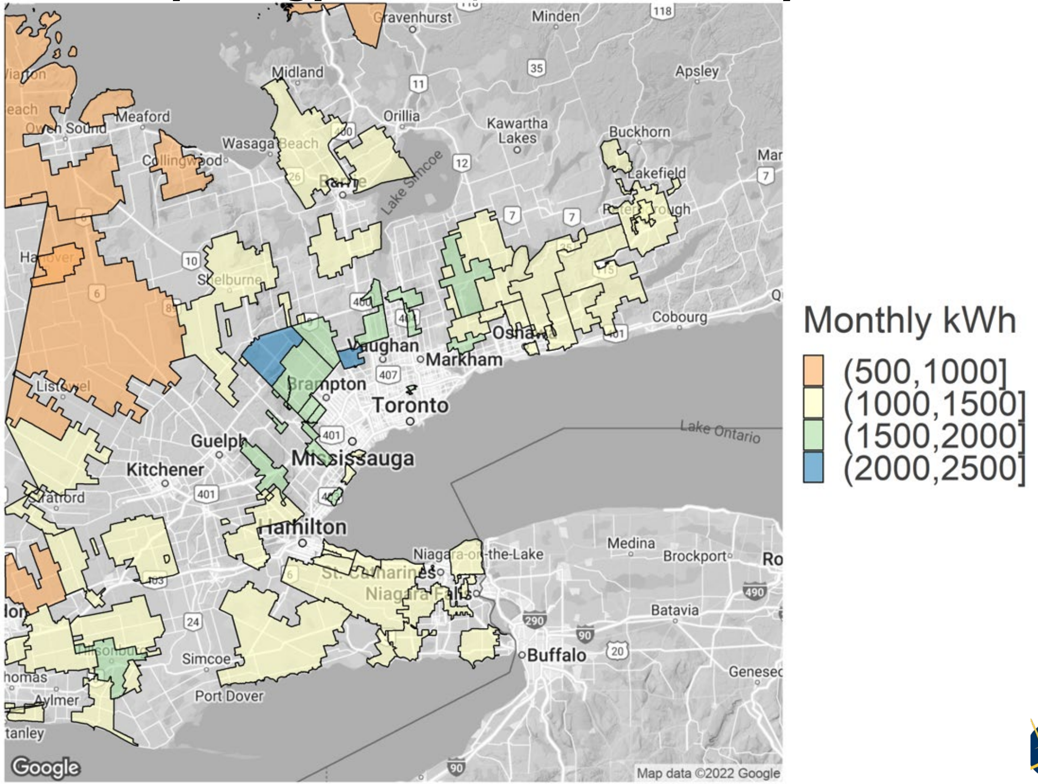
Geospatial Analysis (2 of 3)

Average Residential Monthly Energy in kWh, Broken down by Forward Sortation Area



Geospatial Analysis (3 of 3)

Average Residential Monthly Energy in kWh, Broken down by Forward Sortation Area

Rank	Toronto								
	2019			2020			2021		
	FSA	Average Monthly Energy in kWh	Premise Count	FSA	Average Monthly Energy in kWh	Premise Count	FSA	Average Monthly Energy in kWh	Premise Count
1	L0J	1,925	1,523	L0J	2,193	1,536	L3L	2,117	10
2	L3Y	1,882	67	L6L	1,891	31	L0J	2,094	1,560
3	L6L	1,579	32	L3Y	1,588	70	L6L	1,970	31
4	M2L	1,325	3,858	M2L	1,538	3,843	L0H	1,473	1,203
5	L0H	1,295	1,216	L0H	1,507	1,208	L9P	1,463	826
6	L9P	1,284	810	L9P	1,492	834	L7B	1,436	3,926
7	L1Y	1,281	737	L7B	1,470	3,951	M2L	1,428	3,879
8	L7B	1,263	3,405	L1Y	1,442	737	L1Y	1,380	733
9	L9L	1,255	283	L5H	1,428	5,597	L5H	1,360	5,598
10	L5H	1,222	5,554	L6J	1,397	8,099	L9L	1,354	284

Future Work

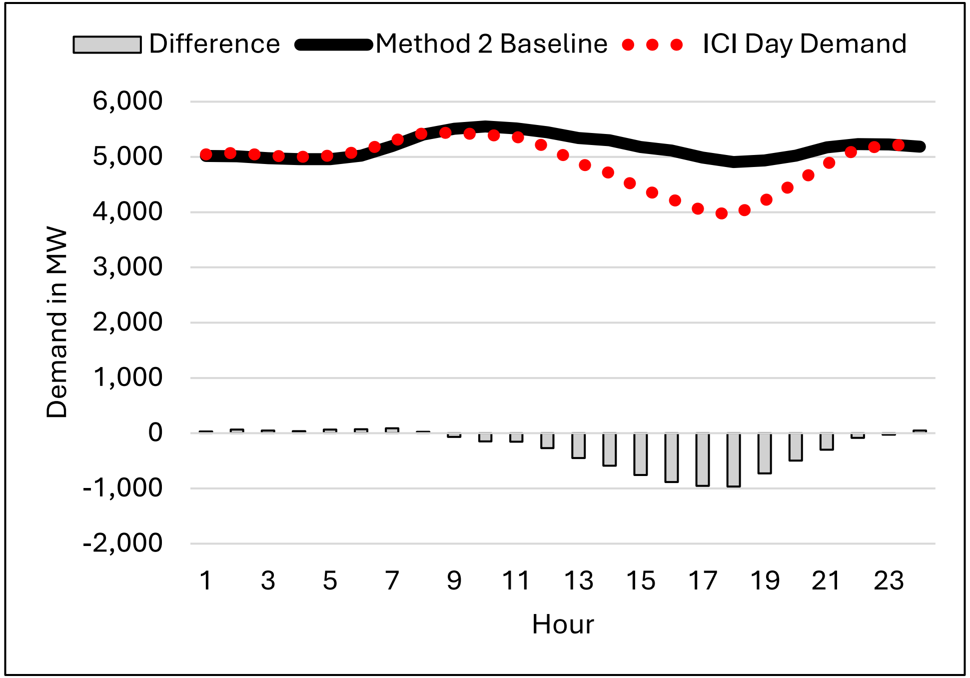
1. Continuing to generate the statistics in this paper to monitor residential and small commercial behaviour as new data becomes available

2. Work with the SME to build new datasets that will more deeply examine the observations made within this paper to further understand historical energy and demand behaviour within the residential and small commercial sectors

3. Apply the learnings from this paper on medium and large commercial as well as industrial consumer data as it becomes available within the SME's DataMart

Next Steps: Class A Demand Reduction Research

- Estimating ICI Reductions for DX and TX Class A Customers
- Prompted by a new set of hourly class A DX customer data provided by distributors to the IESO
- Presents four methods that estimate a range of potential ICI reductions for Class A customers across three ICI seasons: 2021/22; 2022/23; 2023/24



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Technical Paper 2: Large Step Loads

Shivani Nathoo, P. Eng
Planner – Planning Models and Forecasts

Large Step Loads

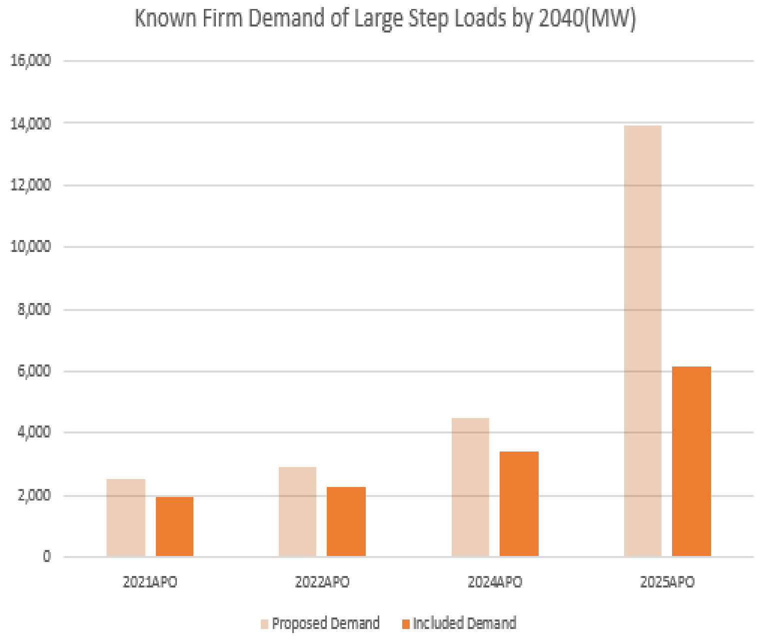
2025 APO shows significant growth due to large step loads (LSL are specific commercial and industrial sector projects that are large in nature (typically over 20 MW) and connect to the grid in large blocks)

Amount of large step loads has grown with each APO

There is significant uncertainty associated with LSL

The forecast reflects demand from large step loads assessed by the IESO for certainty, e.g., projects that are known with certainty, have been announced, or have submitted a System Impact Assessment. This demand is referred to as **"Included Demand"**

Total demand associated with all potential projects is significantly higher. **"Proposed Demand"** represents all projects IESO is aware of at time of APO finalization

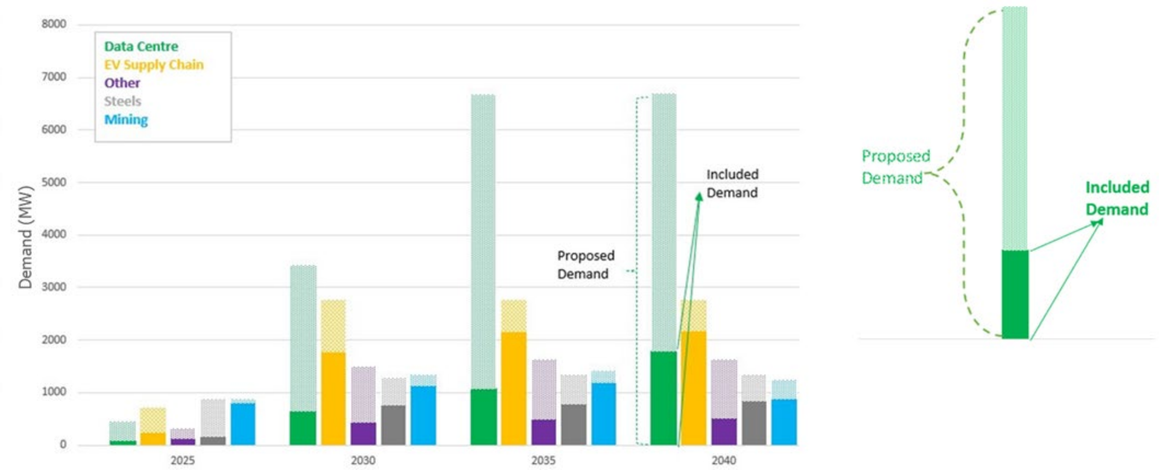


Key Sectors

Two sectors with largest forecasted electricity deman from large step loads are th data centre sector and the Electric Vehicle (EV) Supply Chain sector

Other sectors include Steels (Electric Arc Furnaces), Mining, other projects

2025 APO Large Step Load Breakdown



*'Other' includes large step loads from the following sub-sectors: Hospital, Universities & Colleges, Large Office, Food and Beverage, Chemical, Pulp & Paper Industry

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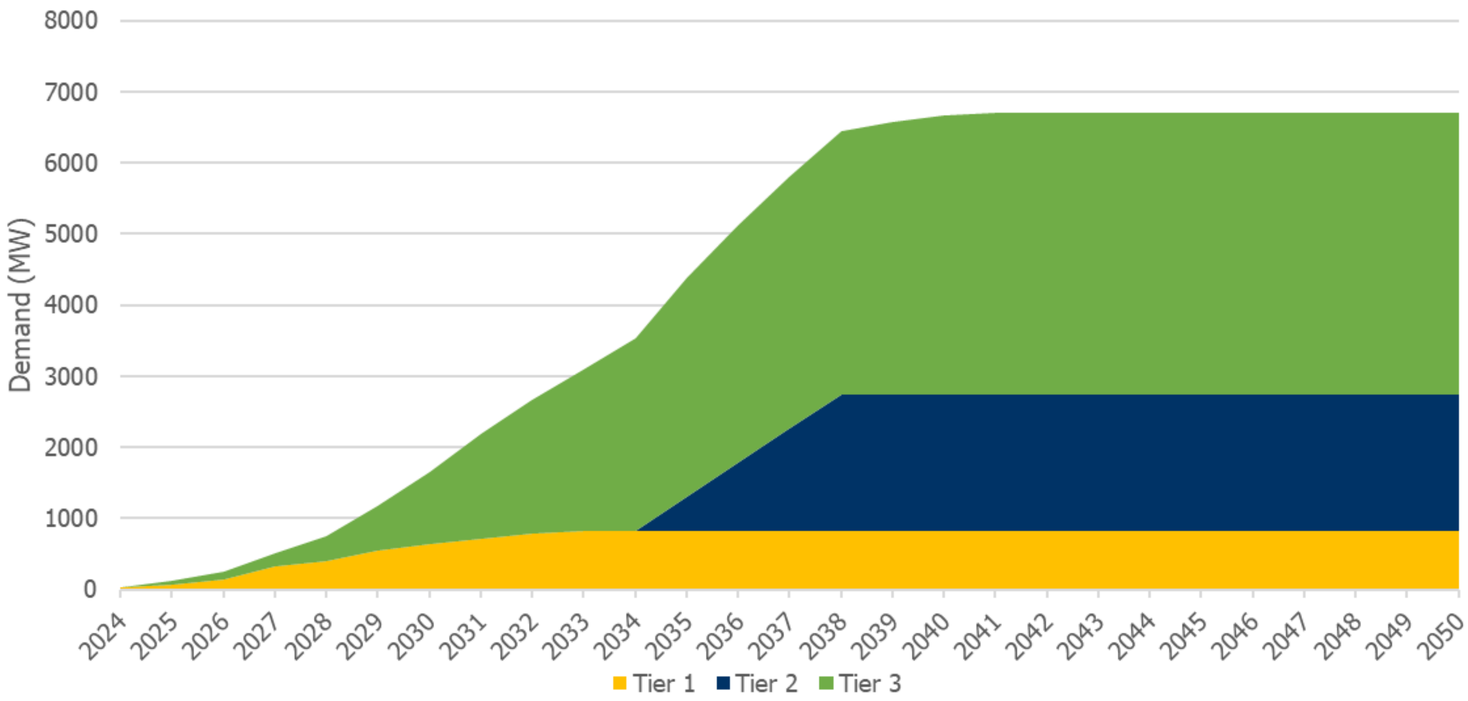
Data Centres

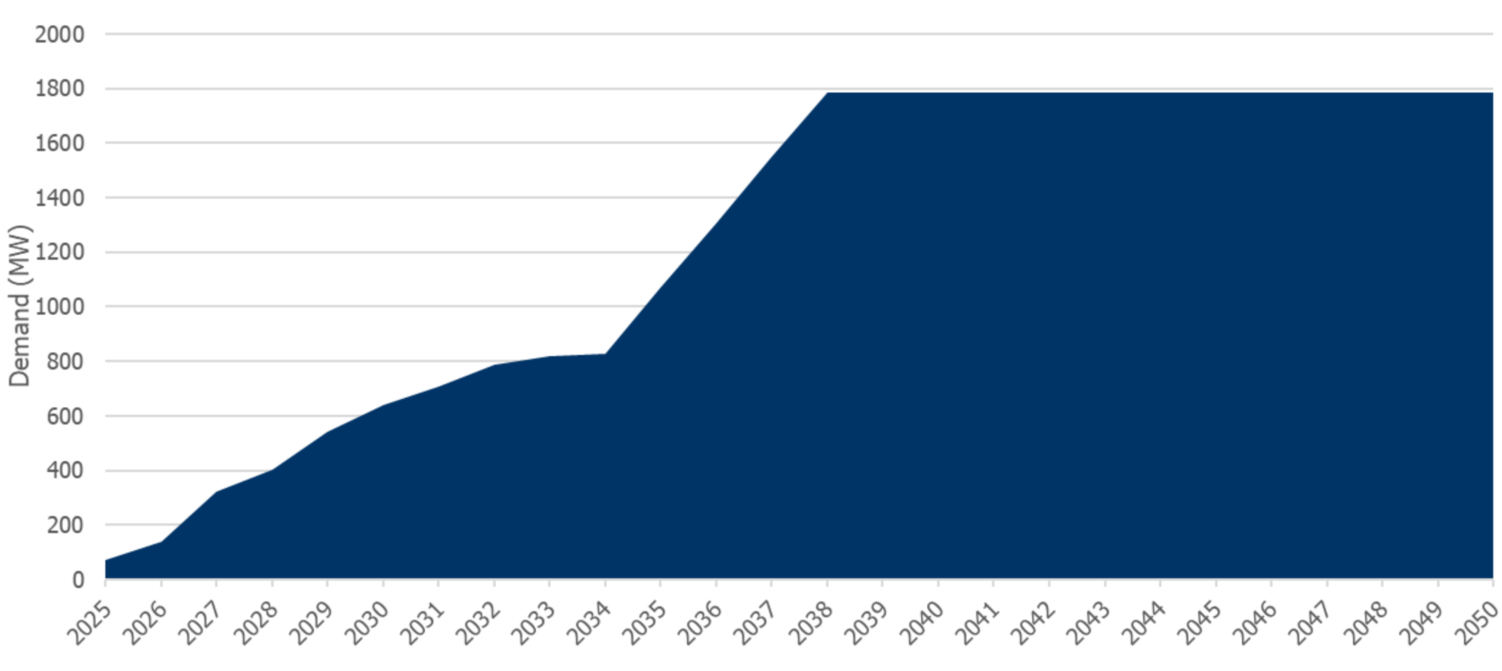
Data Centres overview

- Data centres are facilities containing networked computers used to store, process, and/or distribute information
- Increase in AI and cloud computing driving up need for data centres
- With demand outpacing supply, data centres are extremely profitable, attracting new potential data centre owners into the market
- Data centres are modular and have short construction times (shortest 3 months, typical is 12-18-month), which is faster than utility planning and connection timelines
- New data centres consume 100s of megawatts, some in 1-2 GW range
- Need to be transmission connected, potentially price insensitive
- Latency and fibre distance can be a factor, depending on type

Proposed DC Project Load in 2025 APO by Likelihood



Included DC Project Load in 2025 APO

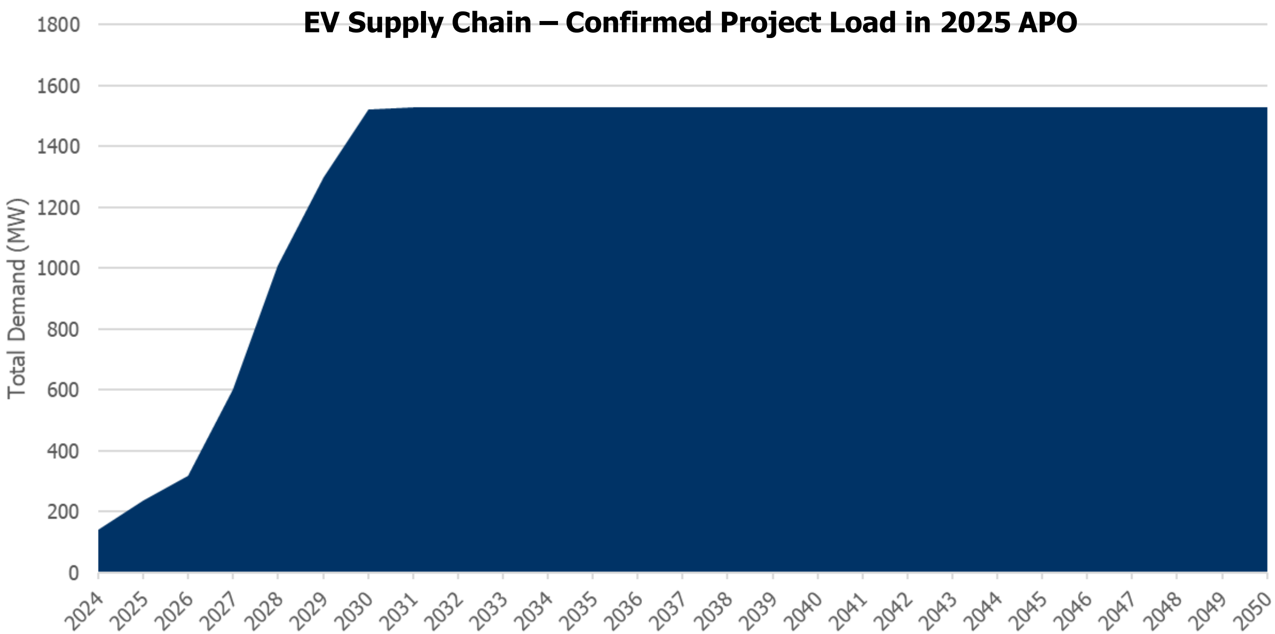


Challenges and Opportunities

- Desired project timelines are faster than typical connection process timelines
- Projects looking to connect in GTA will likely require significant reinforcements to transmission infrastructure to connect
- If data centre timelines outpace timelines for procuring and building new generation, could result in generation inadequacy
- Opportunity to install Data Centre campuses and find efficiencies in transmission connection points, heating, and cooling
- Opportunity for district heating from waste heat

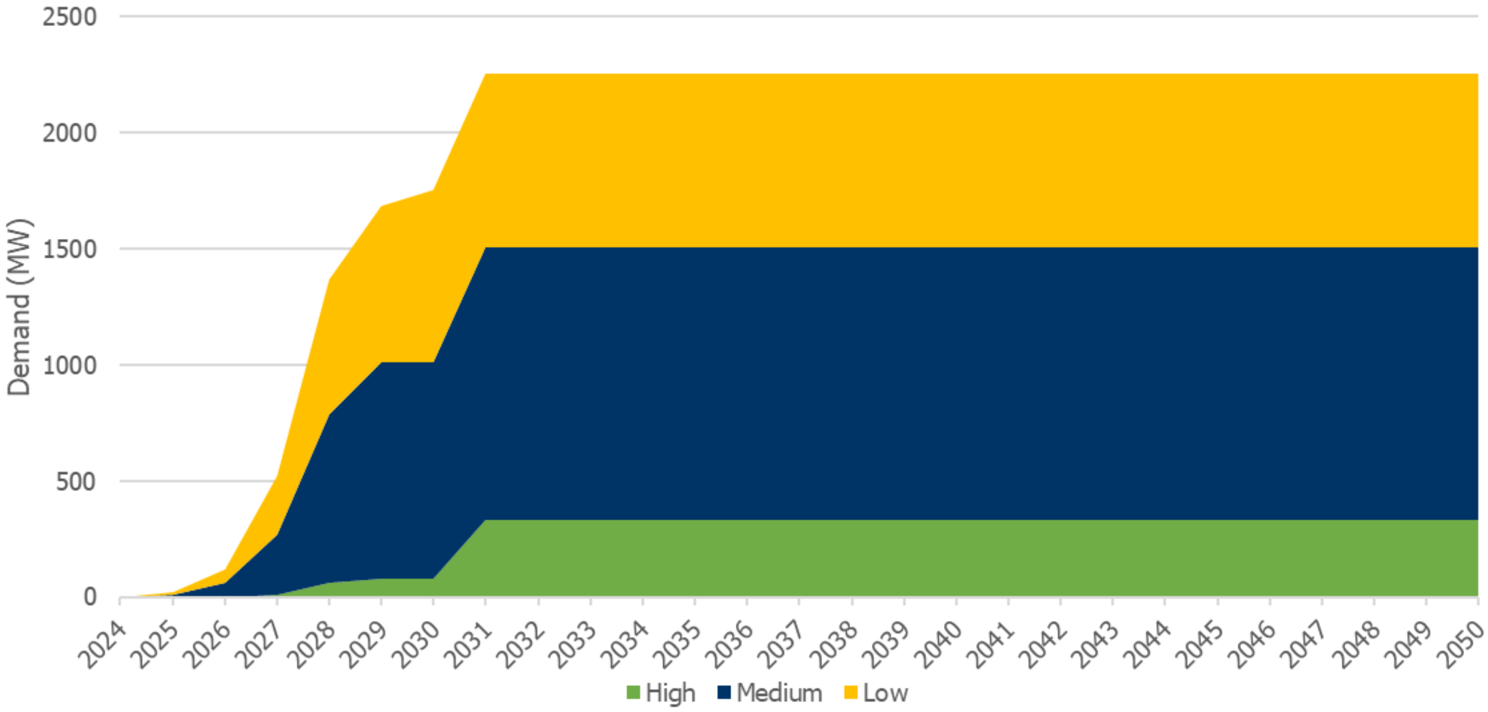
EV Supply Chain

EV supply chain overview



- The end-to-end EV and EV battery supply chain is a focus of the Ontario government as part of the Driving Prosperity Plan

Unconfirmed Proposed Project Load in 2025 APO



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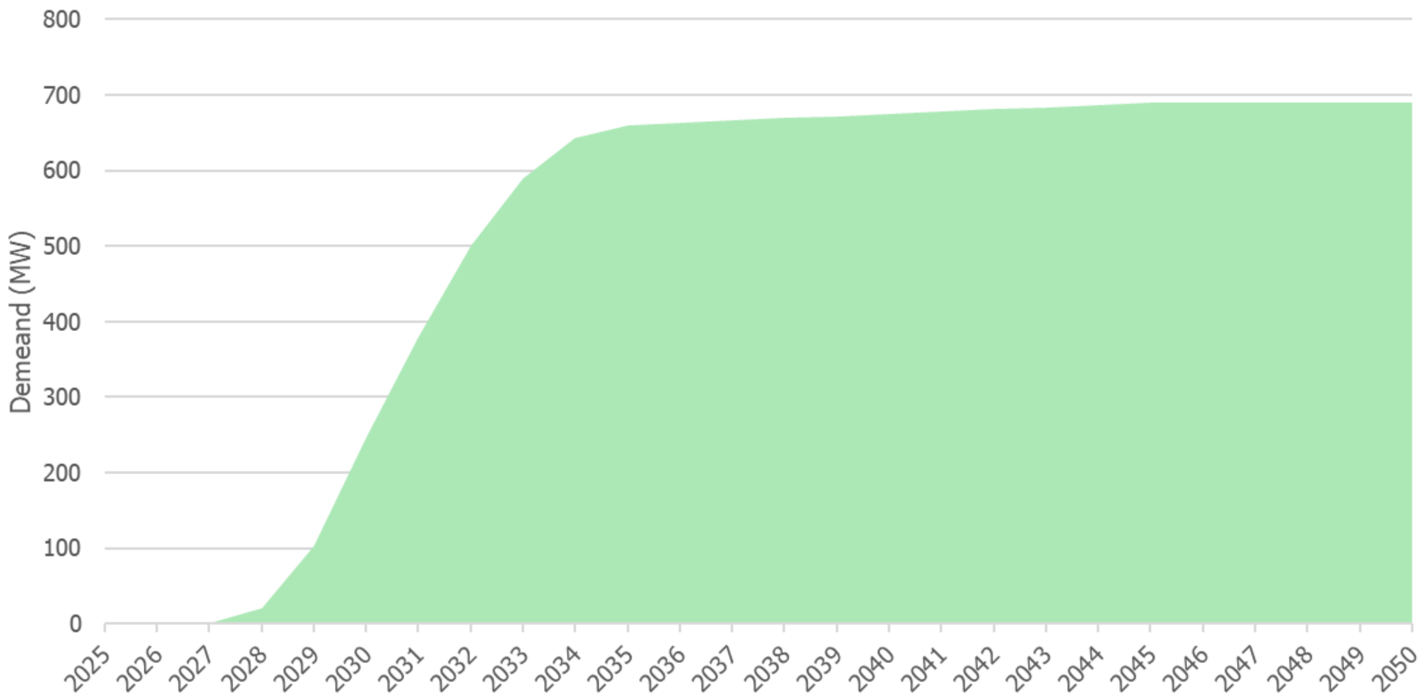
Unconfirmed Included Project Load in 2025 APO



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Uncertainties

Project Risks and Mitigations

- Market forces: if demand for the industry falls, proponents may pause or delay in-service dates. Responses to market forces will vary depending on the project
- Economic impacts: overall economic impacts such as labour shortages and supply chain issues can also result in delays or cancellation

- Increasing sector communication to monitor LSL activity
- Increased research participation on LSL (eg, EPRI, NERC, ESIG)
- Demand Growth Margin – 2026 APO will include a demand growth margin to account for uncertainty

Technical Paper 3: Insights on Space Heating Electrification and its Implication on Ontario Electricity System Planning

Keith Lam
Senior Planner – Planning Models and Forecasts

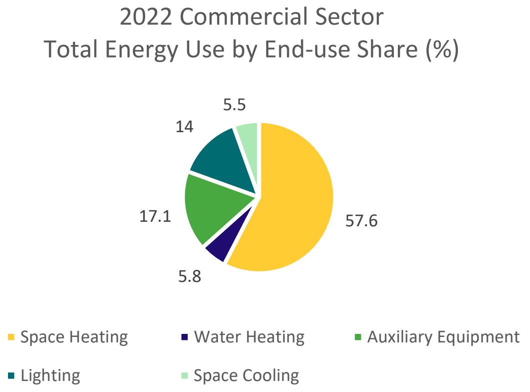
Overview

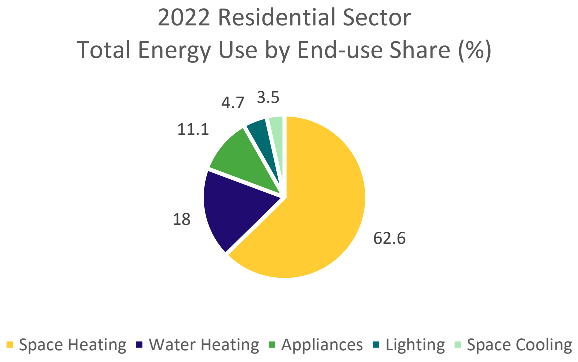
- Background and Purpose
- Space Heating Uncertainties:
  - Heat Pump Adoption
  - Variability in Heat Pump Operation
  - Unclear Replacement Path
  - Government Policies
- Conclusion

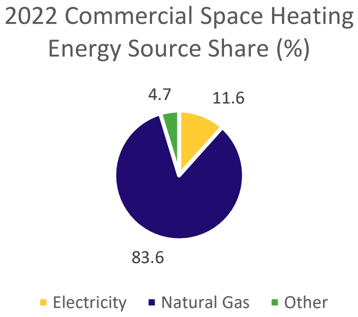
Background & Purpose - Space Heating Uncertainties

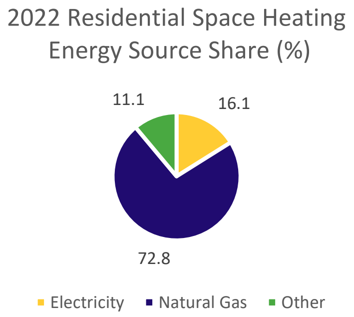
Background

- Space heating energy use ≈ 60% total energy use for residential and commercial sector
- >70% of space heating energy source = natural gas
- Electrifying this end-use will increase electricity demand leading to generation, transmission and distribution system expansion.









Background (continued)

<u>Background</u>

- Heat pumps are the main technology used for electrifying space heating.
  - More energy efficient / use less energy
  - Emit less greenhouse gas than fossil fuel heating
  - Can provide heating in winter and cooling in summer
  - Transfer heat from one source (air, water, ground) to inside home
  - May require backup heating depending unit capacity

Purpose - Space Heating Uncertainties

Purpose

- Identify factors that contribute to long-term demand forecast uncertainties from space heating electrification and how IESO plans to address them:
  1. Heat pump adoption
  2. Variability in heat pump operation
  3. Unclear replacement path
  4. Government policies

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Forecast Uncertainties – Heat Pump Adoption

For the Residential Sector

- Different values presented by Statcan vs NRCAN (addressed)
- Lack of heat pump uptake data from NRCAN's Greener Homes Program (addressed)
- Lack of data representing the breakdown of heat pump types installed (standard efficiency vs. cold climate vs. air to water vs ground source)

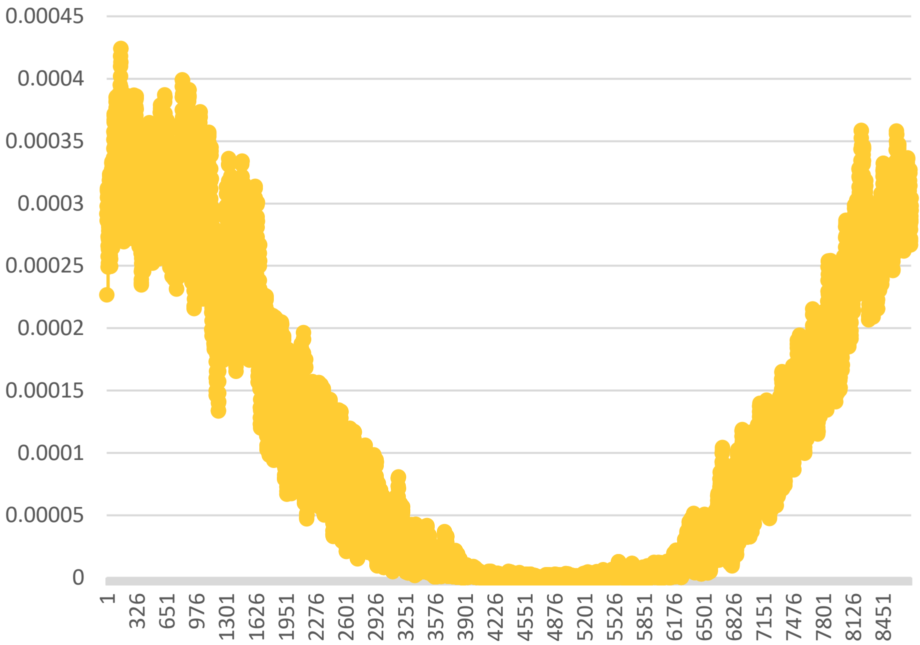
For the Commercial / Industrial Sector

- There are no publicly available data source on heat pump adoption

Forecast Uncertainties – Variability in Heat Pump Operation

Load Profiles

- Limited data available for Ontario specific heat pump load profiles
- Currently relying on American data that may be based on different temperatures, building mix, and occupancy assumptions.



Backup Heating

- Unit capacity, fuel source, controls all can affect heat pump electricity consumption.
- Currently assuming heat pump meets 100% of heating load due to limitations of forecasting tool.

Forecast Uncertainties – Replacement Path

Commercial / Industrial Sector

- For large facilities that are heated with complicated fossil fuel heating systems, there is no direct heat pump replacement that can provide the same temperature output without significant redesign of the existing heating system.

Forecast Uncertainties – Government Policies

Carbon Tax

- Consumer carbon tax has been removed and natural gas continues to remain an affordable energy source for space heating; affecting heat pump adoption.

Municipal Green Building Standards

- Bill 17 was passed, preventing municipalities’ from passing by-laws with respect to the construction of buildings. This may affect heat pump adoption in new construction facilities in both residential and commercial sectors.

Conclusion

The following steps have been taken by the IESO so address some of the electricity demand forecasting uncertainties from space heating electrification:

- New Long Term Electricity Demand Forecasting Tool
- On-going Enbridge Collaboration
- New Save on Energy Heat Pump Incentives
- New Behavioural and Pricing Studies
- Integrated Energy Plan

Technical Paper 4: Scenario Analysis of Electric Vehicle Adoption and Charging Demands

Simon Zhang
Senior Planner – Integrated Conservation Planning

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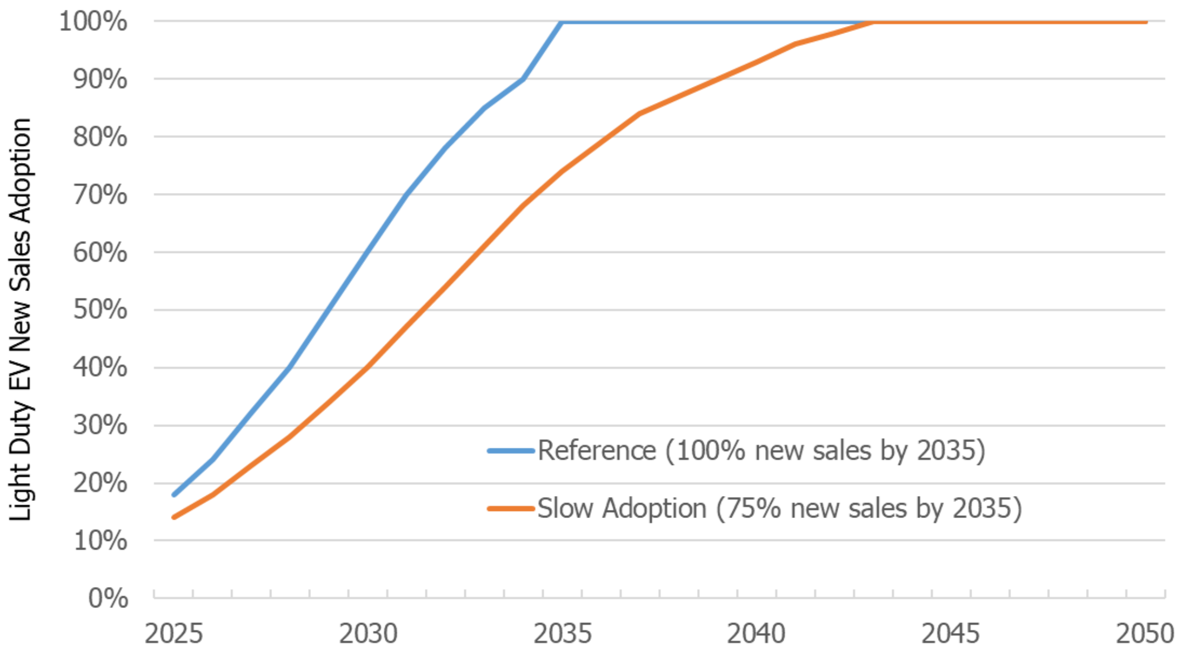
Overview

- Objective: share draft findings from report of the EV adoption technical paper
- Scenarios of adoption, quantity, energy and peak demands
  - Light duty electric vehicle (LDEV) adoption
  - Medium-heavy duty (M/HDEV) adoption
  - Charging profile
- Peak impacts of EV charging
- Conclusions

Important note

- This technical paper was developed in 2024 and analysis reflects the reference demand forecast in the 2025 Annual Planning Outlook
- Acknowledging global automotive industry and policy developments and actual Ontario EV sales trends, the IESO updated its assumptions for the 2026 Annual Planning Outlook, no longer basing the reference demand forecast on the federal *Electric Vehicle Availability Standard*
- In early September, the federal government announced that it was waiving the standard's first interim sales target (20% of new light-duty sales in 2026) and launching a review of the policy

LDEV Adoption Scenarios



- Reference forecast aligns with the government targets and is considered in the 2025 APO.
- Slow adoption forecast is informed from a consulting study.
- A variety of factors can affect EV adoption.

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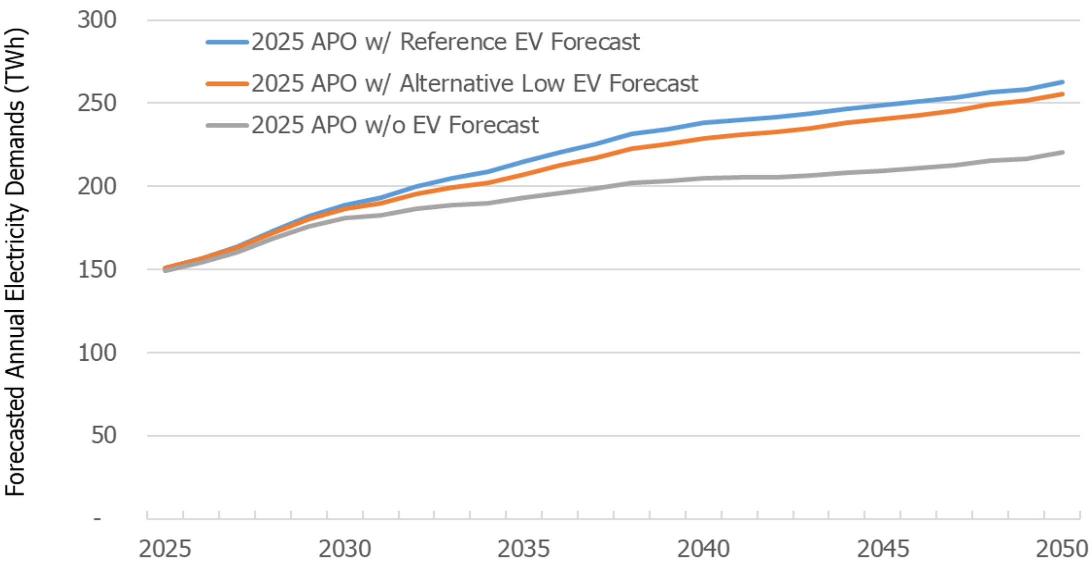
M/HDEV Adoption Scenarios

- Ambiguity in federal targets on medium and heavy duty zero emission vehicles.
- Competition between battery-, hydrogen fuel cell, biodiesel technologies.
- Low population and small impacts (3% of today's vehicles are classified as medium/heavy duty).
- The reference forecast, which is considered in the 2025 APO aligned with forecasts from other provinces.
- The alternative lower EV adoption scenario assumes that transit and school buses are the only medium/heavy duty vehicles will be powered by batteries.

Annual Energy Demand Scenario Analysis



- 2025 APO forecasts 42 TWh EV charging demand in 2050, 16% of total Ontario electricity demand in the year (263 TWh).
- Alternative scenario (slow adoption) forecasts about 9 TWh less around 2040 and 7 TWh less in 2050.

Scenarios of EV Charging Profiles

- Unmanaged charging
- Passively managed charging (e.g. electricity rates)
  - Time of use rate (TOU)
  - Ultra-low overnight rate (ULO)
- Actively managed charging (i.e. utility direct control programs)
- Charging profiles of TOU and unmanaged scenarios were derived from a real-world dataset (Geotab's *Charge the North Study*)
- ULO and managed profiles from a consulting study

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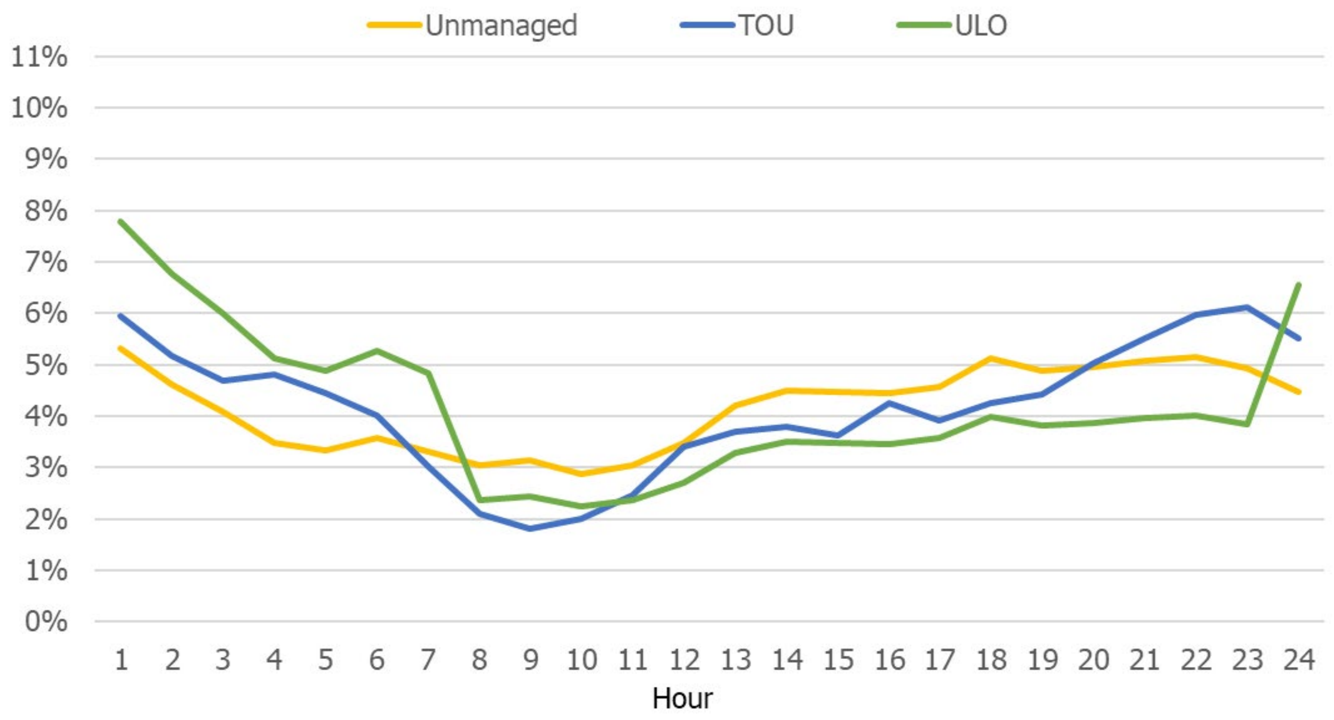
Charging Profiles – Summer



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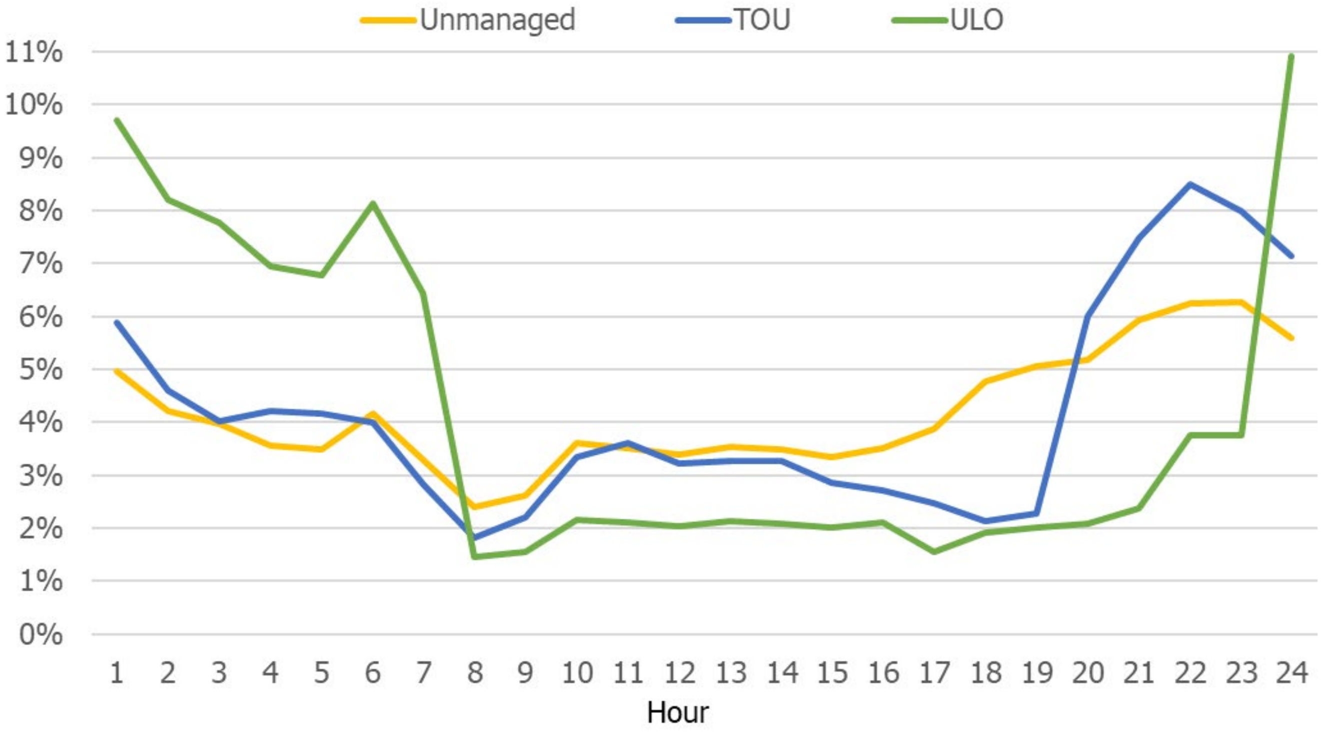
Charging Profiles – Winter



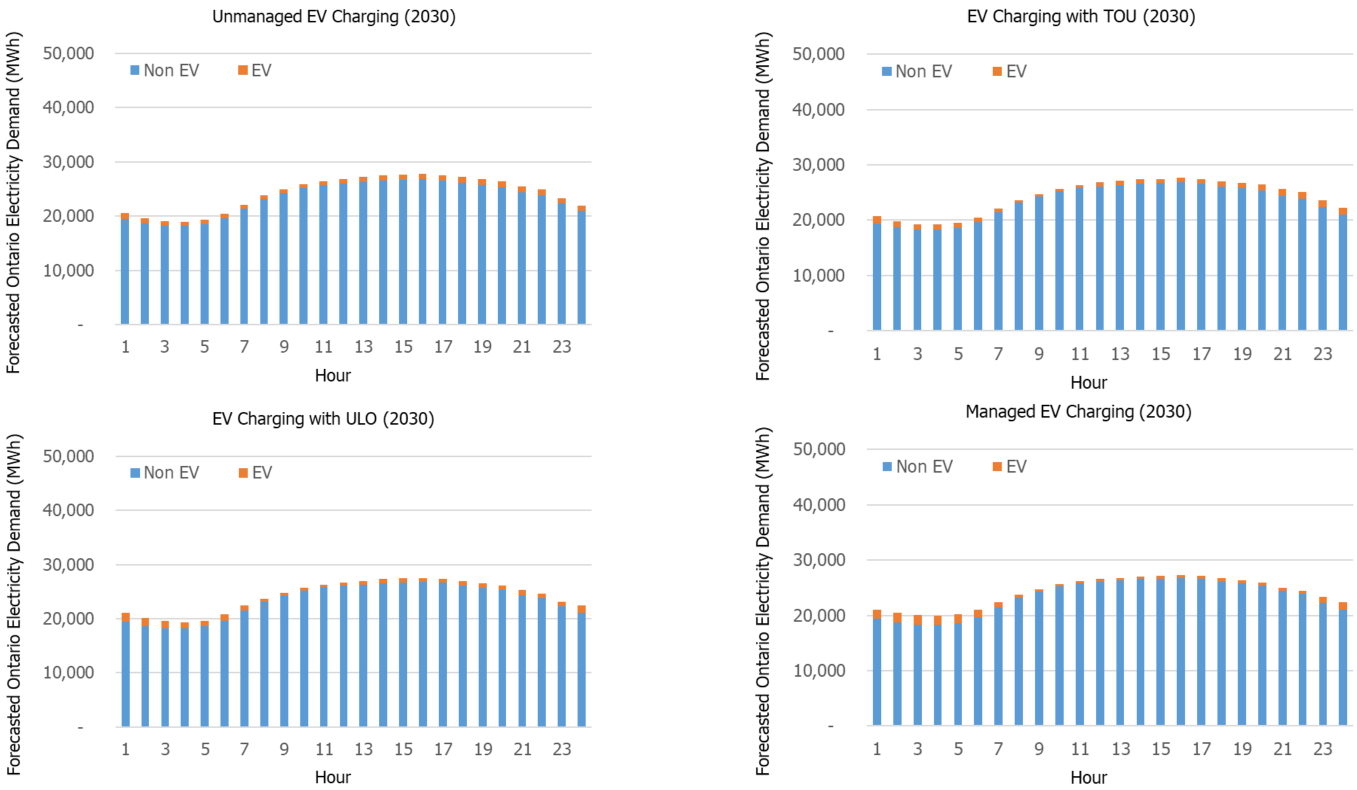
Peak Impacts of EV Charging (1/2)

- Passively managed charging uses price signals to shift charging demands for the benefits of electricity system and rate payers.
  - TOU and ULO are effective to move EV charging from high price period to low price period.
  - Fixed schedule are easy for EV owners to understand and follow.
- However, in the long-term, steep charging demand ramp up between different rate periods may result in secondary peaks and cause challenges for system operation without additional charging coordination mechanisms. The risk is exacerbated with increasing number of EVs and their charging demand profiles.

Peak Impacts of EV Charging (2/2)

- In the long-term, the broader (non-EV) system load shape is expected to evolve over time, particularly becoming flatter in the winter due to overnight heat pump and greenhouse lighting demand.
- This trend may increase the value of active managed charging

Hourly Demands – Summer Peak Day (2030)



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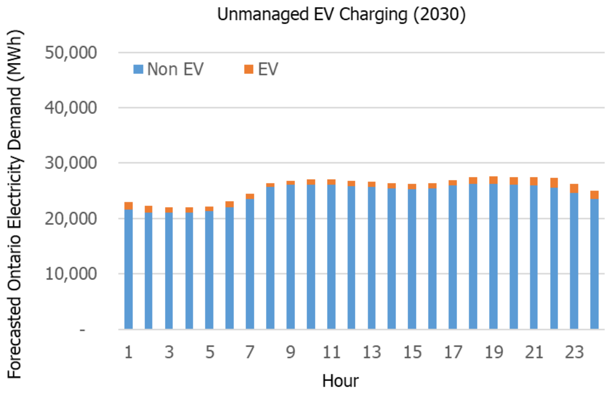
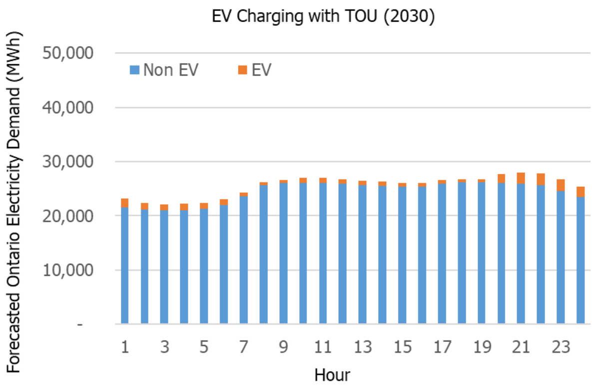
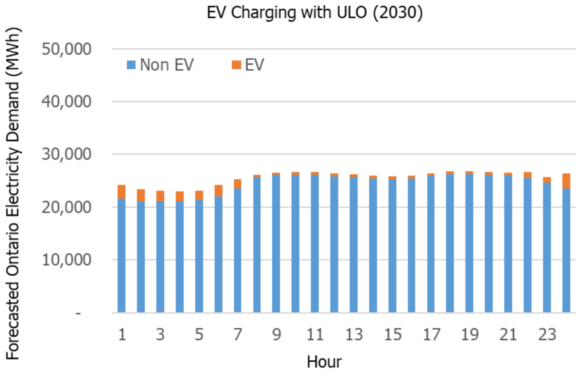
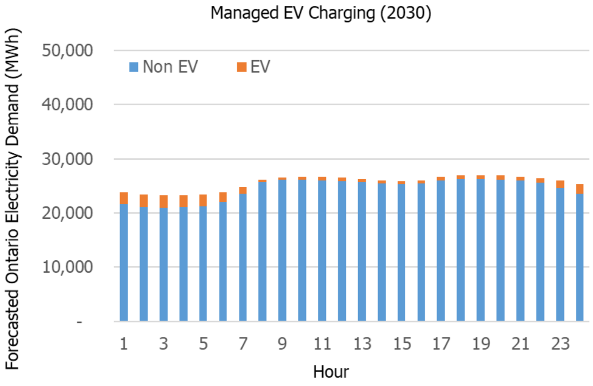
Hourly Demands – Winter Peak Day (2030)

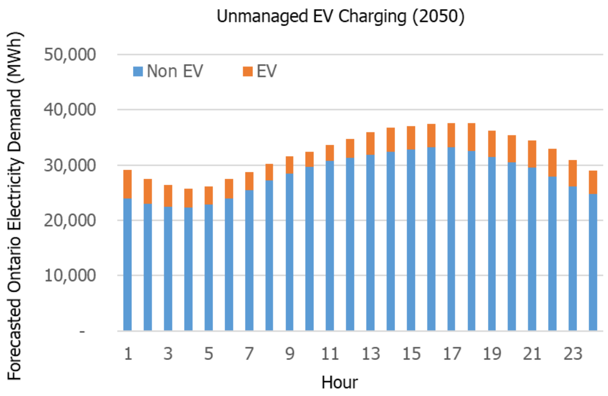


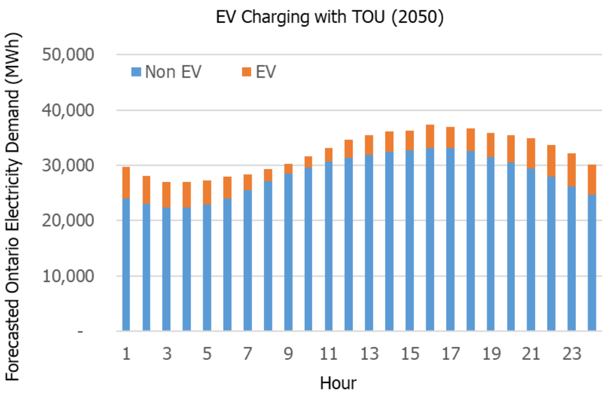


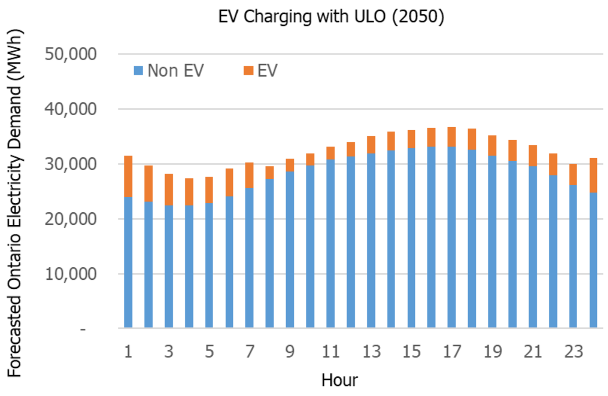


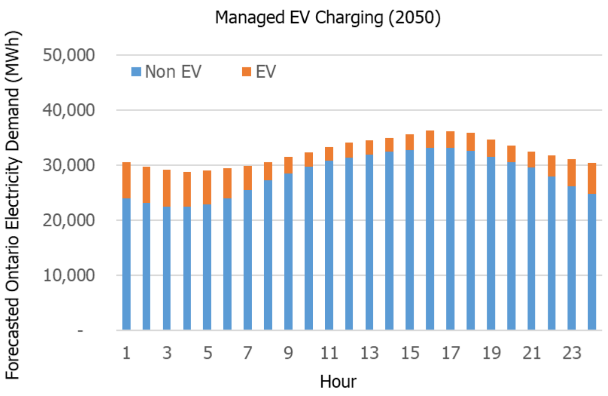


Hourly Demands – Summer Peak Day (2050)

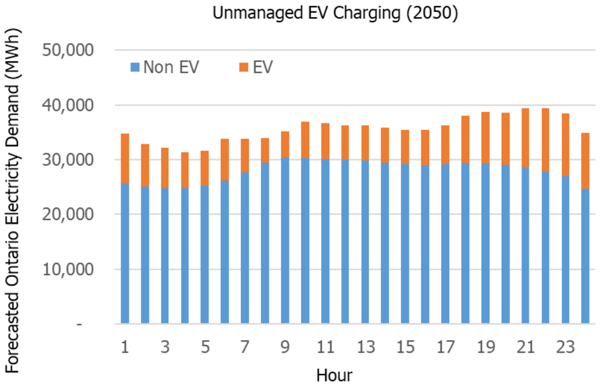


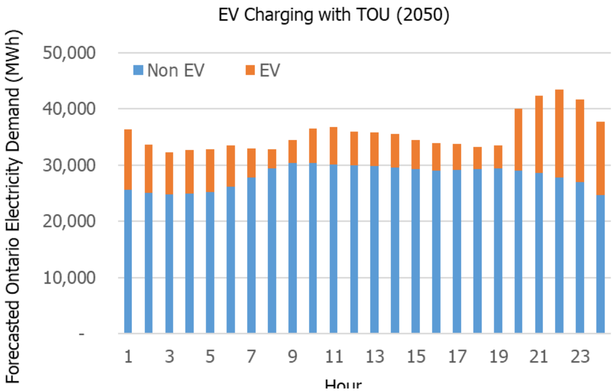


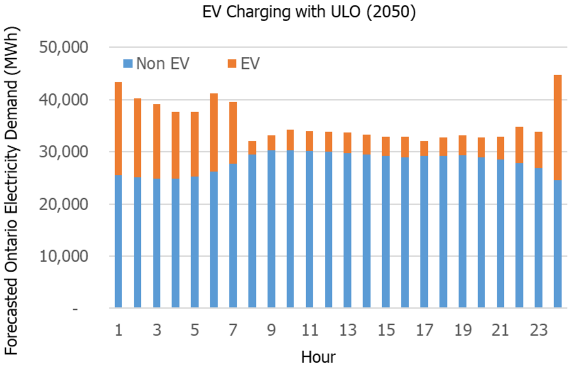


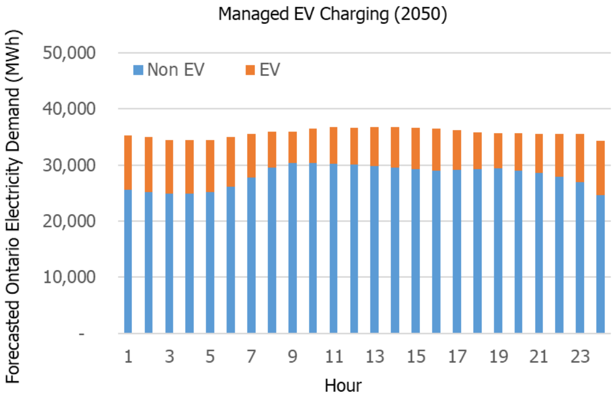


Hourly Demands – Winter Peak Day (2050)









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Conclusion and Key Findings

- Charging demand of a potential slower EV adoption scenario is forecasted to be 9 TWh less than the reference forecast around 2040 but still significant growth from today (approx. +23 TWh).
- Current TOU and ULO rates are effective tools to shift EV demands to off-peak periods. However, rate structures will likely need to be revisited to reflect evolving demand conditions to avoid prompting secondary peaks.
- Long-term, more active charging management tools are required to complement rates.
- EV charging demand remains relatively uncertain, particularly further out in the forecast period.

Next Steps

Next Steps

- All documents associated with this engagement can be found on the Technical Papers engagement page
- If you have any questions on the information shared today, please contact engagement@ieso.ca

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