MEDIUM AND HEAVY-DUTY FLEET ELECTRIFICATION

A National Assessment of Uptake and Electricity Demand

By EMC's Utilities Working Group

October 2025

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ABOUT EMC

Electric Mobility Canada (EMC) is the unifying and authoritative voice for the transition to electric transportation across Canada. Founded in 2006, EMC is the national industry association that enables and accelerates the transition to sustainable electric mobility through advocacy, collaboration, education, and thought leadership, with the goal of creating a cleaner, healthier, and more prosperous future for all Canadians.

EMC has 190+ member organizations, including electricity suppliers; manufacturers of light, medium, heavy, and off-road vehicles; infrastructure providers; technology companies; mining companies; research centres; government departments and agencies; cities; universities; fleet managers; unions; environmental NGOs; and EV owner groups.

Members of EMC collaborate under different working groups to identify barriers and solutions specific to multiple industry segments: Batteries (life cycle), Charging infrastructure (accelerating deployment), Utilities (best practices and grid planning), and MHDV (Fleet electrification).

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BACKGROUND

This report is prepared by EMC's Utilities Working Group as its primary publication for 2025 to increase the familiarity by stakeholders for utility planning of MHDV electrification across Canada. It provides an initial national assessment of MHDV adoption over the next one and a half decades, by vehicle class and use case, and the resulting grid load, based on evidence from previous research and available data.

Although the effects of passenger vehicle electrification on electricity demand have been the subject of numerous studies and discussions, those related to MHDV have not yet been documented to the same extent.

This preliminary analysis is constrained by limited data availability and evolving market conditions. Political decisions, both in the short term and long term, will significantly influence the pace and nature of MHDV electrification, and may alter the assumptions used in this report. Given the early stage of deployment and ongoing policy developments, particularly the government's review of ZEV mandates, this study's findings should be considered preliminary and directional.

The purpose of this report is to initiate dialogue, establish a foundational model that can be refined as more granular data becomes available, and emphasize the importance of coordination between governments, utilities, and industry stakeholders to plan future grid upgrades and energy management strategies. These findings serve as a conversation starter, and the framework will be refined in future iterations with more stakeholder input, more granular data, and additional regional analysis.

This report is intended to support early-stage planning and dialogue between utilities, regulators, and fleet stakeholders. It provides national-level forecasts and vocational insights that can be used for scenario testing, infrastructure planning, and identifying data gaps. Readers are encouraged to interpret the findings considering their regional context and planning responsibilities.

INTRODUCTION

Over the past decades, utilities have successfully forecasted electricity demand using relatively stable indicators such as population growth and economic activity. These models have supported long-term infrastructure planning and rate design across Canada's diverse utility landscape.

However, the electrification of end uses, including data centres, building heating, and electric vehicles, introduces new complexities. Some of these loads are less predictable, more variable, and often concentrated in time and space, making traditional forecasting methods insufficient.

This report focuses on one of the most understudied and impactful segments: medium- and heavy-duty zero-emission vehicles (MHD ZEV).[1] While light-duty electric vehicles (EV) are growing rapidly and supported by emerging data and planning tools, the MHD segment presents a larger gap in terms of available data, planning frameworks, and understanding of electrical infrastructure needs.

To support planning, this report assesses electricity requirements (in GWh) from MHDVs and buses for three different ZEV uptake scenarios. This framing provides utilities with a spectrum of plausible grid impacts.

This first national assessment aims to:

- Forecast the adoption of MHD ZEV over time, from 2025 to 2040.
- Integrate vocational use cases to reflect energy demand by vehicle class and operational behaviour.
- Highlight the need for location granularity, from national to provincial, regional corridor, utility territory, and eventually feeder-level analysis.
- Acknowledge trade-offs in modelling granularity, while emphasizing the vision and gaps that must be addressed to support effective utility planning.

The report concludes with a call for more granular data, especially on vocation, class, and geography. We invite stakeholders to share data and insights to fill current gaps:

- Industry associations and EMC members are encouraged to contribute operational data.
- Utilities want to be ready to support fleet electrification: *"help us to help you"* by engaging early and sharing credible, reliable information.

The next iteration will strive to:

- Add regional analysis by province and territory.
- Include power forecasts and peak demand modelling.
- Improve granularity using better data sources, including vehicle load profiles and more operational insights.

This work will require **funding, collaboration, and data partnerships** to deepen the analysis and support utilities in planning for a rapidly evolving transportation landscape.

[1] The ZEV terminology is used throughout this report. Given hydrogen's very small (and in some MHDV classes absent) market share, results primarily reflect BEVs.

FOUNDATIONAL DATA

This chapter presents the foundational data used to support the forecasts outlined in the following chapter, *Country-Wide Forecasts*. It includes a review of historical vehicle stock and greenhouse gas (GHG) emissions, as well as an overview of energy use trends across different medium- and heavy-duty vehicle (MHDV) segments. These datasets form the basis for understanding current conditions and projecting future electricity demand associated with fleet electrification.

Historical Stock and GHG Emissions[2]

Except for school and transit buses, which have remained relatively stable over the past two decades, accounting for 39,000 and 24,000 vehicles respectively in 2022,[3] the number of trucks on the road has been steadily increasing, driven by the demand for goods, the growth of global trade and e-commerce.

Light and medium trucks have seen particularly rapid growth, reaching nearly 4 million and 2 million vehicles, respectively in 2022. In contrast, the market for heavy trucks has grown more slowly, with just above 540,000 during the same year. **(**Error! Reference source not found.**Figure 1, Left Panel)**

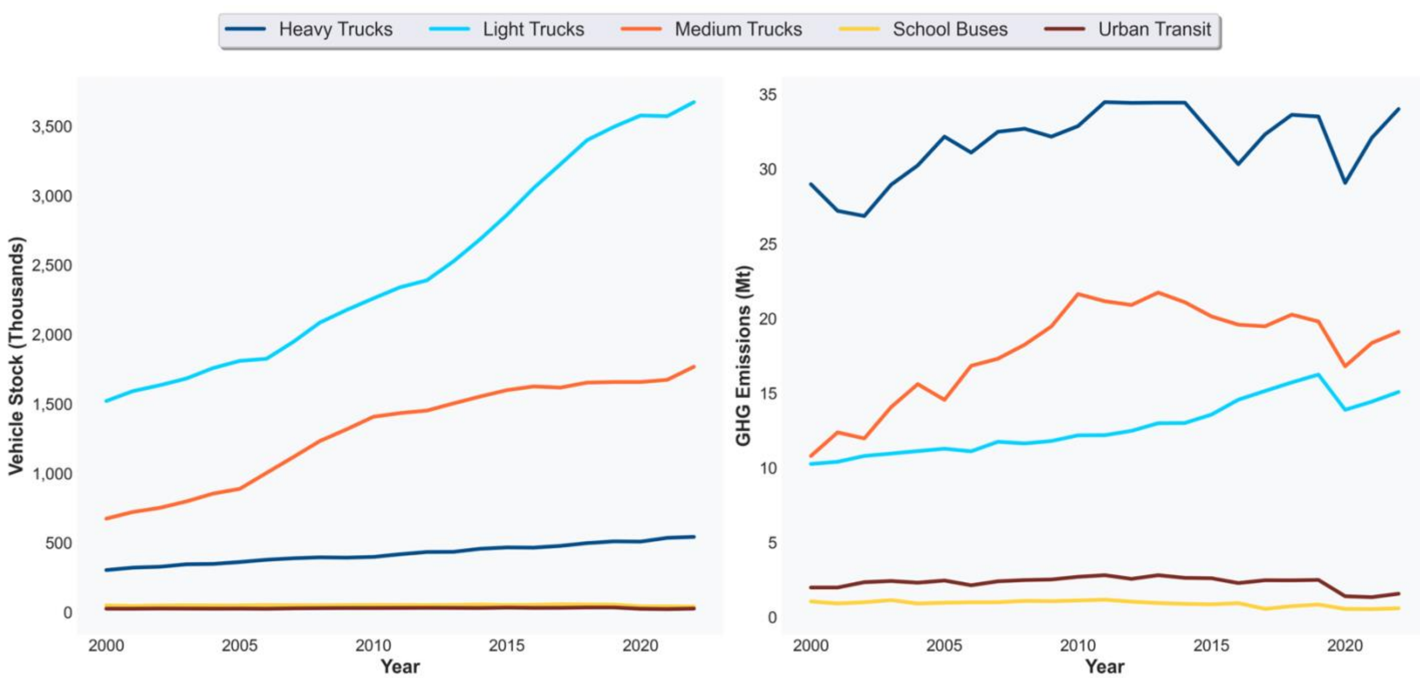

Figure 1: Historical Vehicle Stock and GHG Emissions by Transportation Mode (2000-2022)

Insight: Light and medium trucks have grown rapidly, reaching 4 million and 2 million vehicles respectively by 2022. Heavy trucks remain fewer in number but emit more GHGs due to longer distances and lower efficiency. School and transit buses have stable stocks and lower emissions, partly due to early electrification.

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[2] Natural Resources Canada. Comprehensive Energy Use Database: Transportation Sector. Accessed July 2025

***Note:** The classification used by NRCan differs slightly from the GVWR definition applied in this report. It considers Light Trucks (0–3,855 kg / 0–8,500 lb), Medium Trucks (3,856–14,969 kg / 8,501–33,000 lb), and Heavy Trucks (≥14,970 kg / ≥33,001 lb). The figures for light trucks shown here refer to freight vehicles only, excluding passenger light trucks.*

[3] The school bus stock (yellow line) is included but, due to the scale difference compared to trucks, it is nearly indistinguishable and appears overlapped by the transit bus line.

MHDV have a substantial impact on total transportation greenhouse gas (GHG) emissions, representing between 25% and 30% of the sector's total emissions throughout the period 2000 to 2022.[4] School buses, followed by transit buses, are the least polluting among these vehicles, partly because of their low stock. In addition, a portion of transit buses is already electrified, which contributes somewhat to offsetting their emissions. In 2022, their contributions were 0.6 Mt and 1.5 Mt, respectively, and remained relatively stable throughout the years.

When it comes to trucks, GHG emissions are inversely related to vehicle stock. Although heavy trucks represent the smallest share of vehicles, they account for the largest share of emissions, followed by medium and light trucks. This reflects their longer driving distances and lower energy efficiency.[5] **(Figure 1, Right Panel)**

Energy Use Overview[6]

Historical figures on energy use follow trends like those of GHG emissions, representing 33% to 41% of the transportation sector consumption between 2000 and 2022.[7] Looking at all MHDV combined, energy consumption shows a general upward trend, aside from a dip in 2020. The decline was moderate for heavy trucks compared to other categories (particularly passenger transportation)[8], which underlines their continued role in supplying essential goods during the COVID pandemic.[9]

Breaking down energy use by vehicle type shows that medium trucks experienced the largest increase over the years, with 270 PJ in 2022, followed by light trucks with a modest rise to 215 PJ, and heavy trucks with a smaller increase to 478 PJ. On the other hand, school and transit buses maintained steady and low energy demand, averaging 13 PJ and 34 PJ, respectively, over the considered period. **(Figure 2)**

[4] Ibid
[5] CIMA+. Optimizing EV infrastructure planning with commercial transportation insights. Accessed June 2025
[6] Natural Resources Canada. Comprehensive Energy Use Database: Transportation Sector. Accessed July 2025
[7] Ibid
[8] The relative decrease between 2019 and 2020 is more pronounced for transit buses (-40%), school buses (-33%), light trucks (-18%), medium trucks (-17%) and then heavy trucks (-13%)
[9] Geotab. Connected vehicle data reveals trucking industry continues to support flow of goods amid COVID-19 pandemic. Accessed September 2025

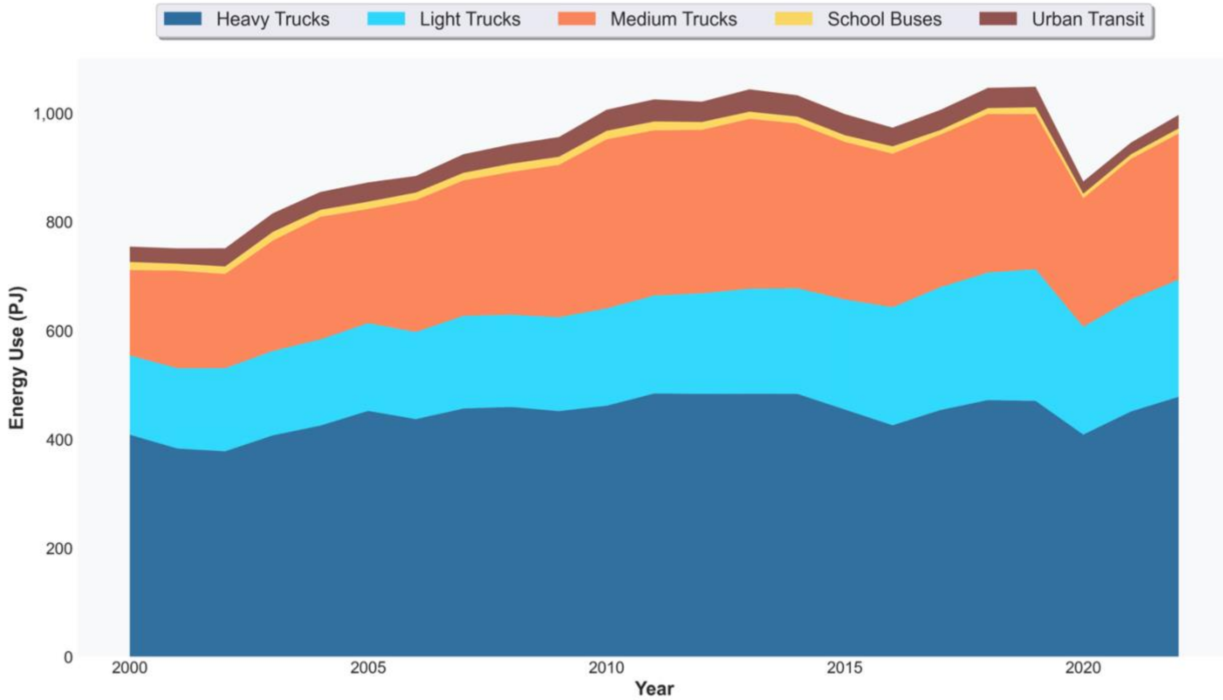

Figure 2: Energy Use Evolution by Transportation Mode (2000-2022)

Insight: Heavy trucks dominate energy use, followed by medium and light trucks. School and transit buses show low and stable energy demand. The 2020 dip reflects pandemic impacts, with heavy trucks least affected, indicating their essential role in the movement of goods.

For transit buses only, a portion of the fleet runs on electricity, accounting for 9% to 21% of total energy used by transit buses over the years.

While diesel and gasoline remain the primary energy sources for freight and passenger transportation, the ongoing electrification of MHDV is expected to substantially increase electricity demand, suggesting the importance of early grid planning for this transition.

QUESTION FOR FURTHER ANALYSIS:
Regional differences in truck activity and energy intensity may significantly affect grid planning due to the electrification of transportation. Are certain provinces more exposed to risks from increases in peak demand due to activity from freight corridors, urban delivery concentrations, or seasonal variations in fleet usage?

COUNTRY-WIDE FORECASTS

This chapter presents national-level forecasts for the adoption of MHD ZEV across Canada. It builds on historical stock and energy use data to project uptake by vehicle class[10] and estimate the resulting electricity demand. While the analysis does not yet include regional breakdowns, it provides a foundational view of how fleet electrification may evolve over time and what it could mean for grid planning at the national scale.

ZEV Adoption by Vehicle Class

To forecast national ZEV uptake across MHDV truck classes and buses, we first compiled active and new registration figures for 2023.[11] This established the baseline stock and sales for all powertrain types combined and for ZEVs only. Assuming that vehicle stock as a proportion of the population remains constant over time, and applying a steady scrappage rate, we projected the total vehicle stock.

ZEV sales targets from the literature and a hypothetical conservative scenario were then applied to estimate annual ZEV figures. Further details on the methodology can be found at the end of the report.

TRANSIT BUSES

ZEV sales for transit buses are projected to ramp up steadily through 2030, stabilizing with population growth thereafter.[12] The stock of electric transit buses grows rapidly until 2030, after which growth slows[13] to reach around 18,000 vehicles out of the total 25,000 buses (72%).[14]

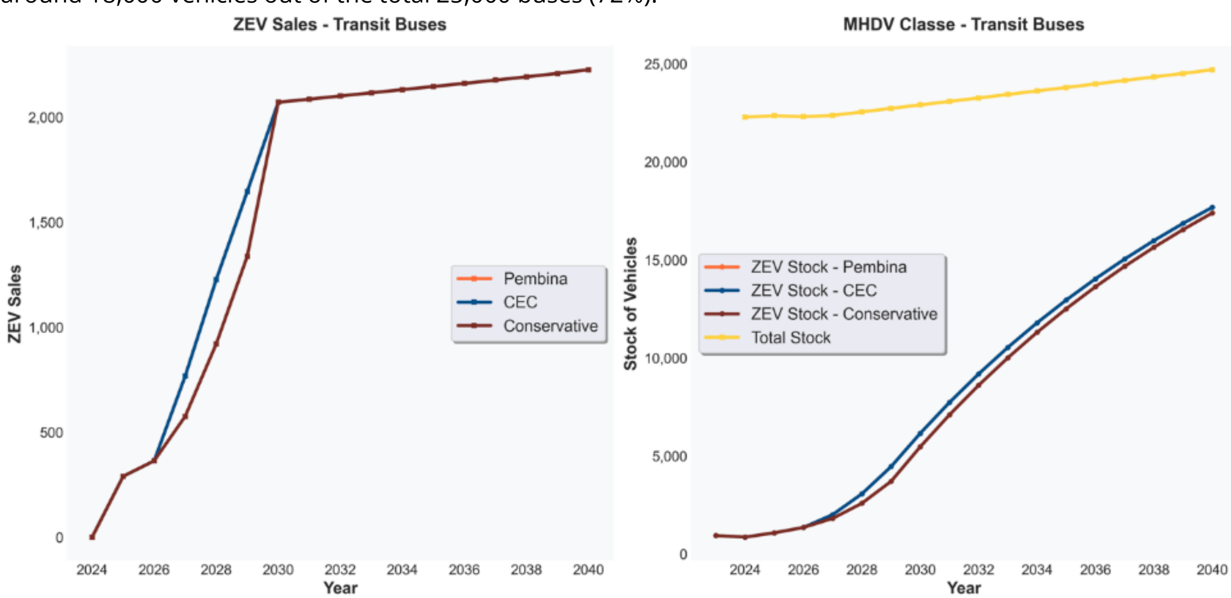

Figure 3: Projected Annual ZEV Sales (left) and Cumulative Stock (right) for Transit Buses (2024-2040)

Insight: Transit bus electrification accelerates until 2030, then continues to grow at a slower pace, reaching 72% of the fleet by 2040. Growth aligns with population trends and procurement cycles.

[10] For MHDV classes as defined by gross vehicle weight rating (GVWR), see Transport Canada. Accessed September 2025.
[11] Active registrations represent the total stock of vehicles on the road, while new registrations are used a proxy for annual sales.
[12] The Pembina and CEC lines for school and transit buses sales and stock uptake overlap, since both scenarios recommend the same sales targets.
[13] There is an inflection point around 2030 when sales reach 100%. Before that, sales are still ramping up, so stock grows rapidly. After 2030, since sales cannot exceed 100%, stock growth continues but at a slower rate.
[14] According to the Pembina scenario.

SCHOOL BUSES

Electric school buses follow trends similar to transit buses. However, annual procurement does not stabilize after 2030 due to projected declines in the school-age population, which constrains demand for new buses. By 2040, approximately 67% of school buses on the road are projected to be ZEV (29,000 of 43,000 fleet).[15]

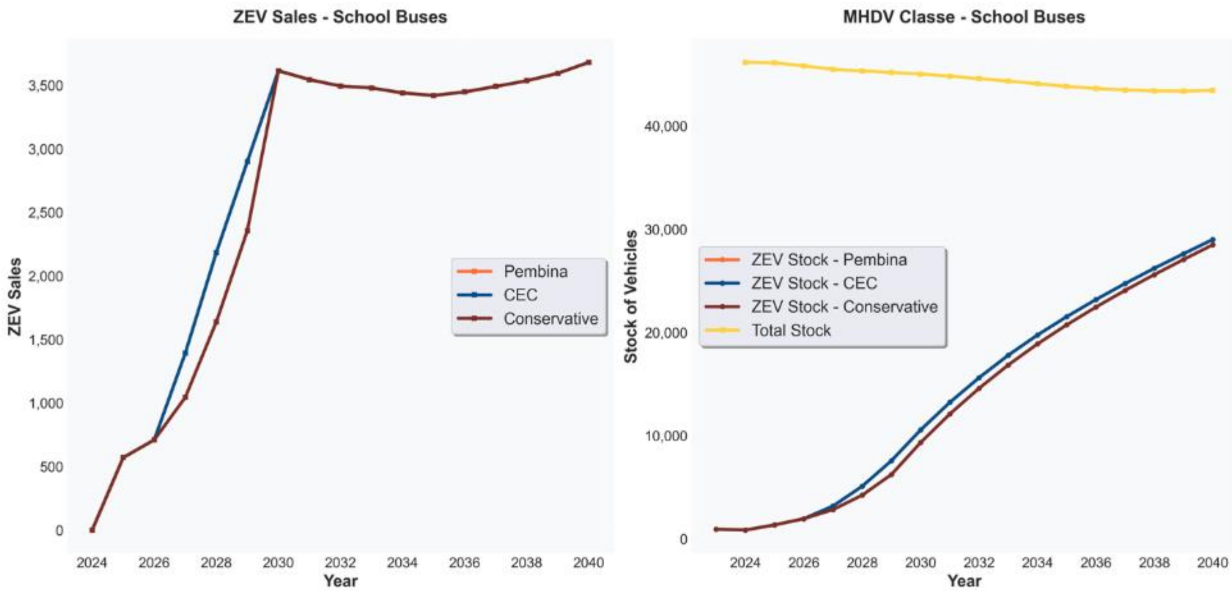

Figure 4: Projected Annual ZEV Sales (left) and Cumulative Stock (right) for School Buses (2024-2040)

Insight: Electrification reaches 67% of the school bus fleet by 2040, but growth slows after 2030 due to demographic shifts reducing demand.

[15] Ibid

TRUCKS – CLASSES 2B AND 3

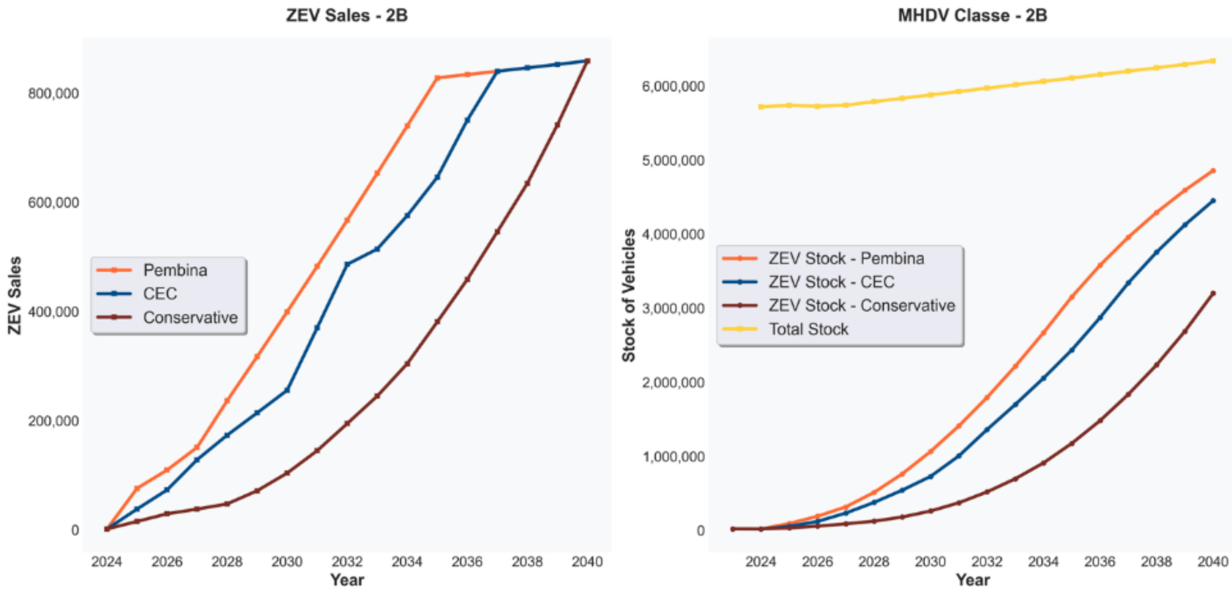

Figure 5: Projected Annual ZEV Sales (left) and Cumulative Stock (right) for Class 2B Trucks (2024-2040)

Class 2B ZEV sales rise steadily across scenarios until the 100% sales mandate year, then level off. By 2040, ZEV are projected to make up between 50% and 77% of the Class 2B fleet.

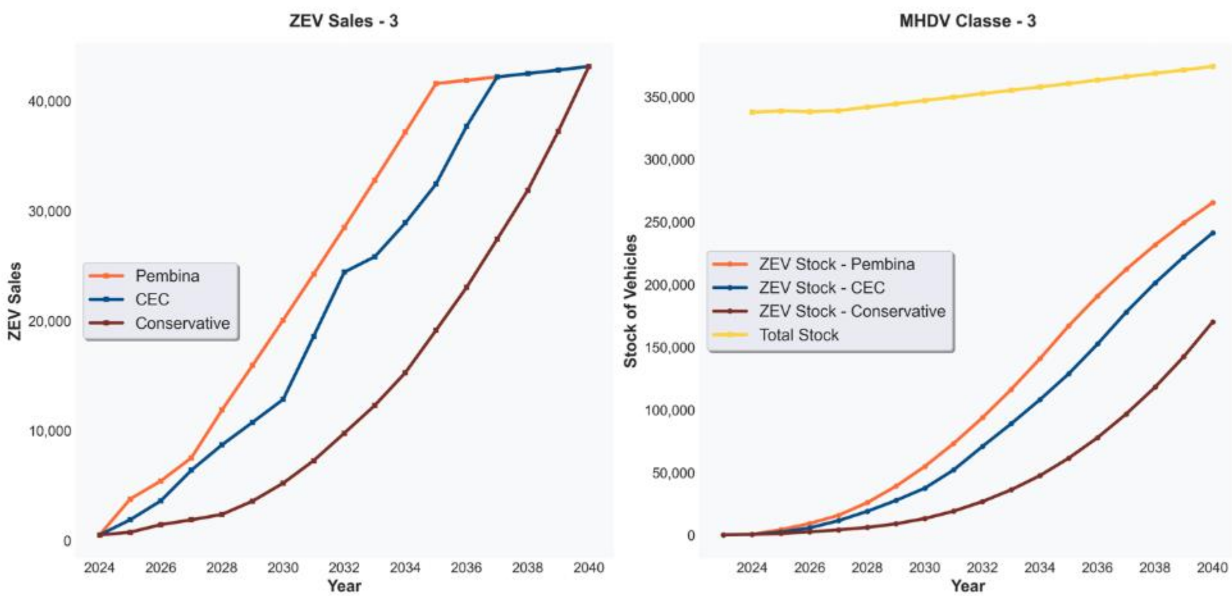

Figure 6: Projected Annual ZEV Sales (left) and Cumulative Stock (right) for Class 3 Trucks (2024-2040)

Class 3 ZEV sales follow the same trajectory as Class 2B since targets are comparable across scenarios, but with smaller sales volumes and fleet size overall. By 2040, electric Class 3 trucks are projected to represent between 45% and 71% of the total Class 3 stock, depending on the scenario.

Insight: Classes 2B and 3 are projected to see strong growth, reaching 50% and 45% ZEV penetration respectively by 2040, even in the conservative scenario.

TRUCKS – CLASSES 4, 5 AND 6

Targets for Classes 4, 5 and 6 are aligned and less ambitious than those for Classes 2B and 3, with 100% ZEV sales reached only by 2040. Across all three scenarios, sales and stock follow similar growth trajectories and differ only in the overall scale of sales and fleet sizes.

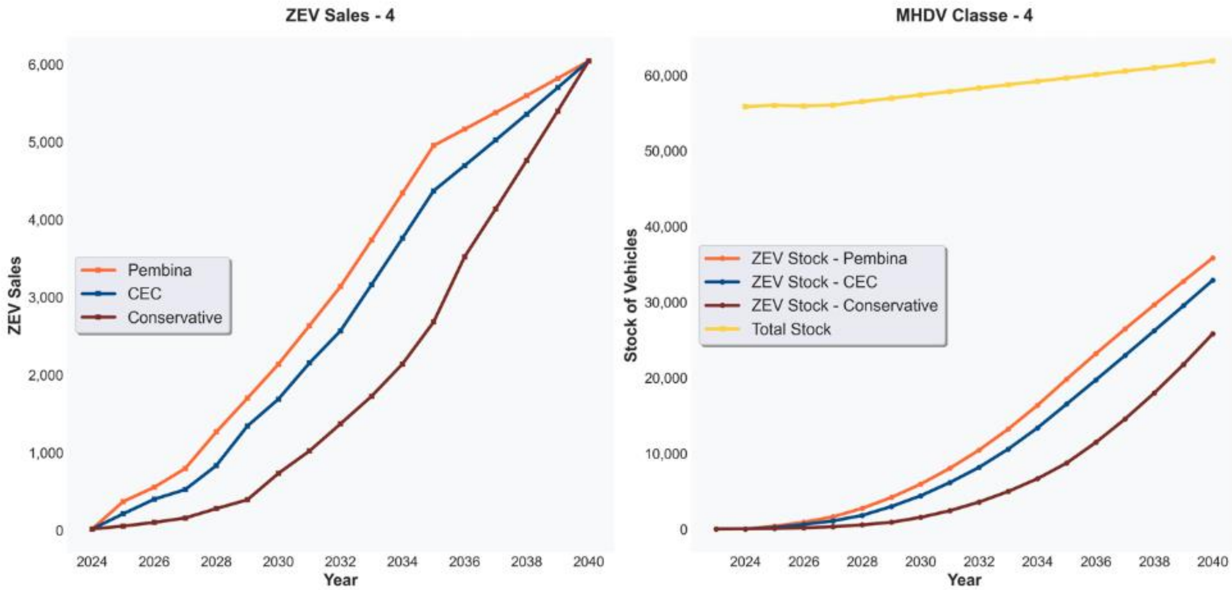

Figure 7: Projected Annual ZEV Sales (left) and Cumulative Stock (right) for Class 4 Trucks (2024-2040)

By 2040, between 42% and 58% of Class 4 trucks on the road are forecasted to be electric, with just below 26,000 estimated ZEV under the conservative scenario and 36,000 ZEV under the Pembina scenario.

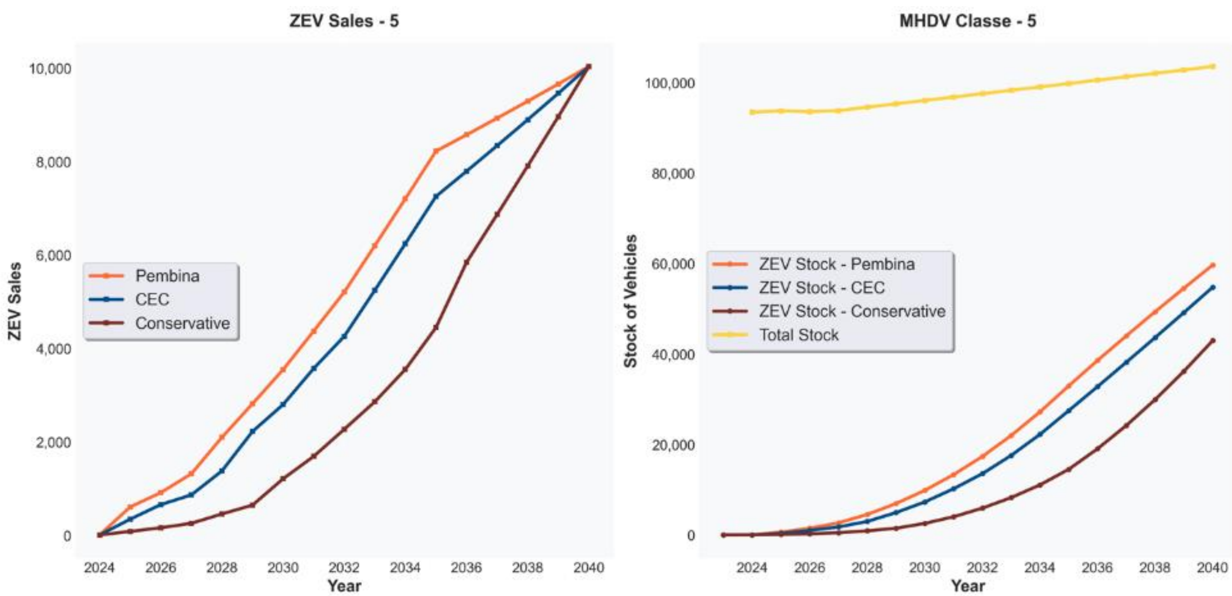

Figure 8: Projected Annual ZEV Sales (left) and Cumulative Stock (right) for Class 5 Trucks (2024-2040)

By 2040, between 41% and 58% of Class 5 trucks on the road are projected to be electric, with about 43,000 ZEV under the conservative scenario and 60,000 ZEV under the Pembina scenario.

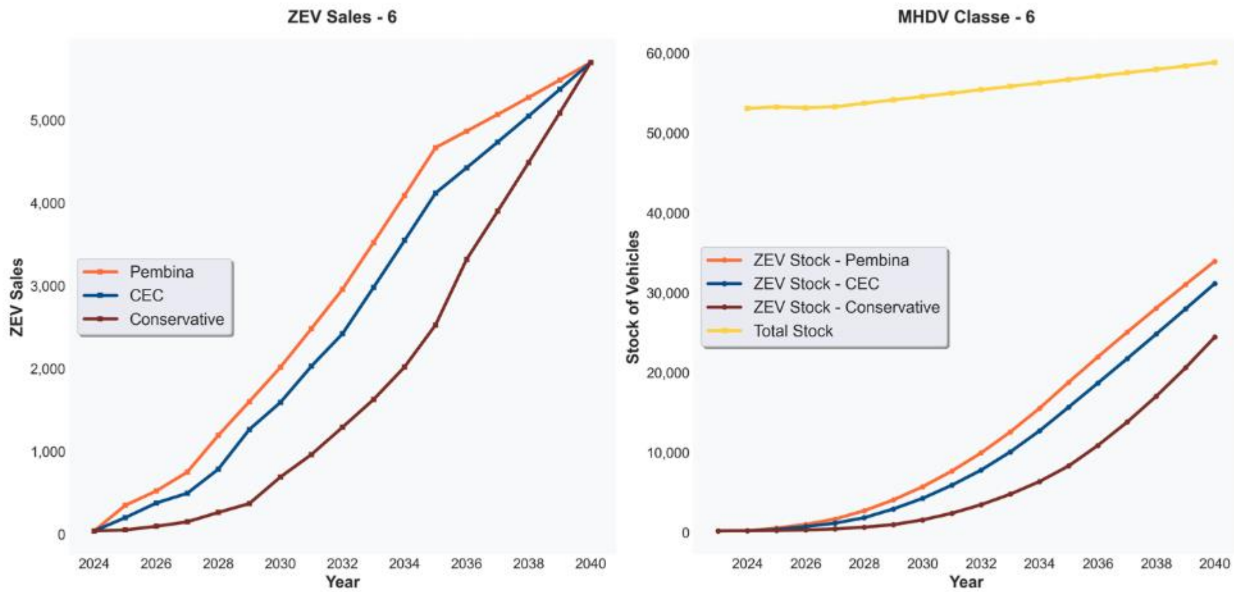

Figure 9: Projected Annual ZEV Sales (left) and Cumulative Stock (right) for Class 6 Trucks (2024-2040)

By 2040, between 41% and 58% of Class 6 trucks on the road are forecasted to be electric, with about 24,000 ZEV under the conservative scenario and 34,000 ZEV under the Pembina scenario.

Insight: Classes 4, 5, and 6 are expected to see moderate ZEV adoption, reaching between 41% and 58% market shares by 2040.

QUESTION FOR FURTHER ANALYSIS:
What role can provincial procurement programs or incentives play in accelerating ZEV uptake in Classes 4–6, which currently show moderate adoption? Could targeted funding or regulations shift adoption curves earlier than projected?

TRUCKS - CLASSES 7 AND 8

For heavy trucks, ZEV sales follow an upward trend like the other classes but reach lower penetration levels across scenarios. From 2034 onward, targets converge and result in nearly identical sales projections across the three scenarios.

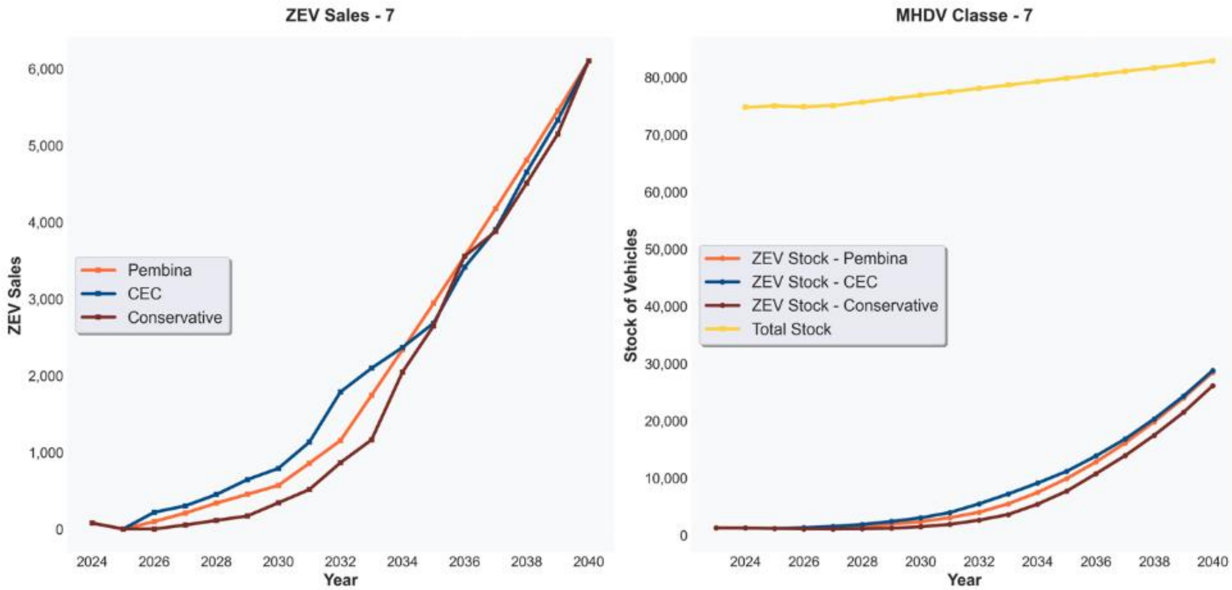

Figure 10: Projected Annual ZEV Sales (left) and Cumulative Stock (right) for Class 7 Trucks (2024-2040)

By 2040, between 32% and 35% of Class 7 trucks on the road are projected to be electric, with about 26,000 trucks under the low scenario and 29,000 under the high scenario.

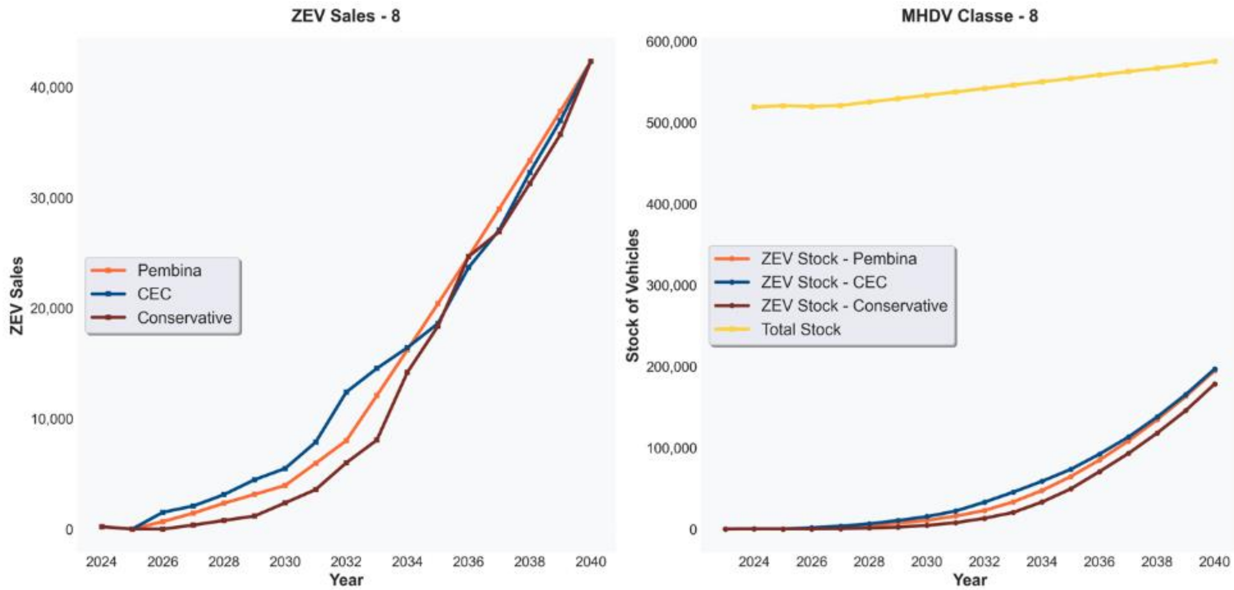

Figure 11: Projected Annual ZEV Sales (left) and Cumulative Stock (right) for Class 8 Trucks (2024-2040)

By 2040, between 31% and 34% of Class 8 trucks on the road are projected to be electric, with less than 179,000 trucks under the low scenario and about 197,000 under the high scenario.

Insight: Classes 7 and 8 show slower ZEV uptake, reaching between 31% and 35% market shares by 2040. These segments face greater electrification challenges due to duty cycles and infrastructure needs.

Electricity Demand by Use Case

Summary: Electrification of MHDVs will have diverse impacts on electricity demand depending on how vehicles are used, not just what type they are. This section reframes the analysis from vehicle class to vocational use cases, offering a more utility-relevant perspective on grid planning.

In the previous section, we forecasted MHDV uptake by vehicle class for trucks, as well as for school and transit buses. However, the literature suggests that grid impacts and electricity distribution system upgrades are much less driven by vehicle type than by the purpose they are serving and their operational characteristics, such as driving distance, dwell time, duty cycle, and charging behaviour.

Combined with the distribution of vocations across MHDV truck classes and approximations of operational data, this section shifts the assessment from a class-based to a use case perspective, showing how electricity demand varies across different fleet applications.

More details on the approach taken are presented in the Methodology section.

Truck Vocational Use Cases

According to *Altitude by Geotab*[16], five use cases of MHDV trucks are used to group similar vehicles based on their operational purpose, which reflects vehicle behaviour rather than classifications such as industry or ownership type. **Table 1** presents descriptions of these five vocations, along with examples. Note that to remain consistent with Geotab's methodology, units of miles are maintained, with kilometre figures in brackets.

Table 1: Description of MHDV Truck Vocational Use Cases (Geotab Altitude)

Vocation	Description	Examples
Long Distance	The vehicle has a very large range of activity and typically does not rest in the same location. The vehicle is also neither hub and spoke nor door to door.	– Freight Trucking – Rental or company vehicles
Regional	The vehicle has a wide range of activity, over the 150-mile (240 km) threshold for short haul exemption but tends to rest in the same location often. The vehicle is also neither hub and spoke nor door to door.	– Building supplies – Fuel carrier
Local	The vehicle's range of activity is below 150 miles (240 km) thus qualifies for the short haul exemption under Hours-of-Service Regulations. In addition, the vehicle does not exhibit behaviour in line with other vocations, such as hub and spoke and door to door.	– HVAC – Beverage distribution
Hub and spoke	The vehicle spends many of its workdays making multiple round trips from a singular location (a centralized hub). Typically, the vehicle would average over one round trip per working day, with round trips accounting for most of its total mileage.	– On-demand services or delivery – Suppliers
Door to Door	The vehicle makes significantly more stops than most per workday but also tends to spend very little time per stop.	– Last mile delivery – Waste collection

[16] Altitude by Geotab, New vocation classification structure allows users to dive deeper into vehicle behavior. Accessed September 2025

Vocational Mix of ZEV Trucks

From the five use cases, local commercial fleet is the dominant application across all truck classes. The distribution of vocations shows many similarities between classes of adjacent weight, particularly Classes 2B–3, Classes 4–5, and Classes 6–7. In contrast, Class 8 stands out with a distinct mix, with regional trucking representing the second largest vocation, while long distance and hub and spoke operations are also major. Door to door use cases are more relevant to lighter trucks (Classes 2B-3), while hub and spoke becomes more dominant in mid weight trucks (Classes 4-5). For the heavier truck classes (6 to 8), regional trucking is consistently well represented. **(Figure 12)**

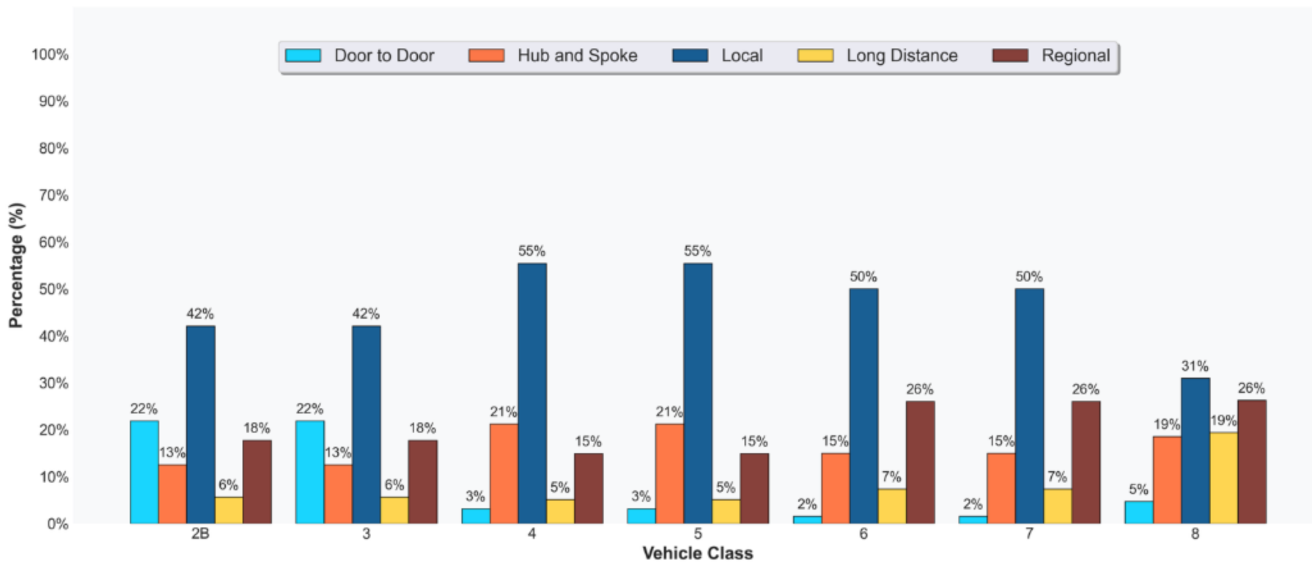

Figure 12: Distribution of Vocations across MHD ZEV Classes in the US (2024)[17]

Insight: Local fleets dominate across all classes, but Class 8 trucks show more diversity, with significant shares in regional and long distance vocations. This mix is critical for estimating charging behaviour and grid impacts.

QUESTION FOR FURTHER ANALYSIS:
This analysis assumes U.S. vocational distributions apply to Canadian fleets. Future iterations would benefit from Canadian-specific data. Are there regional or industry-specific fleet behaviours in Canada that diverge from U.S. patterns?

Assuming vocational shares apply to the Canadian context, along with an unchanged mix over time, we find that ZEV trucks uptake by use cases follows the same patterns noted before, with local applications dominating both medium and heavy-duty trucks. In the Pembina scenario, medium-duty stock uptake increases steadily at an accelerating rate until 2035 and continues to grow at a slower pace thereafter. On the other hand, heavy-duty trucks increase at an accelerating rate through 2040.

By 2040, the medium-duty ZEV stock is projected to reach 5,25 million vehicles, of which 42% are in local applications, 21% in door to door, 18% in regional, 13% in hub and spoke, and 6% in long distance operations. ZEV in the heavy-duty category would reach around 223,000 units, where local applications again have the greater share (33%), followed by regional (26%), hub and spoke (18%), long distance (18%), and door to door (just over 4%). **(Figure 13)**

[17] Based on vocation percentages of included vehicle classes from a US fleet sample of MHDV operations in December 2024. NREL, National Summary Statistics for Depot-Based Medium- and Heavy-Duty Vehicle Operations. Accessed August 2025

For reference, ZEV uptake estimates by vocation for the CEC and the conservative scenarios are provided in the appendix (

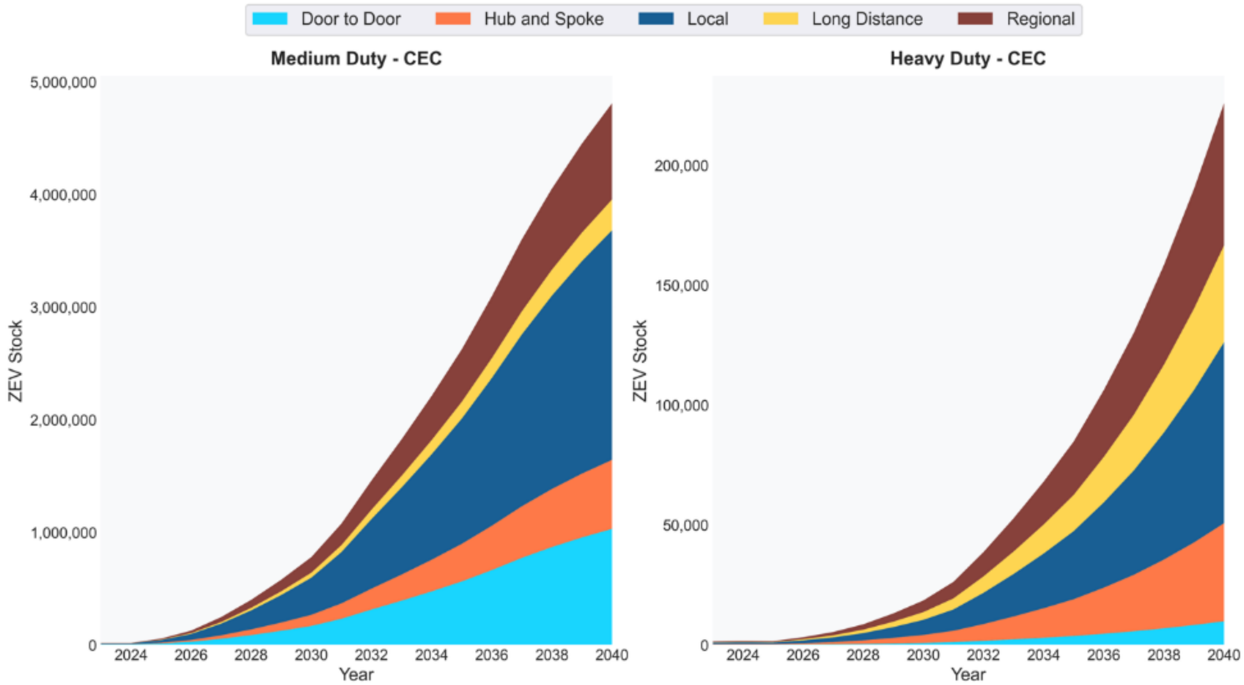

Figure ***16*** and **Figure 17)**

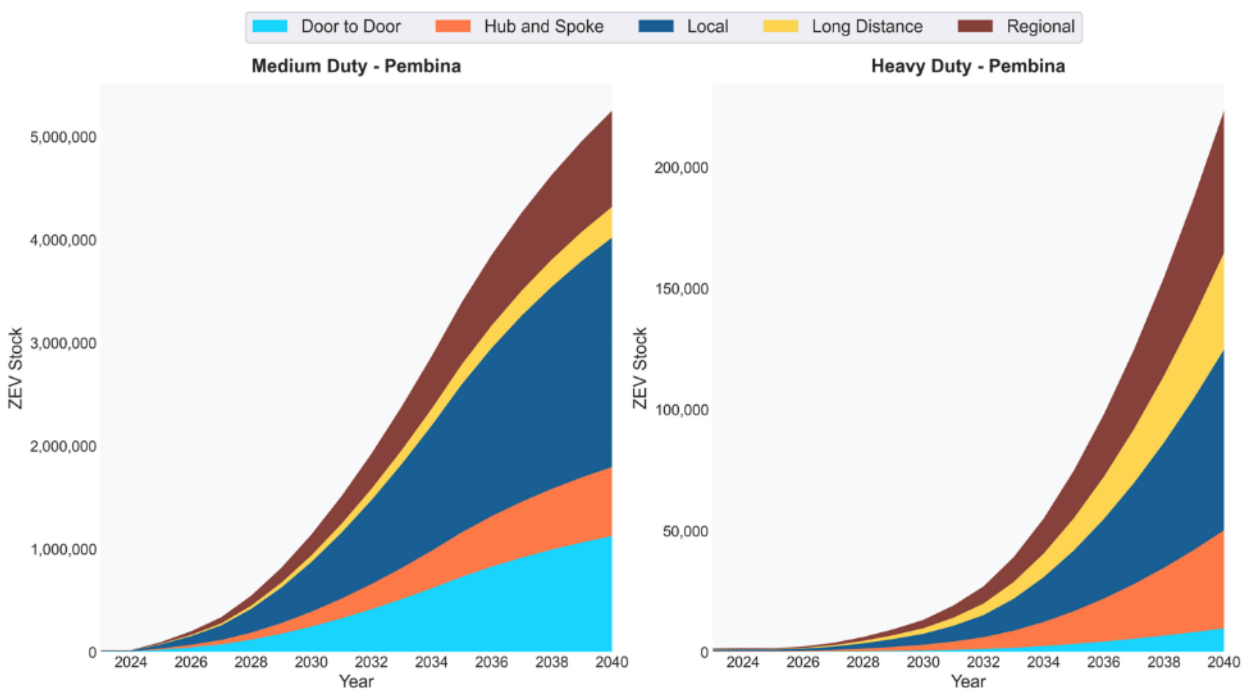

Figure 13: Stock Uptake by Vocation for ZEV Trucks (Pembina Scenario)

Insight: Local fleets remain dominant, but regional and long distance vocations grow significantly in heavier classes. This reinforces the need for differentiated charging infrastructure strategies.

Annual Electricity Demand

Medium and Heavy-duty Trucks

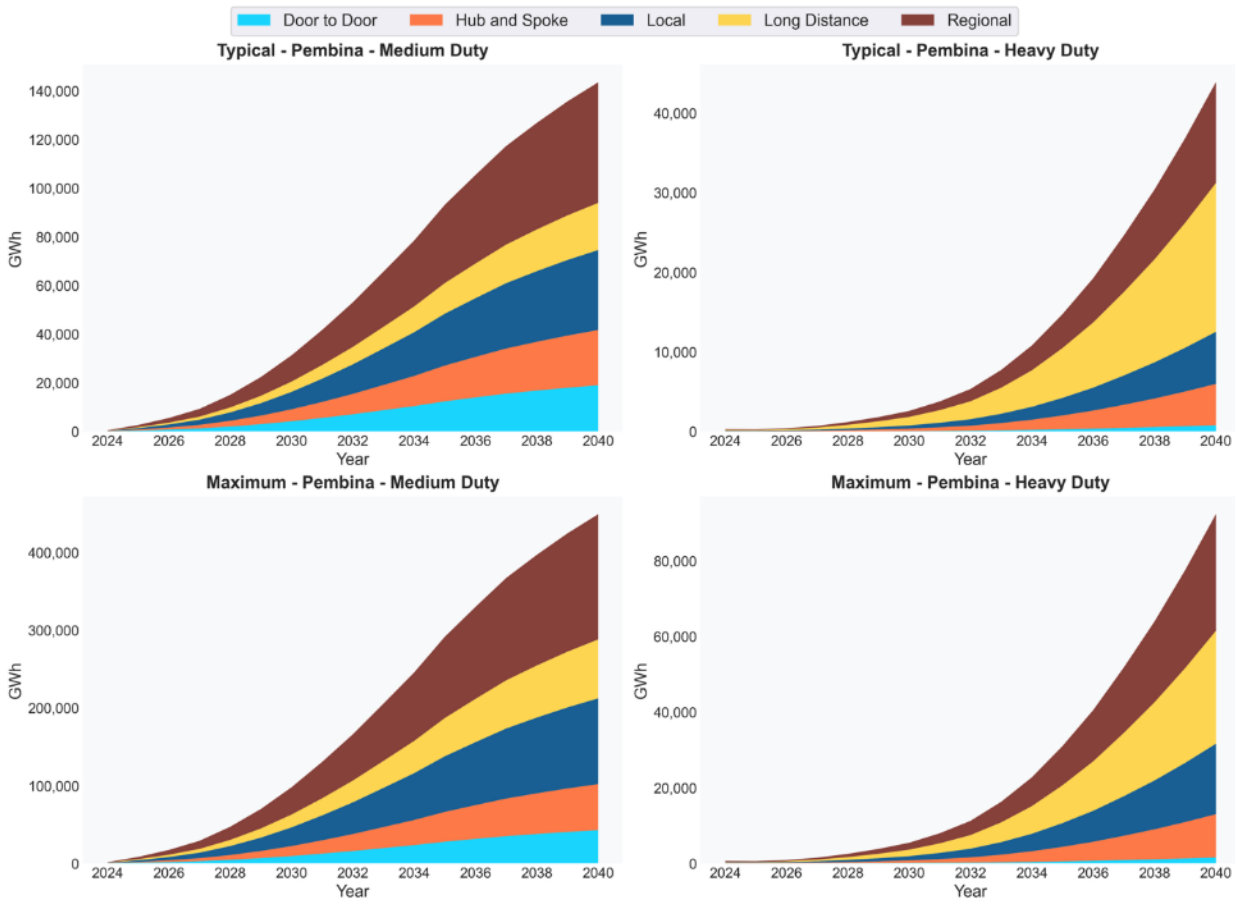

Figure 14: Typical and Maximum Annual Energy Demand (GWh) for ZEV Trucks by Vocation (Pembina Scenario)

Insight: Long distance and regional vocations drive the highest energy demand, with peak loads potentially straining local distribution systems. Hub and spoke and door to door vocations show moderate but concentrated demand.

Figure ***14*** illustrates projected electricity demand for medium and heavy-duty ZEV trucks by vocation under the Pembina scenario, comparing typical and maximum annual energy use. The data highlights that long distance and regional vocations are the most energy intensive, especially in the heavy-duty segment, and may pose significant challenges for grid infrastructure due to their high and variable load profiles.

In contrast, local and door to door vocations, while dominant in vehicle numbers, show more predictable and manageable demand patterns, particularly in the medium-duty category.

These insights suggest that utilities should prioritize grid readiness and charging strategies based on operational behaviour rather than vehicle class alone.

The difference between typical and maximum demand underscores the importance of planning for peak load scenarios, not just average consumption. This has implications for rate design, load management, and infrastructure investment, particularly in regions with high concentrations of long haul or regional fleets.

QUESTION FOR FURTHER ANALYSIS:
What types of rate structures or incentives could help shift peak charging away from high demand periods, especially for long distance and regional vocations? Could time-of-use pricing or demand response programs mitigate grid stress?

School and Transit Buses

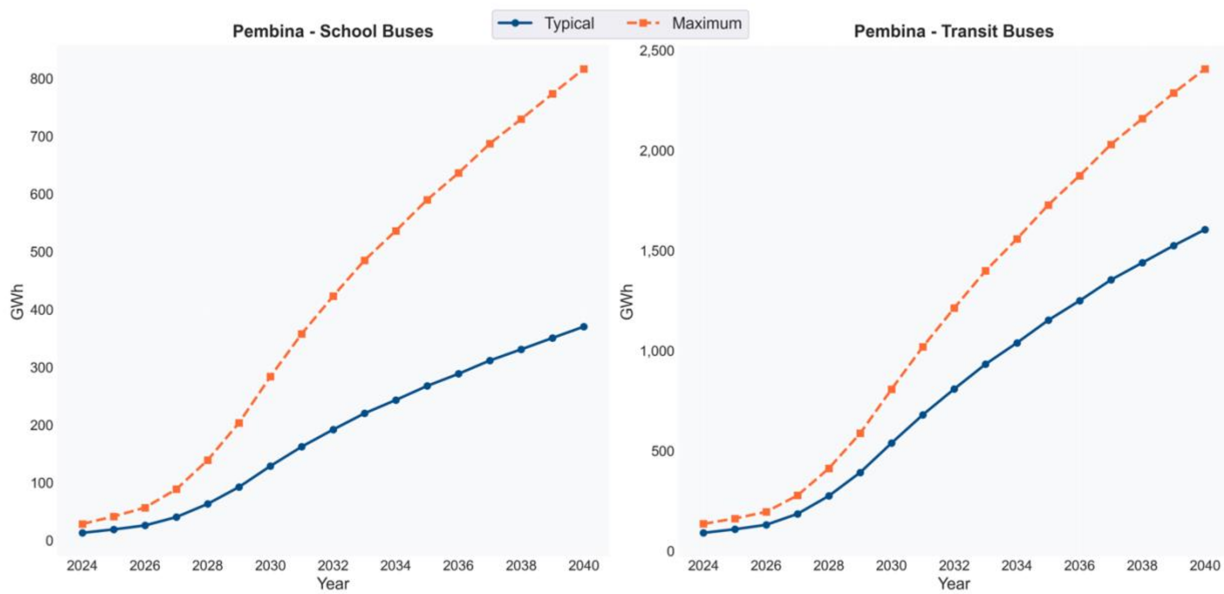

Figure 15: Typical and Maximum Annual Energy Demand (GWh) for Electric School and Transit Buses (Pembina Scenario)

Insight: Predictable and centralized operations make these segments ideal for managed charging. Their grid impact is relatively low and stable.

Figure *15* presents projected electricity demand for electric school and transit buses under the Pembina scenario, comparing typical and maximum annual energy use. The data shows that both segments have relatively stable and predictable demand profiles, with centralized operations and fixed schedules contributing to consistent energy consumption patterns.

These characteristics make school and transit buses ideal candidates for managed charging strategies, such as overnight depot charging or time-of-use rate optimization. Their modest grid impact, combined with high public visibility and policy support, positions them as low risk, high impact segments for early electrification efforts.

Utilities and municipalities can leverage these predictable patterns to pilot smart charging programs, test rate designs, and coordinate infrastructure upgrades with minimal disruption. These fleets offer a strategic entry point for broader electrification planning.

Observations on Electricity demand by use case analysis

1. Use Case Drives Grid Impact More Than Vehicle Class

- The report shifts from a vehicle class-based analysis to a vocational use case framework, recognizing that operational characteristics, such as driving distance, dwell time, and charging behaviour, are more relevant to grid planning than truck class alone.
- This approach aligns with utility planning needs, which must consider charging patterns and peak load implications, not just vehicle counts.

2. Local Fleets Dominate Across Most Classes

- Local commercial fleets are the most common use case across all truck classes, especially Classes 2B–3 and 4–5.
- Door to door operations are more prevalent in lighter trucks, while hub and spoke and regional vocations gain prominence in mid-weight (classes 4-5) and heavy-duty classes.
- Class 8 trucks show a distinct mix, with regional trucking as the second largest use case, and significant shares in long distance and hub and spoke operations.

3. Electricity Demand Varies Widely by Vocation

- **Figure *14***, **Figure *18***, and **Figure *19*** show that annual electricity demand (both typical and maximum) differs significantly across vocations:
  - Long distance and regional vocations have the highest energy demands due to extended driving ranges and less predictable charging locations.
  - Hub and spoke and door to door vocations, while more predictable in location, may still pose challenges due to high peak loads and frequent charging cycles.
  - Local fleets, despite being dominant in number, may have more manageable grid impacts due to shorter routes and centralized charging.

4. Scenario Comparisons Show Similar Demand Patterns

- Across the Pembina, CEC, and conservative scenarios, the distribution of electricity demand by vocation remains consistent, though the scale of demand varies. This is because fleet behaviour and use case mix are stable assumptions under different policy scenarios.
- However, total energy demand and peak load risks increase significantly under more aggressive adoption scenarios, reinforcing the need for early grid planning.

5. School and Transit Buses Have Predictable Demand Profiles

- **Figure *15***, **Figure *20***, and **Figure *21*** show that the forecasted annual energy demand for electric school and transit buses falls within relatively narrow ranges between typical and maximum values, especially when compared to other vocations. This indicates that they have relatively stable and predictable electricity demand, making them low-risk segments for grid integration.
- Their centralized operations and fixed schedules make them ideal candidates for managed charging strategies.

QUESTION FOR FURTHER ANALYSIS:
Are rural or remote regions at risk of being underserved in charging infrastructure deployment, despite hosting long distance or regional fleets with high energy needs? How can equity in infrastructure planning be ensured across

geographies? How can utilities ensure affordable access to power supplies if capacity needs to be brought in from some distance away?

Utility Planning Implications

The projected annual electricity demand by vocation offers utilities and regulators a national-level signal of the scale and timing of grid impacts associated with MHDV electrification. While the current analysis does not identify where geographically these impacts will emerge, and charging profiles are not currently available for each class/vocation type, it provides a foundational estimate of how different operational use cases, such as long distance freight or local delivery, will shape aggregate demand and peak load risks.

Given the fragmented nature of Canada's utility landscape, with varying regulatory frameworks and planning responsibilities across provinces and territories, this data can serve as a starting point for localized scenario testing and strategic coordination. Utilities can use the vocational breakdown to identify which fleet types are most relevant to their service areas and begin assessing infrastructure readiness, rate design options, and potential load management strategies.

For regulators, the demand projections can inform filing guidance, investment review processes, and policy alignment across jurisdictions. As more regional and operational data becomes available, this framework can be adapted to support more granular planning and inter-agency coordination.

While the projected electricity demand associated with MHDV electrification is substantial, it remains a manageable share of Canada's total electricity generation, which was approximately 609,488 GWh in 2024.[18] This corresponds to an increase in annual electricity consumption from MHD ZEV of between 22% and 31% by 2040, depending on final uptake. With coordinated planning, investment in grid upgrades, and deployment of managed charging strategies, this additional demand is reasonably feasible to accommodate over the 15-year horizon. The projections in this report offer a national-level signal to guide scenario testing and planning efforts across Canada's diverse utility and regulatory landscape.

The projected demand is reasonably feasible with adapted planning:

- **Scale**: The projected demand is significant but not overwhelming relative to national consumption. It's within the range that could be absorbed through incremental generation and distribution upgrades.
- **Time Horizon**: The projections extend to 2040, giving utilities and regulators 15 years to plan, invest, and adapt infrastructure.
- **Flexibility**: Much of the demand, especially for buses and local fleets, can be managed through smart charging, load shifting, and depot-based strategies.
- **Provincial/Territorial Planning**: While Canada's utility landscape is fragmented, most provinces and territories already conduct long-term resource planning. The data in this report can inform scenario testing and investment prioritization within those frameworks.

[18] Statistics Canada. Electric power generation, monthly generation by type of electricity (sum of monthly estimates for 2024). Accessed September 2025

Stakeholder Implications

Fleet operators, municipalities, and other stakeholders should engage with their utility as early as possible, ideally during the initial planning stages of fleet electrification. Early engagement ensures that implementation timelines are aligned with available grid capacity and that future energy needs can be anticipated and incorporated into utility planning cycles.

Proactive coordination allows utilities to:

- Assess infrastructure readiness for depot or public charging sites
- Evaluate load impacts and potential mitigation strategies
- Align rate structures and service upgrades with fleet deployment schedules

Stakeholders who wait until the procurement or deployment stages may face delays or cost increases if grid upgrades are required. Early dialogue helps ensure that electrification plans are technically and financially viable from the outset.

Key Takeaways

1. More data is required

- Data on vehicle charging patterns, energy demand, adoption rates, fleet geographical locations, regional variations, etc., are needed to support improved utility planning.
- New federal and provincial policy decisions in 2025 and beyond could shift the timing and types of vehicles that electrify in the near and medium term.

2. Use Case-Based Planning Is Essential

- Electricity demand is more influenced by vehicle vocation (how it's used) than by its class.
- Utilities should prioritize based on operational patterns, e.g., long-distance freight vs. local delivery, and vehicle type, as energy demand is driven by both daily distance and per-kilometre consumption, particularly for long-haul Class 8 vehicles.

3. Local Fleets Dominate Numerically but Not in Energy Demand

- Local fleets are the most common use case across truck classes, but regional and long distance vocations drive higher energy demand and peak load risks.
- This implies that grid stress may be concentrated in fewer locations with high demand vocations, not necessarily where the greatest numbers of vehicles are.

4. Peak Load Management Will Be Critical

- The difference between typical and maximum annual energy demand is substantial, especially for long distance and regional vocations.
- Utilities must prepare for worst case charging scenarios, not just average demand, and consider smart charging, load balancing, and storage solutions, and rate structures that encourage off-peak charging.

5. Electrification of Buses Is Low-Risk and High-Impact

- School and transit buses have predictable, centralized charging patterns, making them ideal for early electrification.
- Their grid impact is modest at the aggregate level compared with other vehicle classes, but can be substantial at single points of charging requiring 5-15 MW.
- As early adopters of electrification, they can serve as a testbed for utility coordination and rate design.

6. Scenario Similarity Suggests Stable Behavioural Assumptions

- Despite differences in ZEV adoption rates across scenarios (Pembina, CEC, conservative), the distribution of electricity demand by vocation remains consistent.[19]
- This stability supports the use of vocational modelling as a reliable planning tool, even under policy uncertainty.

7. Inter-agency Coordination Is Critical

- Effective planning will require coordination between transportation agencies, energy regulators, and local governments to align fleet transition goals with grid capacity and investment timelines.

[19] This is more an implication of the modelling framework, as only sales targets vary while vocation shares and energy intensities are held constant.

Additional Data That Would Refine Projections

To improve accuracy and regional relevance, the following data would be valuable:

Operational and Charging Behaviour

- Real-world duty cycles and charging schedules by vocation and region.
- Truck stop activity and traffic flow variations, particularly along the main corridors.
- Depot locations and grid connection capacity for hub and spoke and transit fleets.
- Charging dwell times and power levels (e.g., overnight vs. opportunity charging).

Fleet Composition and Turnover

- Canadian-specific vocational mix (rather than relying on U.S. data).
- Fleet age distribution and replacement cycles by class and province.

Grid Capacity and Constraints

- Substation and feeder-level capacity data in areas with high fleet concentration.
- Time-of-use pricing impacts on charging behaviour.

Policy and Procurement Signals

- Public fleet electrification targets and funding programs.
- Private sector commitments (e.g., logistics companies, municipal fleets).

CONCLUSION

This preliminary assessment represents an important first step in understanding the electricity demand implications of MHDV electrification across Canada. By shifting the lens from vehicle class to vocational use case, the report offers a more utility-relevant framework for anticipating grid impacts and planning infrastructure upgrades.

Looking ahead, future iterations of this work will aim to incorporate regional analysis, peak demand modelling, and more granular forecasting using improved datasets. This includes vehicle load profiles, operational behaviour, and location-specific fleet data.

Calls to Action:

- **Fleet operators and municipalities**: Engage early with your utility to ensure your electrification plans align with available grid capacity and future infrastructure upgrades.
- **Industry associations and EMC members**: Share operational and vocational data to help fill current gaps and improve future modelling.
- **Utilities and regulators**: Use this framework to initiate scenario testing, investment planning, and stakeholder coordination.
- **Funders and research partners**: Support the next phase of this work to enable deeper regional analysis and more robust planning tools.

The transition to electric fleets is not just a technical challenge; it is a strategic opportunity to modernize Canada's transportation and energy systems. This report invites all stakeholders to contribute to that effort.

ACKNOWLEDGEMENT

Throughout this study, we held consultations with individuals and organizations who generously supported and collaborated with us. We are especially grateful to **Charlotte Argue (Geotab)** for sharing valuable articles and operational data that helped inform our assumptions on vehicle use. We also thank **Jeff Davis and Michael Chan (Asset Market)**, whose ongoing work on a similar project provided key insights. Their contributions helped shape the analytical direction and opened the door for future collaboration.

We acknowledge the support of the **load analysis and forecasting teams at BC Hydro, Toronto Hydro and Hydro-Québec**, who reviewed our methodology and provided thoughtful feedback to help refine our assumptions and improve the accuracy of our estimates.

We also appreciate the engagement of EMC's **Medium- and Heavy-Duty Vehicle Working Group** members, who offered advice on how to make our assumptions more realistic. Their input also helped shape the structure of the analysis.

Finally, a big thank you to **EMC’s Utilities Committee** for their continued engagement and support throughout this study. Their thoughtful feedback, shared resources, and utility-specific insights helped strengthen the foundation of the analysis and guided its direction. The recurring discussions were especially valuable in shaping the direction of the work and aligning it with utility planning needs.

APPENDIX - DATA AND FIGURES

Table 2: Stock of Canadian School and Transit Buses in 2023[20]

Year	School buses	Urban transit buses	ZEV School buses	ZEV Urban transit buses
2023	45,117	21,624	920	938

Table 3: Total New MHDV ZEV Registrations by Weight Class 2023 - 2024[21]

Year	Class	Count	Percent Contribution
2023	2B	1916	4.0%
2023	3	140	0.3%
2023	4	8	0.2%
2023	5	0	0.0%
2023	6	155	6.6%
2023	7	637	13.8%
2023	8	77	0.2%
2024	2B	1315	2.5%
2024	3	509	1.0%
2024	4	15	0.3%
2024	5	12	0.1%
2024	6	38	1.6%
2024	7	77	1.4%
2024	8	214	0.7%

Table 4: MHD ZEVS Sales Targets by Classes for the different scenarios[22]

Model Year	Scenario	Transit Buses	School Buses	Class 2B	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
2025	Pembina	15%	15%	10%	10%	7%	7%	7%	0%	0%
2026	Pembina	20%	20%	15%	15%	11%	11%	11%	2%	2%
2027	Pembina	40%	40%	20%	20%	15%	15%	15%	4%	4%
2028	Pembina	60%	60%	30%	30%	23%	23%	23%	6%	6%
2029	Pembina	80%	80%	40%	40%	30%	30%	30%	8%	8%
2030	Pembina	100%	100%	50%	50%	38%	38%	38%	10%	10%
2031	Pembina	100%	100%	60%	60%	47%	47%	47%	15%	15%

[20] Sources include Statistics Canada. Canadian passenger bus and urban transit industries, equipment operated, by industry and type of vehicle. Accessed February 2025; Équiterre. Pathways for Canadian Electric School Bus Adoption. Accessed June 2025; Calstart. Zeroing in on Zero Emission Buses. Accessed June 2025

[21] S&P Global. *EV Canadian Newsletter Q4 2024*. Accessed January 2025

[22] Sources include Clean Energy Canada. Policy Design Recommendations for a MHD ZEVS Sales Regulation (April 2024); Pembina. Towards Clean MHDVs: Preliminary policy solutions to decarbonize Canada's MHDVs. Accessed July 2025. In addition, a hypothetical scenario with lower target was also modelled. (Some targets may differ slightly from the source to ensure consistency with administrative data)

2032	Pembina	100%	100%	70%	70%	55%	55%	55%	20%	20%
2033	Pembina	100%	100%	80%	80%	65%	65%	65%	30%	30%
2034	Pembina	100%	100%	90%	90%	75%	75%	75%	40%	40%
2035	Pembina	100%	100%	100%	100%	85%	85%	85%	50%	50%
2036	Pembina	100%	100%	100%	100%	88%	88%	88%	60%	60%
2037	Pembina	100%	100%	100%	100%	91%	91%	91%	70%	70%
2038	Pembina	100%	100%	100%	100%	94%	94%	94%	80%	80%
2039	Pembina	100%	100%	100%	100%	97%	97%	97%	90%	90%
2040	Pembina	100%	100%	100%	100%	100%	100%	100%	100%	100%
2025	CEC	15%	15%	5%	5%	4%	4%	4%	0%	0%
2026	CEC	20%	20%	10%	10%	8%	8%	8%	5%	5%
2027	CEC	40%	40%	17%	17%	10%	10%	10%	6%	6%
2028	CEC	60%	60%	22%	22%	15%	15%	15%	8%	8%
2029	CEC	80%	80%	27%	27%	24%	24%	24%	11%	11%
2030	CEC	100%	100%	32%	32%	30%	30%	30%	14%	14%
2031	CEC	100%	100%	46%	46%	38%	38%	38%	20%	20%
2032	CEC	100%	100%	60%	60%	45%	45%	45%	31%	31%
2033	CEC	100%	100%	63%	63%	55%	55%	55%	36%	36%
2034	CEC	100%	100%	70%	70%	65%	65%	65%	41%	41%
2035	CEC	100%	100%	78%	78%	75%	75%	75%	46%	46%
2036	CEC	100%	100%	90%	90%	80%	80%	80%	58%	58%
2037	CEC	100%	100%	100%	100%	85%	85%	85%	65%	65%
2038	CEC	100%	100%	100%	100%	90%	90%	90%	77%	77%
2039	CEC	100%	100%	100%	100%	95%	95%	95%	88%	88%
2040	CEC	100%	100%	100%	100%	100%	100%	100%	100%	100%
2025	conservative	15%	15%	2%	2%	1%	1%	1%	0%	0%
2026	conservative	20%	20%	4%	4%	2%	2%	2%	0%	0%
2027	conservative	30%	30%	5%	5%	3%	3%	3%	1%	1%
2028	conservative	45%	45%	6%	6%	5%	5%	5%	2%	2%
2029	conservative	65%	65%	9%	9%	7%	7%	7%	3%	3%
2030	conservative	100%	100%	13%	13%	13%	13%	13%	6%	6%
2031	conservative	100%	100%	18%	18%	18%	18%	18%	9%	9%
2032	conservative	100%	100%	24%	24%	24%	24%	24%	15%	15%
2033	conservative	100%	100%	30%	30%	30%	30%	30%	20%	20%
2034	conservative	100%	100%	37%	37%	37%	37%	37%	35%	35%
2035	conservative	100%	100%	46%	46%	46%	46%	46%	45%	45%
2036	conservative	100%	100%	55%	55%	60%	60%	60%	60%	60%
2037	conservative	100%	100%	65%	65%	70%	70%	70%	65%	65%
2038	conservative	100%	100%	75%	75%	80%	80%	80%	75%	75%

2039	conservative	100%	100%	87%	87%	90%	90%	90%	85%	85%
2040	conservative	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 5: Stock estimates of Canadian MHDV by Classes in 2023[23]

Class	All fuel types	ZEV
2B	5550354	14211
3	327575	36
4	54185	1
5	90763	1
6	51513	11
7	72585	637
8	503669	77

Table 6: Lifespan of MHDVs by Class[24]

Class	Lifespan (years)
2B	7.75
3	9.2
4	11
5	11.1
6	11.1
7	11.9
8	11.9
School Buses	12
Transit Buses	12

Table 7: Operational Characteristics by Vocation and Vehicle Class[25]

Vocation	Class category	Typical average daily distance (km)	Typical longest daily distance (km)	Efficiency (KWh/km)
Door to Door	Medium-duty	80	180	0.5
Door to Door	Heavy-duty	120	235	1.6
Hub and spoke	Medium-duty	115	300	0.7
Hub and spoke	Heavy-duty	190	420	1.6
Local	Medium-duty	70	235	0.5

[23] Sources include Statistics Canada. Vehicle registrations, by type of vehicle and fuel type. Accessed April 2025. Transport Canada. ZEV Council Dashboard. Accessed May 2025. S&P Global. EV Canadian Newsletter Q4 2024. Accessed January 2025

[24] Sources include Community Energy Association. Class 2-4 Trucks Landscape in Canada. Accessed April 2025. Transport Canada. Commercial vehicle collisions in Canada, 2012-2021. Accessed April 2025. Pollution Probe. Opportunities For Accelerating School Bus Electrification In Ontario. Accessed April 2025. Équiterre. Pathways for Canadian Electric School Bus Adoption. Accessed June 2025

[25] Sources include CIMA+. Optimizing EV infrastructure planning with commercial transportation insights. Accessed June 2025. Transport Canada. Medium and Heavy-Duty Vehicle (MHDV) Grid Integration Study. Accessed August 2025.

Local	Heavy-duty	130	370	1.6
Regional	Medium-duty	180	585	0.7
Regional	Heavy-duty	320	780	1.6
Long Distance	Medium-duty	220	860	0.7
Long Distance	Heavy-duty	695	1110	1.6
Transit Buses	Transit Buses	200	300	1.2
School Buses	School Buses	58	128	0.6

The results for the Pembina scenario were presented in the body of the report to reflect the most ambitious ZEV uptake and grid impacts. If utilities can plan for this more challenging case, they will be well prepared for the less demanding scenarios (CEC and conservative scenarios) presented below for comparison and reference.

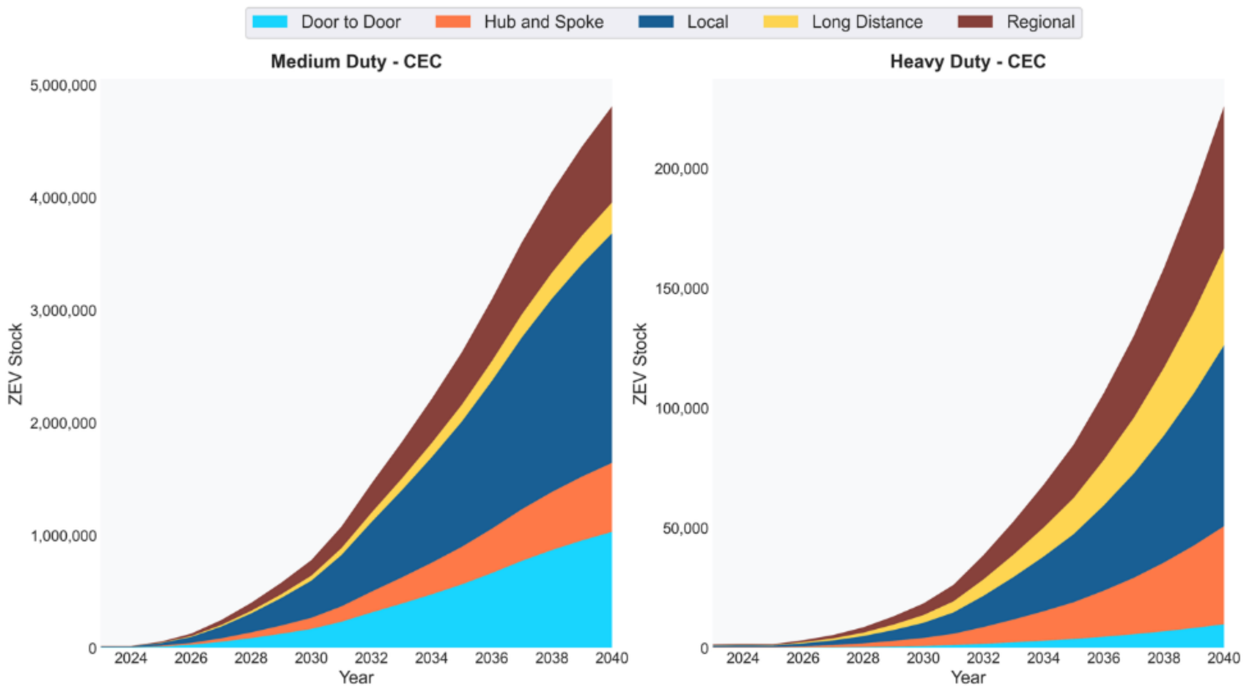

Figure 16: Stock Uptake by Vocation for ZEV Trucks (CEC Scenario)

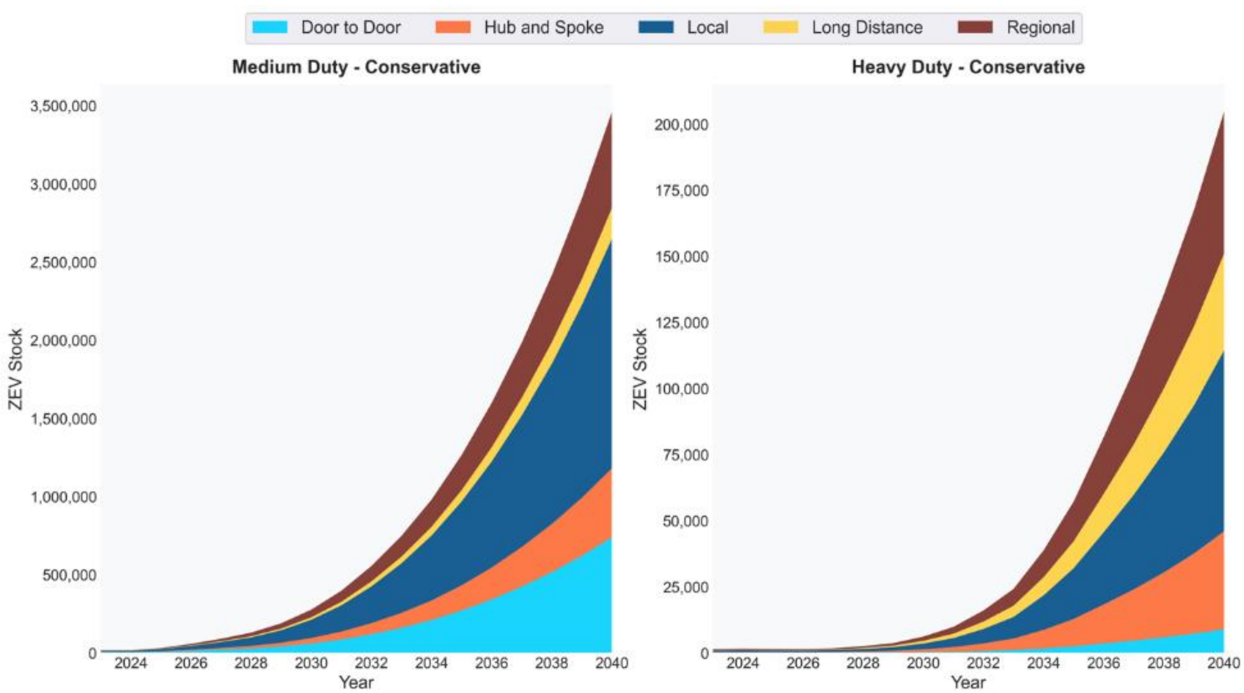

Figure 17: Stock Uptake by Vocation for ZEV Trucks (conservative Scenario)

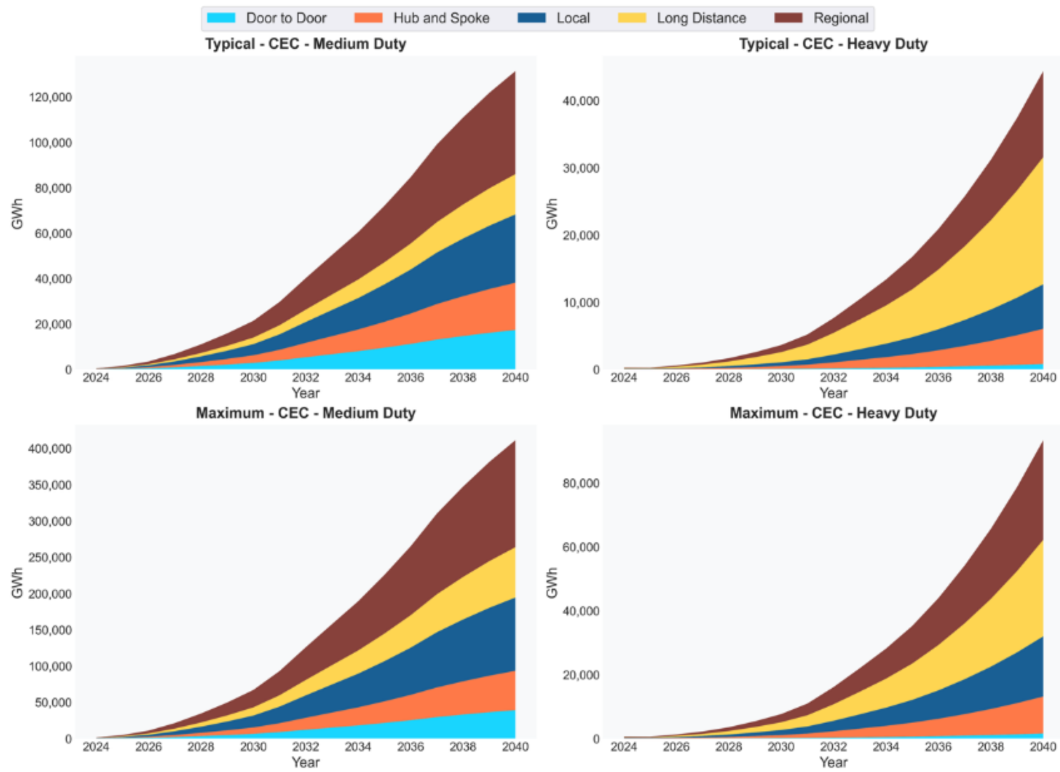

Figure 18: Typical and Maximum Annual Energy Demand (GWh) for ZEV Trucks by Vocation (CEC Scenario)

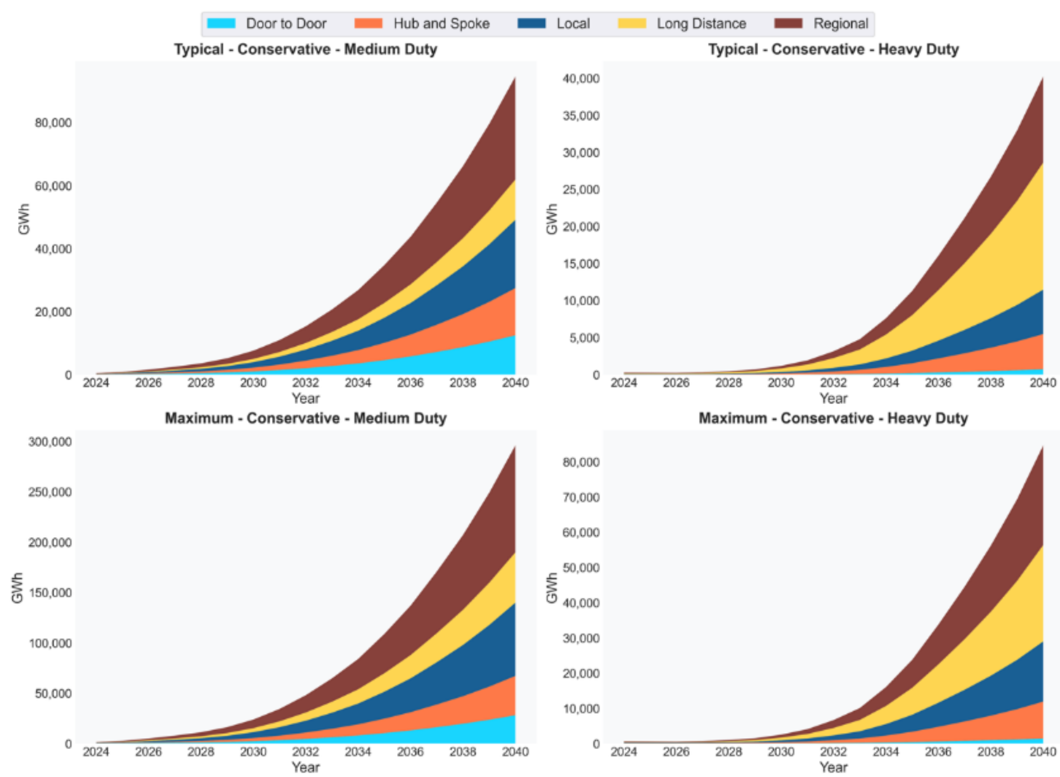

Figure 19: Typical and Maximum Annual Energy Demand (GWh) for ZEV Trucks by Vocation (conservative Scenario)

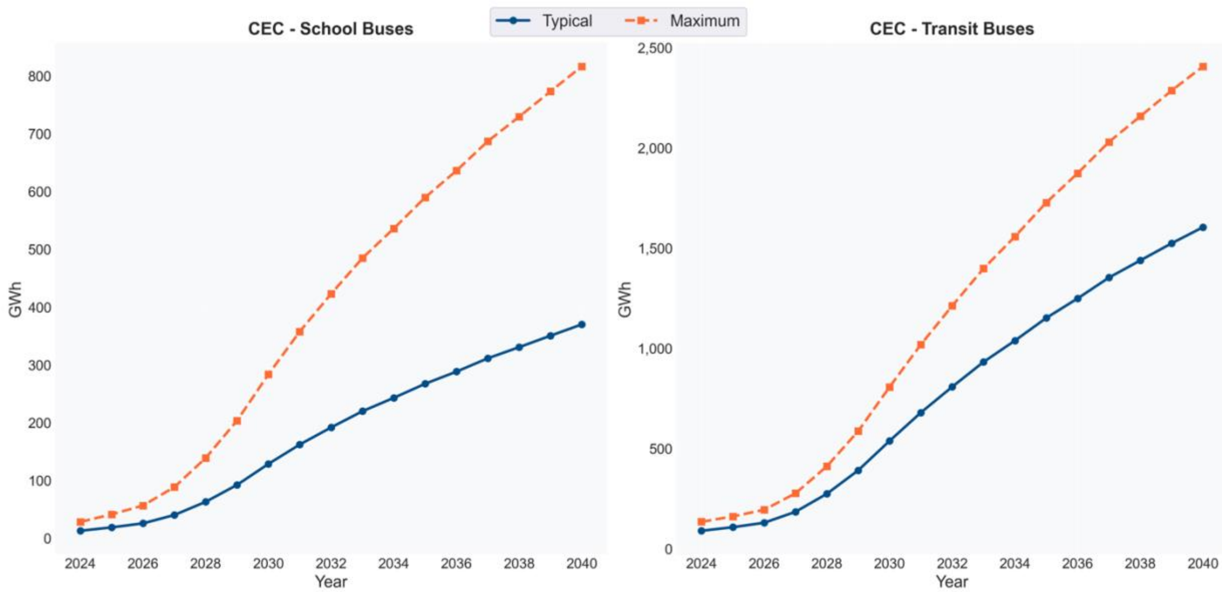

Figure 20: Typical and Maximum Annual Energy Demand (GWh) for Electric School and Transit Buses (CEC Scenario)

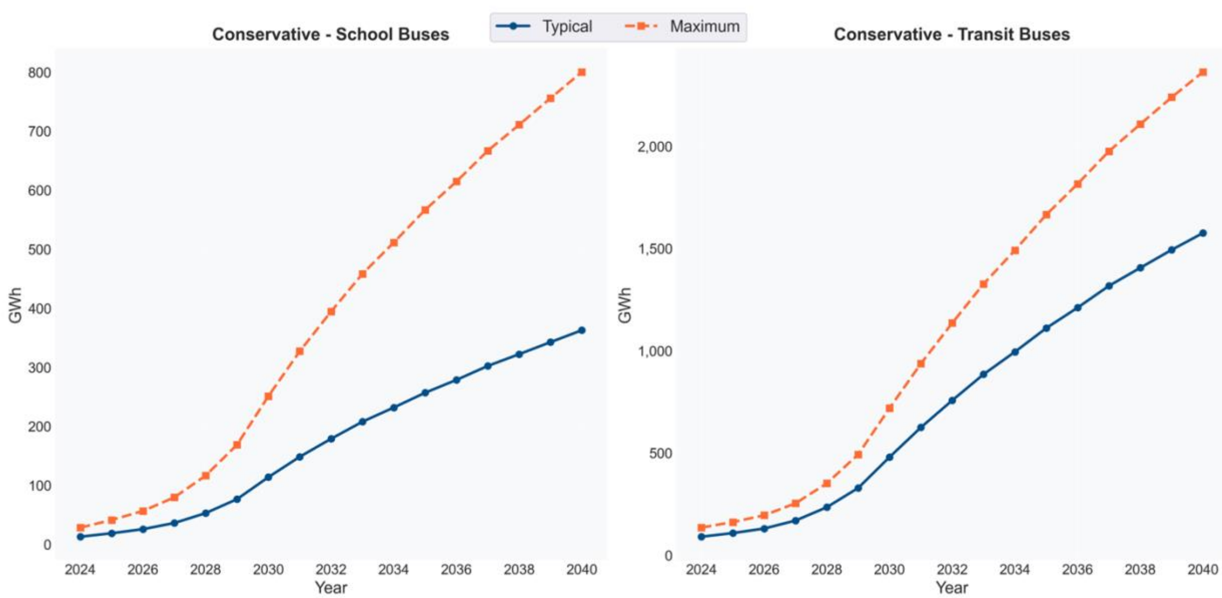

Figure 21: Typical and Maximum Annual Energy Demand (GWh) for Electric School and Transit Buses (conservative Scenario)

METHODOLOGY

This study assesses the adoption of MHD ZEV in Canada and estimates the resulting impact on the electric grid.

The methodology is divided into two main phases: (1) forecasting MHD ZEV adoption by vehicle class, and (2) estimating annual energy demand based on vocational use cases. Each phase is built upon a structured analytical framework supported by publicly available datasets, recommended policy targets, and operational assumptions.

1) Forecasting MHDV ZEV Uptake by Vehicle Class

The first phase of the analysis focuses on estimating the future stock of MHD ZEV across vehicle classes from 2023 to 2040. This was achieved through a dynamic stock evolution model that incorporates historical registration data, new sales data, vehicle lifespans, and sales targets. The foundational data used in this phase is presented in the « Data and Figures » section of the report, including baseline stock values for 2023 (both total and ZEV only) and average lifespans by class.

The model begins by establishing the base year (2023) stock for each class, using active registration data from Statistics Canada. For Classes 3 to 6, which are aggregated in the Statistics Canada dataset, a disaggregation was performed using proportional shares derived from S&P Global's new registration data and a commercial vehicle population extract that was provided to us by ICBC. These shares were applied to estimate the distribution of vehicles within each class, allowing for a more granular forecast.

Vehicle lifespans were sourced from industry reports and vary by class, ranging from 7.75 years for Class 2B to 11.9 years for Classes 7 and 8. These lifespans were used to calculate annual retirements, which, along with new sales, determine the net change in stock each year. The model follows a standard stock evolution formula:

$$Stock_t = Stock_{t-1} + Sales_t - Retirements_t$$

Where retirements are calculated as:

$$Retirements_t = \frac{Stock_{t-1}}{Lifespan}$$

Sales are derived from the difference in total stock year-over-year, adjusted for retirements:

$$Sales_t = Stock_t - Stock_{t-1} + \frac{Stock_{t-1}}{Lifespan}$$

To initiate the forecast, ZEV sales from 2023 were added to the base ZEV stock, particularly for classes with low penetration. These values were sourced from S&P Global and integrated into the model to ensure a realistic starting point.

Three policy scenarios were modelled: **Pembina, Clean Energy Canada (CEC), and conservative**. Each scenario applies different sales targets by class and year. For instance, Pembina proposes 100% ZEV sales by 2035 for Classes 2B and 3, while CEC adopts a more gradual ramp-up, reaching full adoption by 2037 for these classes. For Classes 4 to 6, Pembina's targets were adjusted to align with administrative vehicle data, assuming a configuration split of 70% box trucks and 30% non-box trucks, based on the Canadian Vehicle Survey (2009).[26] For Classes 7 and 8 under CEC, sales targets were weighted between tractors (70%) and rigid trucks (30%) using insight from a heavy-duty vehicle tire market study.[27] These adjusted targets were then applied to calculate annual ZEV sales, which were used to update the ZEV stock for each class.

[26] Natural Resources Canada, Canadian Vehicle Survey 2009, Accessed October 2025.
[27] Transport Canada, Heavy-Duty Vehicle Tire Market Analysis Study, Accessed October 2025.

Population projections from Statistics Canada's M1 scenario[28] were used to scale ZEV adoption forecasts, assuming that the vehicle stock as a proportion of the population remains constant over time. The school-age population (ages 4–18) served as the denominator for stock-per-capita calculations for school buses. Transit buses and the other MHDV classes were treated similarly, but without age restrictions on the population.

The output of this phase includes annual forecasts of total and ZEV stock by class, under each scenario. These results are visualized in the report and form the basis for the second phase of the analysis.

2) Estimating Energy Demand by Vocation

The second phase shifts the focus from vehicle classes to vocational use cases, aiming to estimate the annual energy demand resulting from MHD ZEV adoption. This approach recognizes that energy consumption varies significantly depending on how vehicles are used and thus requires a vocation-based lens.

Five vocational categories were considered, based on operational data from Geotab and NREL **(Table 1**): Door to Door, Hub and Spoke, Local, Long Distance, and Regional. School and transit buses were retained as standalone categories due to their distinct operational profiles.

The distribution of vocations within each class was derived from the *"Vocation_Pct_Of_Included_Class"* variable in NREL's Depot-Based MHDV Operations dataset. These shares were assumed to apply to the Canadian context and remain constant over time, acknowledging that future work could refine this assumption.

Each vocation was mapped to a set of operational archetypes, including average and maximum daily distances, energy efficiency (in kWh/km), and vehicle class (medium or heavy-duty). For example, Local (Medium-duty) vehicles were assumed to travel an average of 70 km/day at 0.5 kWh/km, while Long Distance (Heavy-duty) vehicles were modelled at 695 km/day and 1.6 kWh/km.

To account for climate-related efficiency variations, temperature adjustments were derived from a Geotab figure showing the relationship between temperature and EV range.[29] As the underlying data were not publicly available, the main temperature–range ratio pairs were noted from the figure, and then we applied a polynomial fit to reconstruct the functional form of the relationship. Canada's projected temperature anomalies from Canada's Changing Climate Report (low emission scenario RCP2.6) were then rebased to estimate annual mean temperatures from 2024 to 2040.[30] The resulting values were then used to calculate a temperature-adjusted range ratio for each year.

Energy demand was calculated for each year, vocation, and scenario using the following formulas:

- **Typical Energy Demand:**

$$Energy_{typical} = \frac{Efficiency}{Range\ Ratio} \times Average\ Distance\ Driven \times ZEV\ Stock$$

- **Maximum Energy Demand:**

$$Energy_{maximum} = \frac{Efficiency}{Range\ Ratio} \times Longest\ Distance\ Driven \times ZEV\ Stock$$

[28] Statistics Canada, Projected population, by projection scenario, age and gender, Accessed April 2025.
[29] Geotab, Top EV range factors to extend fleet efficiency, Accessed March 2025.
[30] Bush, E. and Lemmen, D.S., editors (2019): Canada's Changing Climate Report; Government of Canada, Ottawa, ON. 444 p.

These calculations were performed for each vocational category and aggregated to estimate annual energy needs in gigawatt-hours (GWh).

The final results include stacked area plots showing typical and maximum energy demand by vocation, as well as scenario comparisons. These visualizations highlight the relative contribution of each use case to overall grid load and provide initial insights into peak demand risks.