IESO Demand & Conservation Planning Technical Paper: Large Step Loads

Spotlight on data centres and electric vehicle supply chain

July 2025

Connecting Today. Powering Tomorrow.

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1. Executive Summary

As the operator and planner of Ontario's electricity system, one of the Independent Electricity System Operator's main roles in the electricity sector is to plan and prepare for future needs. A significant function of this work is demand forecasting, which projects demand into the future based on available information and data. Forward-looking analyses of this nature naturally come with uncertainties, owing to anticipated developments that have not yet happened, or may not necessarily occur at all.

With electricity demand in Ontario forecast to increase by 75 per cent by 2050, the IESO anticipates growth at great speed and scale, driven in large part by electrification, and specific commercial and industrial sector development. To ensure electricity procurements and energy policy are aligned with system needs, it's crucial that the IESO enhances its understanding of the underlying factors of this growth to minimize forecast uncertainties and optimize value to the system over the long-term planning horizon.

Looking ahead, the aggregated assessment of these inherent uncertainties with new load development will inform an Ontario demand growth margin, a new forecasting measure to provide a stable growth signal for the province to manage the uncertainty over the next few years, while also providing clarity for electricity planning purposes. In the meantime, the IESO has published a series of technical research papers that examine underlying trends in specific sectors or use cases that will drive demand growth in the long term.

This technical paper looks at electricity demand from large step loads – that is, specific commercial and industrial sector projects or operations that are typically more than 20 megawatts and connect to the grid in large blocks over a short time – such as data centres and electric-vehicle supply chain facilities, and it outlines the planning considerations that contribute to uncertainty in future demand.

Based on the IESO's latest demand forecast, significant growth is expected from large step loads as they connect or seek connections to the grid by 2040. However, as the paper notes, there is forecasting uncertainty around the timing, size and location of the load growth due in part to shifting market forces, geopolitical conditions, and other uncertainties which the IESO will continue to study and monitor to inform future demand growth margins.

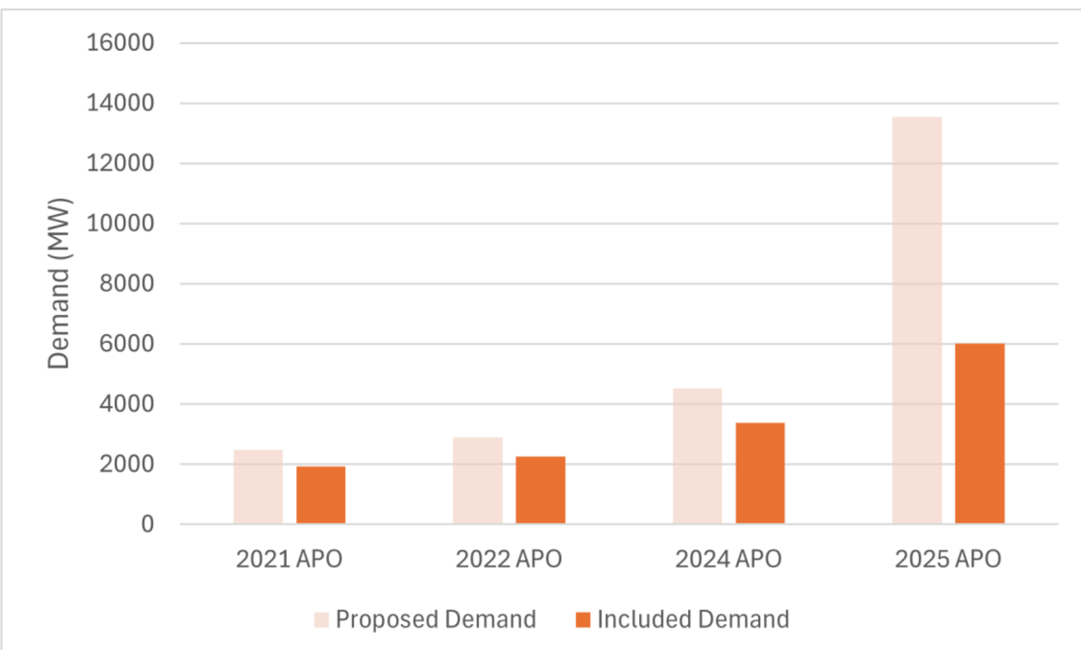
2. Introduction

2.1 Large Step Loads

The 2025 APO Demand forecast shows significant growth due to "large step loads", which are specific commercial and industrial sector projects that are large in nature (typically over 20 MW) and connect to the grid in large blocks, as opposed to slowly ramping up their growth over time.

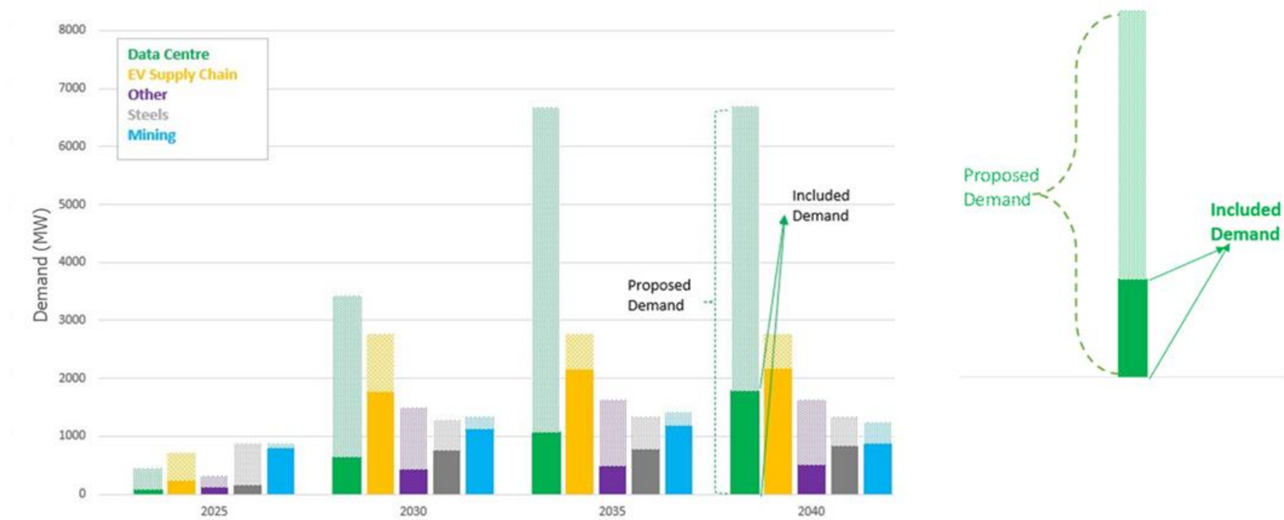
The number of known large step loads has increased over time, reflecting economic development and sector specific growth. The forecast reflects demand from large step loads assessed by the IESO for certainty, e.g., projects for which there is a higher degree of confidence that they will materialize, informed by the connections process, regional planning or other sources, or projects that have been announced publicly. This demand is referred to as "Included Demand" in the chart below. Total demand associated with all potential projects is significantly higher. In the chart, "Proposed Demand" represents all demand submitted via different channels, such as MEDJCT or Hydro One, regardless of the likelihood of development.

Figure 1 | Known New Step Loads



While large step loads are present in many sectors, as shown in the graph below, two of the sectors that currently have the current largest forecasted electricity demand from large step loads are the data centre sector and the Electric Vehicle (EV) Supply Chain sector. This paper explores these two sectors, their drivers, and the uncertainty related to their growth.

Figure 2 | Large Step Loads Demand by Sector - Evolution



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

3. Data Centres

3.1 Background

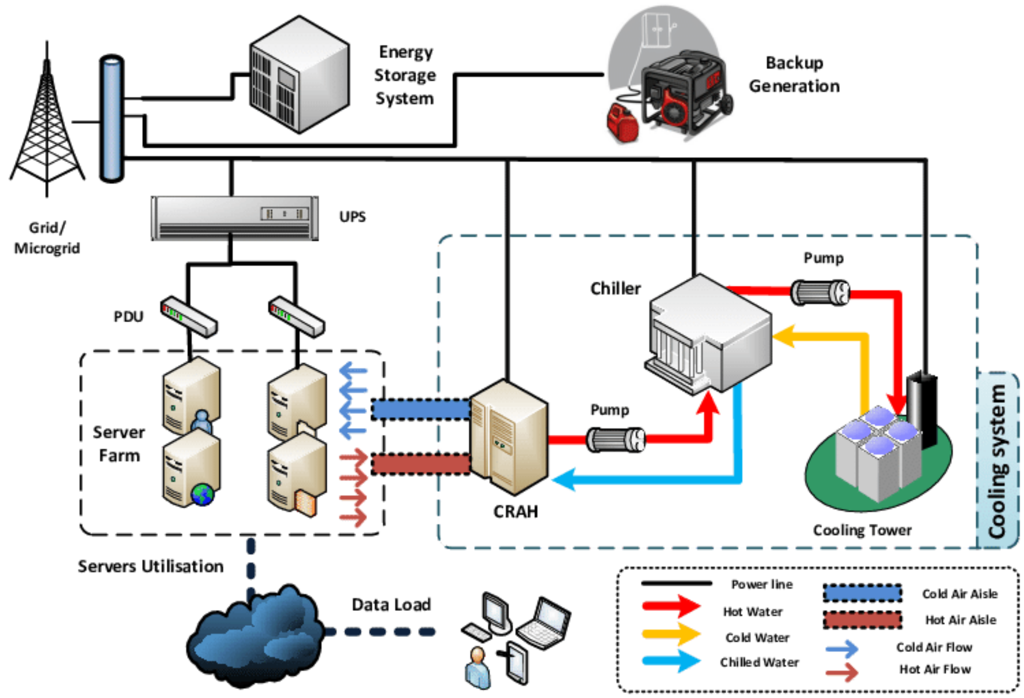
Data centres are facilities containing networked computers used to store, process, and/or distribute information. Due to the increase in artificial intelligence and cloud computing, there is currently a high need for data centres which exceeds the number of data centres presently built. With demand outpacing supply, data centres are extremely profitable, attracting new potential data centre owners into the market.

There are multiple different types of data centres, including Enterprise, Colocation and Hyperscale data centres[1]. Enterprise data centres are data centres dedicated to large cloud providers, which include Amazon, Google, and Microsoft. Colocation data centres are data centres where the owner leases server space to multiple businesses, known as offtakers. Most colocation data centres will not look to connect to the grid until they have a third of their server space allocated to offtakers, to ensure project viability. Typically, colocation data centres will begin operations under their rated capacity and take a few years to scale up to full operation. Hyperscale data centres are any data centres which contain at least 5,000 server racks and 10,000 square feet of floor space.

Components of a typical data centre include a server farm, power supply equipment, backup generation, an energy storage system, a heat and air flow system, a cooling system, and control and security systems[2]. Due to the modular nature of data centres, they tend to have short construction times (as low as 3 months[3], but typically falling within the 12–18-month timeframe[4]), and are able to scale their server spaces as need increases. This timeframe may be extended due to project delays. Today project delays are commonly caused by rising costs, labour shortages, power limitations[5], and supply chain issues[6].

1 What is a data center?
2 A Complete Model for Modular Simulation of Data Centre Power Load
3 How long does it take to build a data center? - Green Mountain Data Center
4 Speed-to-Market: Data Center Design & Construction | STACK
5 High Demand, Power Availability Delays Lead to Record Data Center Construction | CBRE
6 Five Key Causes of Delay in Data Centre Projects | FTI

Figure 3 | Components of a typical data centre[2]



According to Rahmani et al. (2017), data centre load is primarily consumed by servers, chiller plants, and the CRAH (computer room air handler) [2]. These systems take up 43%, 28%, and 12% of peak power respectively. Smaller portions of peak load are consumed by pumps at 4% and miscellaneous power at 6%. At peak, approximately 44% of peak power is consumed by the cooling system and 43% by the server farms. However, from an energy standpoint, servers take up a larger percentage of annual energy at 55% compared to the cooling system at 31%.

Specific data centre load shapes depend on the workload. Data centres that primarily serve businesses peak between 4 PM and 8 PM, while data centres that have a large AI training workload are often 'baseload'[7]. Note that the former typically refers to colocation data centres, while the latter can refer to all three types of data centres.

Ontario is currently home to 104 data centres, the most out of all the provinces[8]. As of September 2023, Toronto alone was home to 293 MW of data centres[9]. The data centres that are operational in Ontario today are smaller and connected to the distribution grid, with the majority around 10 MW or less, and the largest around 50 MW.

3.2 Recent Trends in Data Centre Sector

As mentioned above, the advancement and adoption of AI and cloud computing are resulting in a need for new data centres. These AI and cloud computing data centres tend to be larger, and use

[7] Load Growth is Here to Stay, but are Data Centers?
[8] DataCenterMap
[9] Toronto: North America Data Center Trends H1 2023

significantly more power than current data centres. Instead of only consuming 10-50MW, these data centres tend to consume 100s of megawatts, up to a gigawatt. The larger power demands require these data centres to be transmission connected. Despite being transmission connected, due to the consistent and flat nature of their operations, data centre loads will likely be price insensitive to things like the Industrial Conservation Initiative (ICI). However, there is currently work ongoing to determine the extent of data centre load flexibility, including EPRI's DCFlex initiative.

The increase in data centre demand is materializing in both colocation and enterprise data centres. While colocation data centres previously took time to ramp up to full production, demand for server space is currently outpacing supply, and thus colocation server space is getting leased faster and reaching capacity sooner than before. As a result, more parties are looking to start colocation data centres and offer their services to the markets. In key American markets such as Northern Virginia and Dallas-Ft. Worth, vacancy rates[10] have dropped precipitously despite 18% and 43% increases in inventory[11]. Overall, the North American market increased by 24.4% with most markets decreasing in vacancy rates. Toronto added 43.1 MW of colocation data centres in 2023[12], compared to 8 – 10 MW added yearly before 2019[13]. This represents a ~19.3% increase in supply while vacancy for colocation centres dropped from 17.2% to 11.1%[14].

With companies such as Google, Microsoft, Meta, and Amazon developing AI models, and the increase in cloud-based computing by these and other companies, the need for large enterprise data centres has also increased. The high power consumption per AI request and higher AI usage are both contributing to this need, with models such as ChatGPT, Bloom, and Google's AI powered search engine using ~4.92 watt-hour per request[15], and the number of AI tool users doubling between 2020 – 2023 to more than 250 million[16]. Cloud computing is also on the rise, contributing to a need for more server space. According to Statistica[17], in 2022 60% of corporate data was stored in the cloud, up from 30% in 2015. 96% of companies are currently using the public cloud while 84% of companies are using the private cloud[18]. With AI and cloud computing becoming so widely adopted, the IEA projects that data centre usage globally will double to over 800 TWh in 2026 compared to 2022[19].

As more data centres look to connect, they are reaching out to utilities across North America to determine the best location for their projects. According to a study done by the Electric Power Research Institute which surveyed 25 North American utilities, 60% of utilities have seen connection requests from data centres 500 – 1000 MW in size, while 48% have seen connection requests from facilities over 1000 MW large. 84% of utilities surveyed have seen 20% of their current peak load in new data centres connection requests, with a further 23% seeing up to 100% or more of their current peak load in data centre connection requests. In terms of forecasted demand, almost half of

10 'vacancy rates' refer to the available server space across colocation centres

11 Global Data Center Trends 2024

12 Toronto: North America Data Center Trends H2 2023

13 Toronto Data Center Market

14 Toronto: North America Data Center Trends H1 2024

15 Analyzing Artificial Intelligence and Data Center Energy Consumption

16 Number of AI tool users: 2020 - 2030

17 Share of corporate data stored in the cloud

18 Cloud Computing Statistics for 2024

19 Big tech's great AI power grab

the 25 utilities are projecting that 10% or more of their five-year forecasted peak will come from data centre load, more than double the number of utilities that see this load contribution today[20].

3.3 Ontario's Advantage

Data centre providers are increasingly interested in connecting to a clean grid, especially as consumers pressure tech companies to reduce their carbon footprint. As of 2021[21], carbon intensity per computing workload for hyperscale, enterprise, and colocation data centers were 0.44, 0.45, and 0.42-tons CO2-eq/MWh respectively, in comparison to Ontario's electricity grid which had a carbon intensity of 0.0385 CO2-eq/MWh in 2022[22]. Ontario also has a robust fibre network, which makes it an ideal home for data centres requiring fast connection speeds.

Federally, the Canadian government was the first country to develop an AI strategy, back in 2017[23]. Since then, the government has announced $2.4 billion in funding for AI, with $2 billion earmarked for infrastructure to attract data centres[24]. Some data privacy laws also dictate that data has to be housed in Canada[25], and driving companies to look at Ontario and Quebec to house their data.

Between the two, Ontario has an edge with Toronto named the AI hub of Canada due to a number of factors[26], including: the opening of the Vector Institute, an AI research nonprofit, AI research hubs at local universities, and access to VC funding and the New York and Chicago markets. The strong presence of tech giants like Microsoft, Google, Samsung, and Nvidia, is also driving interest in the province.

3.4 Siting Considerations

Siting considerations differ based on the type of data center being developed. Cloud computing data centers need fibre optics or an extremely fast connection and therefore typically site themselves within a certain distance from a main fibre hub. Gaming data centres are also required to be within this distance. In some cases, siting near users of the service is also beneficial.

For AI applications, the user interface must be within a certain distance from a fibre hub for fast user experience, but the learning models can be located farther. With learning models, the processing is done on site and the answer is transported back to the user. Therefore, they can be located anywhere in Ontario. The Ontario market is leaning towards AI data centres because there are fewer constraints.

Outside of those constraints, the existing fibre network routes are not an issue, as many companies will expand off of them and build their own.

With tech companies' desire to procure exclusively carbon-free energy, and constraints on how quickly projects can connect to the grid, there is growing interest for on-site generation to

20 Utility Experiences and Trends Regarding Data Centers
21 Environmental footprint of data centers in the United States
22 Ontario Energy Profile
23 Canada's AI Policy: Leading the way in ethics, innovation, and talent - Oxford Insights
24 Highlights from Budget 2024 - blog post
25 Canadian Data Residency Requirements: A few more thoughts on a tricky subject | IAPP
26 How Toronto Is Competing to Become a Global AI Destination - Bloomberg

supplement or replace grid connection. Amazon has already signed an agreement with utilities Energy Northwest and Dominion Energy to enable the development of SMRs[27]. Likewise, Google has signed an agreement with Kairos Power to purchase at least 6 SMRs[28]. Microsoft has made similar moves – in September, they signed a deal with Constellation Energy to restart a unit at the Three Mile Island nuclear plant in Pennsylvania[29]. Outside of nuclear Power Purchase Agreements, Microsoft also signed the largest corporate clean-energy Power Purchase Agreement with Brookfield Assessment Management for over 10.5 GW of renewables[30]. Amazon and Meta are also active in corporate Power Purchase Agreements, signing 8.8 GW and 3.1 GW of agreements globally in 2023[31].

3.5 Planning Considerations

3.5.1 Challenges for Timely Connections

As discussed earlier, until recently data centres in Ontario have been distribution connected; the largest of which consumes approximately 50MW of demand. The IESO has now been receiving connection requests for up to 750 MW on a single connection point with very quick implementation timelines. The size and the speed at which these data centres want to connect highlights the importance of ensuring the system is prepared to meet demand. Electricity demand in the GTA is forecasted to put pressure on the capability of the bulk transmission system in the next 10 years due to other drivers like population, economic growth and electrification. Therefore, projects looking to connect in the GTA will likely require significant reinforcements to the transmission infrastructure to connect. This will be explored as part of the South and Central Bulk Study and applicable regional plans.

Ensuring sufficient supply to meet demand will become particularly critical if multiple data centre companies put in requests with short timelines, especially if the data centre timelines outpace the timelines for procuring and building new generation.

3.5.2 Data Centre Forecast as of 2025 APO

A number of prospective data centre operators have reached out to the IESO and its sector partners within the last year, seeking to connect to the Ontario grid. These projects are in various stages of development, ranging from project owners who have purchased land, drawn up specifications, and are seeking grid connection, to other proponents seeking general information on how to connect in Ontario.

As mentioned above, many companies are looking to connect within areas of the province which require transmission reinforcements, which can impact project timelines and viability.

Projects were categorized into multiple tiers based on information from proponents and sector partners, including but not limited to: current project development stage, transmission constraints, and project timelines. The graph below shows the full load levels of all of the proposed projects that

27 Amazon signs SMR agreements

28 Google to buy nuclear power for AI datacentres

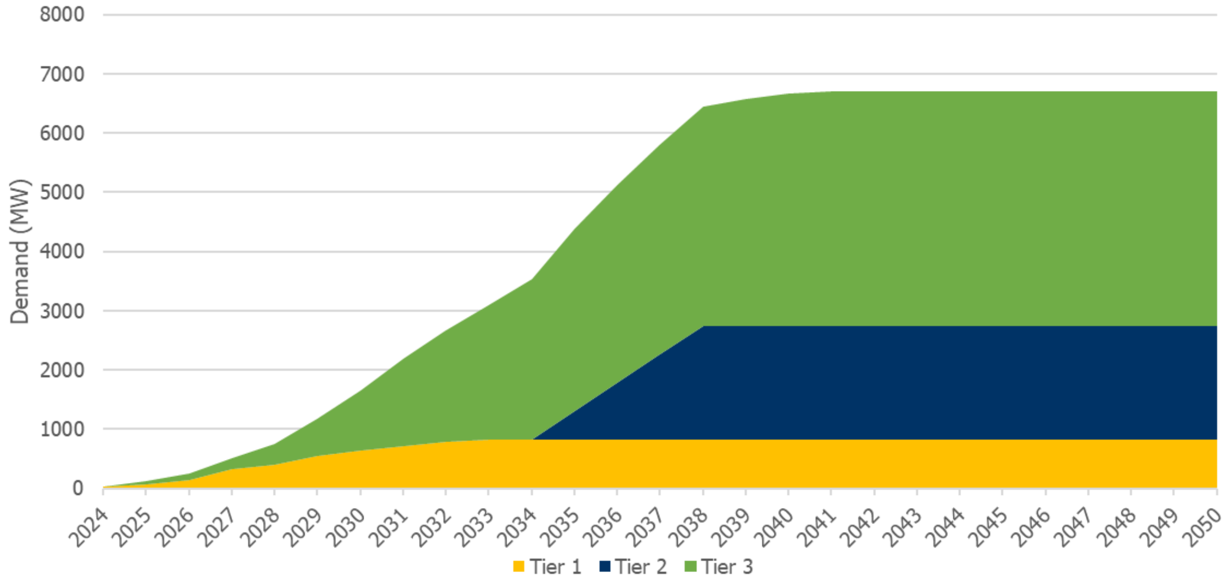
29 Microsoft deal restarts Three Mile Island restart

30 Brookfield and Microsoft Collaborating to Deliver over 10.5 GW of Renewables

31 Corporate PPAs hit record high in 2023

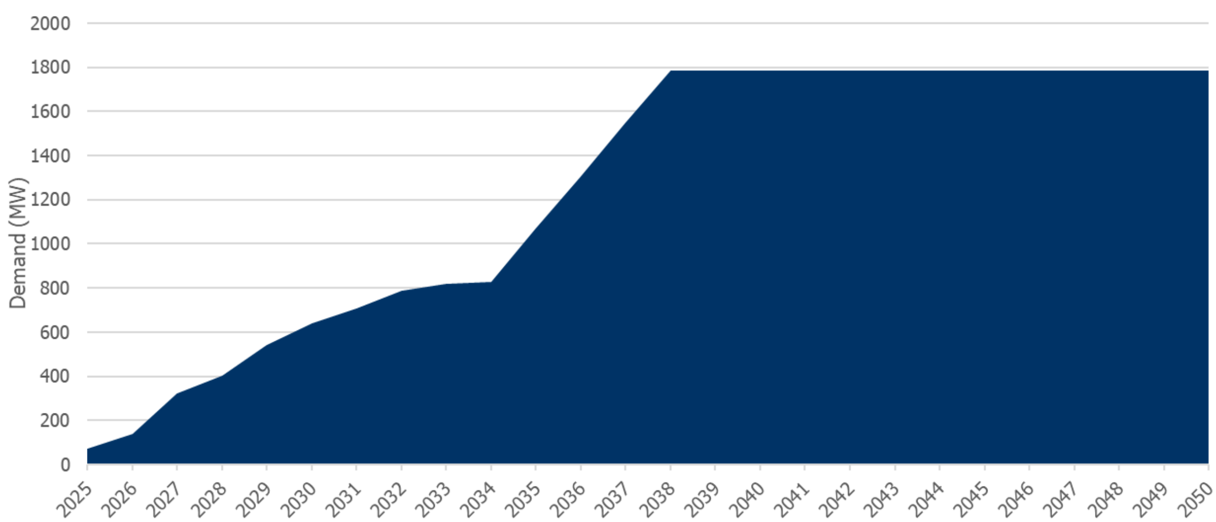
the IESO was aware of at the time of the 2025 APO forecast development, categorized by tiers. Tier 1 represents confirmed load. Tier 2 and Tier 3 represent loads that are more uncertain.

Figure 4 | Data Centres – Proposed Project Load in 2025 APO by Likelihood



The tiered system was then used to determine a "likelihood factor" for the loads. The resulting data centre load that is included in the 2025 APO is shown below. All of tier 1 and a percentage of tier 2 and 3 were included.

Figure 5 | Data Centres – Included Project Load in 2025 APO



The graphs above include data centre projects that IESO is aware of based on information from distributors, transmitters, and internal IESO processes. However, this list continues to be updated on a regular basis as new projects seek to connect. While there are a finite number of sites that are suitable for certain data centre types due to their fibre requirements and their size, there are fewer restrictions on other data centre types, which can make predicting where data centre growth will occur very challenging. Additionally, the size of the data centres and the ramp rate of the data centres can vary drastically. Ultimately, the load characteristics will depend on what projects land and where they land. It can be very difficult to account for the sector's load until projects are committed, and as a result there is a large amount of uncertainty regarding the timing, magnitude, and location of the load growth in the data centre sector.

3.6 Opportunities

While there may be many challenges associated with connecting data centres to the grid, there are also a lot of opportunities that arise due to these new loads. For example, in Japan, many data centres have been built as campuses, with multiple buildings at the same site[32] [33] [34] , which allows for efficiencies in terms of transmission connection points and other services such as heating and cooling.

With data centres producing a lot of waste heat, there is also an opportunity to utilize that waste heat for district energy, as is currently being done in Dublin, Ireland, Denmark, Sweden, and the Netherlands. As more residential and commercial buildings look to electrify their heating, and as district energy networks across Ontario begin to expand [35] [36], using waste heat from data centres is an energy efficient way to meet increased heating demand and is a demand side management opportunity that will continue to be explored in Ontario.

32 Ada Starts Work on Second Building at Tokyo Data Centre Campus - Mingtiandi

33 ST Telemedia Global Data Centres Commences Construction for Second Data Centre at Goodman Business Park in Tokyo | STT GDC (sttelemediagdc.com)

34 Goodman's digital infrastructure offering powers ahead with data centre expansion in Asia

35 District Energy system at Lakeview Village could inch Peel closer to critical climate targets

36 Markham District Energy expanding world's largest wastewater-to-energy project

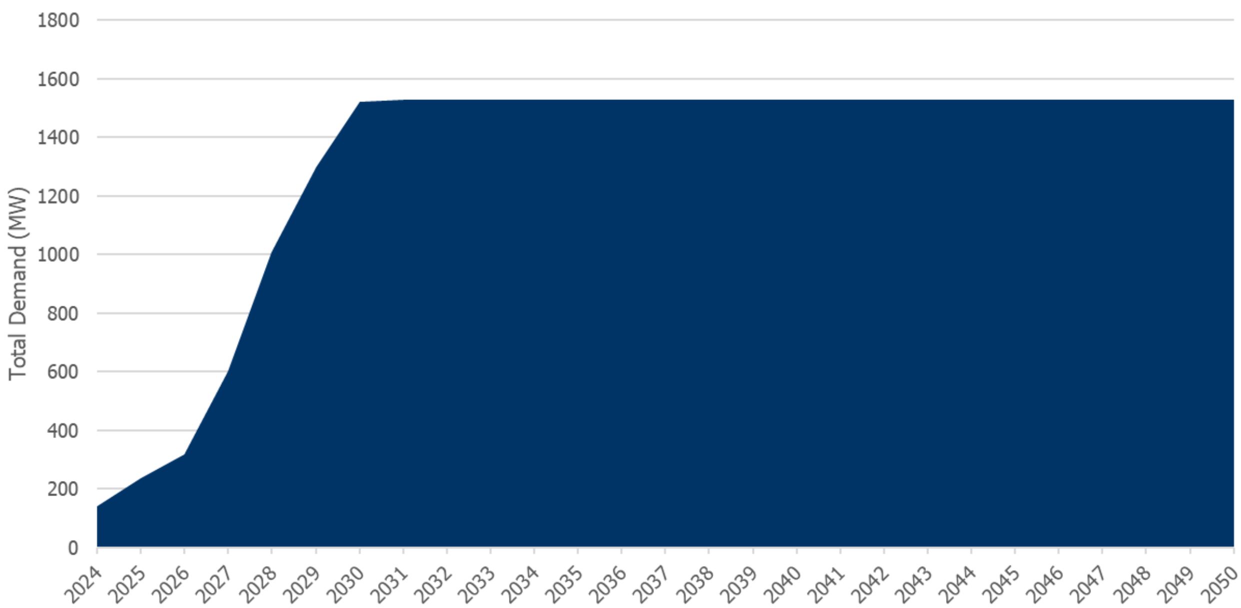
4. EV Supply Chain Projects

4.1 Current State and Committed Projects

The end-to-end EV and EV battery supply chain has been a focus of the Ontario government as part of the Driving Prosperity Plan, with the government supporting siting of the projects through the Ministry of Economic Development, Job Creation and Trade, and providing grants and subsidies to the sector through Invest Ontario [37] [38].

At the time of the 2025 APO forecast development, 6 EV Supply chain projects have had committed to operating in Ontario [39]. These projects are expected to come online between 2025 and 2027 and be 1530 MW of load once they're fully ramped up in 2030.

Figure 6 | EV Supply Chain – Confirmed Project Load in 2025 APO

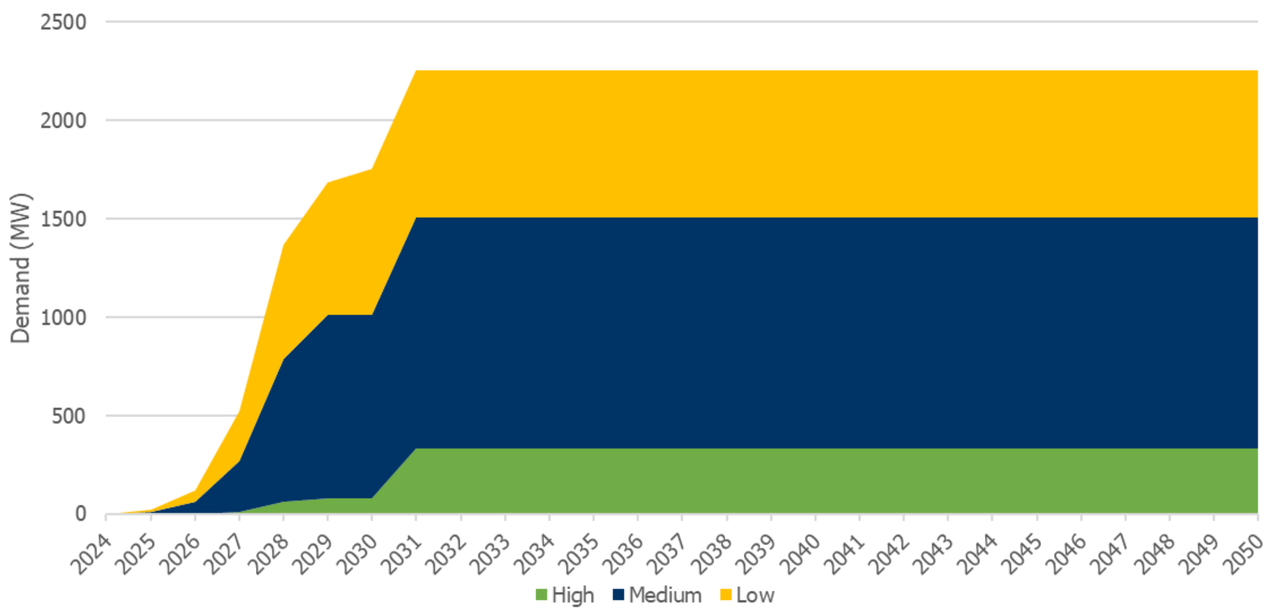


[37] Ontario Strengthens Electric Vehicle Supply Chain With New Manufacturing Investment
[38] Driving Prosperity: The Future of Ontario's Automotive Sector
[39] Here's a list of recent electric vehicle and battery plant announcements in Canada

4.2 Potential New Projects

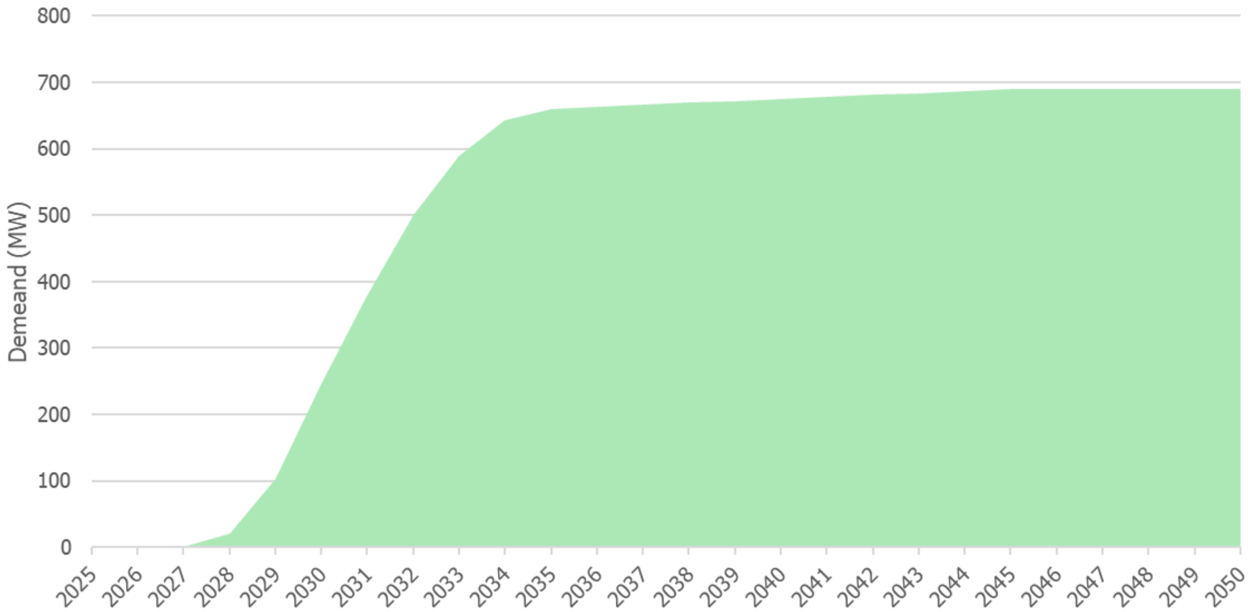
Other potential EV supply chain projects are still looking to connect in the province. Many of these companies are also considering multiple locations around North America, and therefore there is inherent uncertainty as to whether their projects will ultimately materialize in Ontario. Ontario has clean energy leadership, stable and reliable supply, affordable energy for businesses, grid modernization and innovation and superior energy efficiency programs. Many of these companies are also looking at common locations and connection points within the province, and therefore not all projects will be able to connect within their desired timeframe and locations.

Figure 7 | EV Supply Chain – Unconfirmed Proposed Project Load in 2025 APO



Note: The projects are displayed in the graph above at their full load levels (i.e. if all projects were to connect at their desired demand levels). A likelihood factor is applied to the projects, based on their likelihood of connecting. Once the factor is applied, projects of all likelihoods are added up together and included in the 2025 APO demand forecast. The result is shown in the graph below.

Figure 7 | EV Supply Chain – Unconfirmed Included Project Load in 2025 APO



The graphs above include EV projects that IESO is aware of based on information from the Ministry of Economic Development, Job Creation and Trade, Invest Ontario, and internal IESO processes. However, this list continues to be updated on a regular basis, as economic development activities continue to take place across all levels of government. While there are a finite number of sites that can fit these loads, the size of the loads and the ramp rate of the loads can vary drastically. Ultimately, the load characteristics of the sites will depend on what projects lands at the sites. It can be very difficult to account for the sector's load until projects are committed, and as a result there is a large amount of uncertainty regarding the timing and magnitude of the load growth in the EV supply chain sector.

5. Uncertainties

5.1 Project Risks

Large step loads, whether they are EV supply chain related, data centres, or from other sectors, face a number of common risks which can impact their timelines.

1. **Market forces:** If demand for the industry falls below projections, some proponents may delay their in-service dates until there demand increases again. While information on general trends is available, how these trends translate into project delays is not inherently clear due to the varying risk tolerances and decision-making processes of different companies.
2. **Economic Impacts:** Economic issues such as supply chain issues, labour shortages, and changes in policy or tariffs can also result in project delays or cancellations.

To address uncertainties in the 2025 APO, as discussed above, projects were given a likelihood factor based on their likelihood of siting in the province. These likelihood factors were then used to calculate overall demand for the sector. Moving forward, the IESO is looking to address uncertainties in a number of different ways.

5.2 Addressing Uncertainties

5.2.1 Increased Sector Communication

The IESO will continue to work with sector partners such as transmitters, distributors and the Ministry of Economic Development, Job Creation, and Trade to monitor large step load activity within the province. This will ensure that the IESO is aware of activities before the formal system impact assessment (SIA) process has begun, and can ensure that province wide investments are made in a timely manner. The IESO will also explore working groups within Ontario and North America, with data centre developers, operators, investors, and other utilities to increase understanding and awareness of data centre development. IESO will also explore DSM opportunities for large step loads. For example, the IESO is actively seeking to fund data centre specific Demand Side Management measures such as central room air conditioners (CRAC) and more advanced energy efficiency opportunities.

5.2.2 Leveraging Research

The IESO will continue to work with sector partners across North America and the globe to monitor large step load activity globally. This includes participating in research such as the Electric Power Research Institute's Load Forecasting Initiative, and leveraging other reports and insights as they are published. IESO is also seeking to conduct Ontario specific research to better understand which energy efficiency opportunities would be most advantageous to large step loads, including both new and existing data centers located in Ontario. This will ensure that the IESO is aware of the latest information and follows industry best practices with regards to forecasting large step loads.

5.2.3 Demand Growth Margin

Looking ahead, the IESO is working towards developing an Ontario demand growth margin, which will be informed by an aggregated assessment of the inherent uncertainty with new load development in the province. Year-over-year changes to growth projections within different sectors are expected, however for power system planning it will be important to ensure an understanding of how these sector-level evolution impact the aggregated Ontario's electricity demand forecast. This approach will provide a stable growth signal for the province to manage the uncertainty over the next few years, while also providing clarity for electricity planning purposes. The methodology for determining the demand growth margin is currently under development.