FUTUREPROOF YOUR FLEET

HEAVY DUTY Vehicle Resource Guide

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Partners in Project Green

A Program of Toronto and Region Conservation Authority

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Executive Summary

Freight transportation accounts for 10% of Canada's GHG (greenhouse gas) emissions[i]. More locally, the transportation sector is seen as the second largest contributor to the Greater Toronto area's overall emissions[ii]. This highlights the urgent need for fleet owners and operators to adopt cleaner alternatives.

There are a wide range of alternative technology options available for fleets today. Each one of them offers unique benefits and challenges, in terms of vehicle performance, emission reduction and more. To make informed decisions that can balance environmental benefits with operational feasibility, it is crucial for fleet managers and business owners to have access to technical expertise, financial incentives, and support for infrastructure development

With the evolution of low carbon and zero emission vehicles and fuel types, fleet owners are faced with several opportunities and challenges. This guide is designed to help fleet owners of Heavy-duty vehicles (HDVs), a category includes Vehicle Classes 7 to 8, as per Transport Canada[iii]. Urban Delivery trucks, buses, freight carriers and yard tractors are common examples of HDVs. For companies aiming to switch their fleets to cleaner alternatives, it is crucial to have access to technical expertise, financial incentives, and support for infrastructure development.

This guide gives an overview of four Zero Emission Vehicle (ZEV) technologies for HDVs:

- Battery Electric
- Compressed/Renewable Natural Gas (CNG/RNG)
- Hydrogen
- Renewable Diesel

The path to fleet decarbonization may involve the use of multiple technologies, based on the size of the fleet, its unique duty cycle, operations, facility and available infrastructure. As technology adoption increases, the availability and affordability of low-carbon alternatives suited to HDV fleets are expected to increase.

About Futureproof Your Fleet

Futureproof Your Fleet is a program by Toronto and Region Conservation Authority's Partners in Project Green. It brings together leaders in the green vehicle space to offer information, resources, discussions, and networking opportunities to develop a low carbon fleet. Low carbon and zero emission technologies like hydrogen fuel, natural gas, renewable diesel and battery electric are discussed in detail, through expert-led workshops, insightful presentations and panelist discussions. The Futureproof Your Fleet Resource Hub offers helpful information, guides and tools to businesses and fleet operators.

This project is funded in part by the Government of Canada, through its Zero Emission Vehicle Awareness Initiative.

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About the Authors

Partners in Project Green

Toronto and Region Conservation Authority's Partners in Project Green is a not-for-profit community of leaders advancing environmental action and economic prosperity across the GTA. Comprised of businesses, government, institutions and utilities, PPG works to collectively advance social and environmental sustainability through knowledge sharing, technology and infrastructure implementation, and network building.

We thank our partners and technology experts who have helped develop these resources:

Change Energy Services (CES) is a strategic engineering services firm specializing in gaseous fuel systems solutions. They help their clients transition to the low carbon economy by guiding them to execute major fuel system changes within their operations to achieve desired economic, environmental, and social outcomes.

Refuel Energy Inc. produces renewable fuels for use in existing equipment and infrastructure. Toronto-based Refuel Energy is planning to build a renewable fuel production facility in Ontario.

Enbridge Gas is Canada's largest natural gas storage, transmission and distribution company based in Ontario. They provide an energy choice for approximately 3.9 million residents and businesses, and are actively supporting the transition towards a net-zero future.

Plug 'N Drive is a non-profit organization committed to accelerating the adoption of electric vehicles in order to maximize their environmental and economic benefits. Since 2011, Plug'n Drive has established itself as a Canadian leader in the electric vehicle industry, a trusted and unbiased source of information about electric cars, charging stations and the electricity sector.

The Transport Project Canada is a national coalition of fleets, vehicle and engine manufacturers, servicers, suppliers, and fuel producers and providers dedicated to the decarbonization of the transportation sector.

FleetZero is a turnkey solution provider helping medium and heavy duty fleets transition to low and zero emission propulsion technologies. It offers advisory, implementation and maintenance services as well as safety tooling and personal protective equipment.

Introduction

I. Overview

The transportation sector is responsible for 36% of the GTHA's emissions, driven by gasoline and diesel use[iv]. A sizable portion of these transportation-related GHG emissions is related to medium and heavy-duty vehicles (MHDV). This sector primarily operates on conventional fuels. Identifying potential pathways for reducing emissions can aid efforts to lower carbon emissions from freight transportation.

There are a wide range of alternative technology options available for fleets today. Each one of them offers unique benefits and challenges, in terms of vehicle performance, emission reduction and more. According to the State of Sustainable Fleets 2024 Market Brief, the transport industry is entering a "period of peak complexity" at this early stage of a sustainable transition. Any shift in vehicle technology can lead to some expected, as well as some unintended, consequences. It is important for fleet managers and operators to be well informed and consider several different factors during the planning phase, which can include the type of fuel, availability of refueling and/or recharging stations, driving range, vehicle usage, infrastructure development and safety.

II. Fleet Transition Planning

Managing a fleet requires extensive planning, careful decision-making and staying up-to-date with the changing technology landscape. The Greening Government Fleets report[v] by Natural Resource Canada (NRCan) outlines several best practices for transitioning to a low carbon fleet that may be applicable to businesses. These include data collection to optimize the existing fleet and developing a fleet transition plan.

Fleet managers and operators may consider the following recommendations for the transition to low-carbon and zero emission vehicle (ZEV) technologies:

1. Evaluate Fleet Needs: Assess the business needs and operational patterns to select the most suitable ZEV technology for your fleet. Collect baseline data and determine the scope, budget and timeline for the transition.

2. Assess Infrastructure Readiness: Develop a comprehensive plan for the necessary infrastructure, such as charging stations for electric vehicles or fueling stations for CNG/RNG, renewable diesel and hydrogen fuel vehicles.

3. Initiate Pilot Programs: Start with pilot programs to test the performance and feasibility of different technologies and vehicle options.

4. Monitor and Optimize Results: Compare results with the baseline data from existing fleet technologies. Monitor the performance of the new technologies and continue to optimize operations to achieve higher efficiency.

5. Train Staff: To ensure safe and efficient operations, train all operators, managers and support staff and prepare them to work with new technology.

III. How to use this guide

This guide is designed to help with decision making on transitioning to low carbon and zero emission heavy-duty vehicle (HDV) fleets. It covers four key technology options with a high-level discussion on vehicle availability, market outlook, infrastructure, economics, maintenance and safety. This resource guide provides guidance to help fleet managers plan and deploy new technologies for their HDV fleet to reduce their environmental impacts and operational challenges.

What are Heavy Duty Vehicles?

Heavy duty vehicles (HDVs) are categorized under Classes 7 and 8, based on their Gross Vehicle Weight Rating (GVWR) by Transport Canada. These vehicles include cargo trucks, truck tractors, cement mixers and Dump trucks and more. Transport Canada offers additional information on vehicles classification: Eligible vehicles (canada.ca)

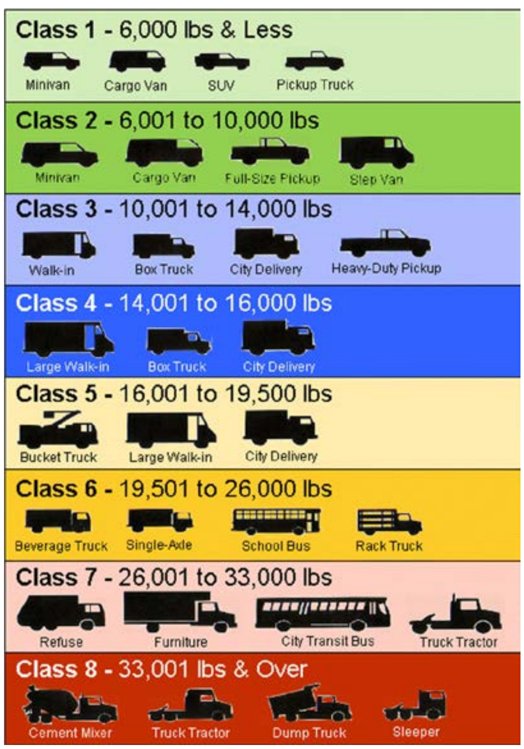

Figure 1. Vehicle weight classes as defined by the Federal Highway Administration, US Department of Transportation (USDOT) *Source*: US Department of Energy, Office of Energy Efficiency and Renewable Energy webpage

2. Low Carbon and Zero Emission Technologies

Several low carbon and zero emission technologies are available for fleet managers to consider. This list includes hydrogen fuel, battery electric, compressed natural gas, renewable diesel and more. Each of these options offers opportunities for heavy duty vehicle (HDV) fleet decarbonization and the right choice for fleet managers depends on their organization's specific fleet needs, infrastructure requirements, budget, and environmental goals. Fleet managers must assess the duty cycle of fleets effectively, which involves understanding the operational patterns and refueling needs. In addition to emissions and decarbonization targets, fleet managers must consider several critical factors, including vehicle availability, costs, maintenance, safety, and infrastructure development to make a well-informed decision. It is important to consider how switching to any one of these technologies can impact fleet and vehicle performance in the long term. The above mentioned four technologies are presented in the following section:

I. Battery Electric

Electric vehicles can be classified as Battery Electric Vehicles (BEVs), which run solely on electricity or Plug-in Hybrid Electric Vehicles (PHEVs), which operate on both electricity and gasoline/diesel:

- **BEVs** are powered by electricity stored in rechargeable batteries that are typically made from a variety of materials, including metals and minerals such as lithium, cobalt, and nickel, etc. As they do not burn any fossil fuels when operating, they produce zero tailpipe carbon emissions making them an effective option for reducing fleet emissions[vi].

- **PHEVs** make use of batteries as well as gasoline/diesel to power an internal combustion engine. Depending how often the vehicle is operated in all-electric mode, PHEVs[vii] can offer lower operating costs, fuel savings and emissions reduction, relative to conventional vehicles.

  Recent developments in battery technology have significantly improved the driving range and efficiency of EV vehicles from their earlier versions. BEVs offer noise reduction benefits and quieter operations, which leads to a more comfortable working environment for the drivers[viii].

KEY CONSIDERATIONS:

Applications and Market Outlook: Electric battery technology is considered suitable for decarbonizing return-to-base and regional or short-haul duty cycles due to their limited range, as compared to conventional fuels. Diesel and gasoline based conventional trucks have a substantial advantage when it comes to range, as they can travel up to 3,000 km without refueling, compared to most electric tractor-trailers which have a range of 800-1000km[ix]. This could be higher with extended-range vehicles.

The use of telematics, also known as fleet tracking or GPS vehicle tracking, can enhance EV adoption by optimizing routes, planning charging infrastructure, and predicting maintenance needs[x]. It helps manage energy consumption, leading to increased efficiency of vehicle charge and therefore reduced charging-related costs. These devices, if installed across all the fleet vehicles, allow operators to accurately identify opportunities for improvement. This can include identifying patterns to determine how energy consumption can be optimized or predicting battery maintenance needs that are best suited to a fleet's duty cycle. For example, charging during mandatory health breaks and loading times could help electric HDVs to maintain efficient schedules.

Telematics are offered by several providers such as Geotab, Bell, Telus and FleetChallenge.

Vehicle Availability & Timelines: A multitude of factors can impact the timelines for transitioning a fleet to electric battery technology. Key considerations include fleet size, vehicle availability, and the infrastructure requirements on-site. Sufficient fleet data collection should also be incorporated into planning timelines. While there has been an increase in the availability of heavy-duty electric vehicles in the market, site level infrastructure changes are likely the most time-consuming aspect of fleet transition. If site level infrastructure changes are required, they should be planned for early on to ensure that facilities are ready to support the vehicles when they arrive. Larger fleets could require even more time due to the need for more upgrades, charging stations and staff training.

Clean Energy Canada's catalogue provides a list of zero-emission HDV models and their availability in the market

Infrastructure: Adopting BEVs can result in a significant load on the local electricity grid, as additional electrical capacity is required for vehicle charging needs. Fleet managers have two infrastructure options to consider when evaluating fleet conversion to EVs: on-site charging or off-site charging.

On-site charging involves the installation of EV chargers and the necessary electrical infrastructure to charge their fleet vehicles at their facility. To ensure that proper electrical capacity is secured for on-site charging needs, it is important for fleet managers to identify licensed electrical contractor and ensure that the equipment is 'ULc' or 'CSA' certified. Off-site charging can involve the use of public infrastructure or private, third-party charging locations.

When comparing on-site charging to off-site or public infrastructure, fleet managers need to weigh the costs and benefits of setting up on-site chargers and the use of public infrastructure and plan for future expansion[xi]. Each option has its pros and cons, which are further described below.

Table 1. On-site vs. Public Charging for Electric Fleets

	On-site charging	**Public infrastructure**
Benefits	On-site charging offers higher convenience and control. Fleet managers can optimize charging schedules to reduce energy costs.	Operators can utilize a growing network of public chargers without a high upfront cost.
Challenges	The cumulative expense of charging, equipment, installation, site upgrades, space requirements, along with ongoing maintenance can be very high.	With public chargers, operators have less control over the charging time. This can lead to potential downtime. In certain cases, there may be compatibility challenges with public charging stations.
Fleet managers are advised to: • Compare the cost of installing charging stations on-site vs. public infrastructure. • Analyze the daily usage patterns to determine infrastructure needs. • Take future expansion and technological advancements into account. • A hybrid approach, combining both on-site and public charging, can balance costs and provide flexibility in case of fleet expansion.		

Safety: In addition to standard electrical safety training, fleet managers and mechanics need to follow specialized protocol when working with EVs due to their high-voltage system[xii]. Many manufacturers publish guides for their vehicles which must be adhered to. It is important to ensure that mechanics are equipped with the right personal protective equipment and professional tools such as fault-detection probes and insulated hand tools.

The U.S. Department of Energy's Alternative Fuels Data Center (AFDC.) provides a helpful checklist for fleet managers to implement electric vehicles and charging infrastructure.

Maintenance: Fully electric BEVs generally have lower maintenance needs, compared with conventional vehicles. This is because the battery and electronic components typically require minimal scheduled maintenance, and the regenerative brake systems generally last longer. However, it is important to note that Plug-in hybrid electric vehicles (PHEVs) and hybrid electric vehicles (HEVs) have internal combustion engines, with maintenance requirements that are similar to conventional fleets[xiii].

Adhering to the battery manufacturer's maintenance schedule is critical to keeping the electrical systems in good condition. Temperature sensitivity is a significant challenge, particularly affecting the driving range in colder climates. Special measures for maintaining EV fleets include having a Battery Thermal Management

System in place. Regular software updates may also be needed to ensure that the battery management system is functioning optimally[xiv].

Economics: While the upfront cost price of an electric vehicle is typically higher than a comparable conventional vehicle, it is important to compare the fleet's total cost of ownership (TCO). TCO is the overall associated with purchasing and operating the vehicle over its lifetime and provides a balanced way to compare technology options[xv]. It is influenced by a number of factors[xvi], such as the cost of chargers, electricity costs, the charging facility, maintenance, payload capacity, and repairs. As more fleets transition to electric vehicles, the affordability of both BEVs and PHEVs is likely to improve. This trend may be driven by innovations in battery technology, economies of scale, and government incentives aimed at EV adoption. Additionally, owing to simpler mechanics than combustion engines, BEVs can lead to a lower operational cost.

The **Electricity vs Gas/Diesel Fuel Cost Calculator** tool by Electric Autonomy allows users to compare the cost of operating a fleet of electric vehicles vs. combustion vehicles based on local electricity rates.

II. Compressed Natural Gas (CNG) and Renewable Natural Gas (RNG)

Compressed Natural Gas (CNG) and Renewable Natural Gas (RNG) are different forms of natural gas, mainly composed of methane, stored under a high-pressure system[xvii]:

- CNG is extracted from fossil fuel sources and compressed to a high pressure. Being less carbon dense, the combustion of CNG produces 20% less greenhouse gas (GHG) tailpipe emissions and nearly 90% less NOx, SOx, and particulate matter (PM) than the combustion of conventional diesel[xviii].
- RNG is produced by purifying biogas from decomposing organic waste material and is chemically identical to CNG. It offers a cleaner alternative to gasoline and diesel, and can promote a circular economy, as it is primarily composed of methane sourced from waste matter. It is considered to have a high potential to reduce GHG emissions[xix]. This is because the use of RNG has the potential to avoid the use of fossil fuels and divert the methane that would otherwise be released into the atmosphere by decomposing organic waste, in landfills, wastewater treatment plants and farms.

KEY CONSIDERATIONS:

Application and Market Outlook: CNG and RNG vehicles can be a practical choice for both short and long-haul applications. The range, payload and fueling time are similar to those of petroleum-diesel operated vehicles. The range of CNG/RNG vehicles can vary, depending on the size of the storage array, payload, driving environment and additional energy loads like hydraulics. On average, CNG heavy-duty vehicles can travel from 650 to 1300 km on a full tank. However, this driving range can be further extended with the help of additional CNG/RNG storage tanks[xx]. This modularity to CNG/RNG storage on-board can help vehicles meet a wide range of applications including straight truck, line haul, cement mixers and car carriers.

Liquefied natural gas (LNG) is another form of natural gas which is on the horizon and may gain more traction in the heavy-duty truck market[xxi].

Vehicle Availability & Timelines: Conventional vehicles can be converted to operate on natural gas, similar to propane. CNG technology and equipment is compatible with most of the existing vehicles, and minimal modifications are needed in some cases. This may include upgrading the ignition system to handle the different combustion characteristics of CNG.

Diesel engines can be adapted to CNG blending kits, which are fitted to displace some diesel (30% to 45% by equivalent energy) fuel with natural gas as part of the diesel combustion cycle. Natural gas is mixed with air through the intake manifold. A computer rachets back the amount of diesel fuel pumped into each cylinder.

The local inventory of vehicles, as well as the availability of compatible components, will ultimately have an impact on the overall timeline for transitioning to CNG or RNG[xxii].

Infrastructure: As CNG/RNG vehicles require natural gas for their operations, access to fueling infrastructure is an important consideration for fleet managers interested in transitioning their fleets. Existing natural gas infrastructure is being leveraged to develop CNG and RNG fueling stations[xxiii]. In the future, the extensive network of natural gas pipelines across Canada can be used to transport RNG to fueling stations. Existing CNG fueling stations can also be upgraded to handle RNG and reduce the need for new infrastructure.

To switch to CNG or RNG, fleet managers may consider a few infrastructure options:

- Option 1 – Public stations: Fleet managers and business owners must confirm natural gas supply in the area. Ontario has refueling stations available for public/commercial use, with more being developed along the Trans-Canada Highway.
- Option 2 – Onsite Station: Fleet managers can work with gas utilities and contractors to build an onsite CNG/RNG Station. Additional retrofits and approvals/licenses may be required at the site to ensure safe operations[xxiv].
- Option 3 –Refueling as a service: Fleet managers may work with third party providers and opt for a portable fast filling system for transportation fleets, where no direct gas connection is required.

Safety: CNG/RNG are considered to be high integrity fuel systems with years of data available and are similar to diesel vehicles in terms of their safety factors. Potential risks may include fire hazards and leakage[xxv]. Other safety risks can be attributed to the need for high-pressure gas storage. Collision risks are not exacerbated by weight, as the vehicle weight is at par with conventional vehicles. Drivers and operators should receive proper training on the safe handling and operation of CNG vehicles. This training should include leak detection and how to handle emergencies. When refueling CNG, drivers and operators must follow safety precautions and ensure that fire extinguishers and first-aid kits are present in the vehicle[xxvi].

Maintenance: Service intervals similar to diesel vehicles are recommended for CNG/RNG vehicles. Natural gas fuel filter and coolant recovery tanks levels must be monitored daily and air intake must be checked at regular intervals. Operators and mechanics must be trained as per the manufacturer's instructions[xxvii].

Economics: As more companies make fuel technology transitions, the affordability of CNG vehicles is expected to increase. There is a high potential for continued adoption of this fuel by fleet owners seeking sustainability and cost-efficiency in operating their HDV fleets. Due to a cleaner combustion process, the maintenance costs associated with CNG/RNG are lower than conventional diesel engines. However, the overall cost is highly dependent on the duty cycle of the fleet.

CNG and RNG vehicles may have a higher upfront cost compared to traditional diesel vehicles due to the need for a specialized fuel system or vehicle modification. Therefore, it is important to consider the Total Cost of Ownership (TCO) for a comprehensive assessment. Market data suggests a 30-50% reduction in fuel costs with CNG, when compared with conventional diesel as there is no requirement for diesel after-treatment systems, regenerated burn off of soot, nor the added cost of diesel exhaust fluid (DEF). There is a high potential for continued adoption of this fuel by fleet owners seeking cost-efficiency and sustainability goals. Providers such as Cummins and Enbridge offer capital cost comparison and comparative performance modelling analysis.

🔗 Retail prices for different fuel types including CNG can be found on Ontario Government’s website: **https://www.ontario.ca/motor-fuel-prices/**

III. Hydrogen Fuel

Seen as a promising clean source of energy, hydrogen can be used to power vehicles in primarily two different ways:

- Fuel Cell Electric Vehicles (FCEV): Hydrogen acts as a carrier of energy, which flows into a fuel cell, reacts with oxygen and creates electricity that powers the electric motor.
- Hydrogen Internal Combustion Engines: These vehicles burn hydrogen in a modified internal combustion engine, similar to gasoline used in conventional engines.

Both FCEVs and Hydrogen ICE are complementary technologies for reducing transportation emissions. Their adoption can drive the development of hydrogen production, transportation, and distribution infrastructure. Significant public and private investments will provide the impetus to advance the supply and infrastructure for hydrogen, for it to be taken up as a public retail technology for in the Greater Toronto Area[xxviii].

Hydrogen Strategy for Canada's Report *highlights significant developments across the hydrogen value chain*

The following section provides more information on the adoption of FCEVs:

KEY CONSIDERATIONS:

Application and Market Outlook: FCEV technology is considered to be highly suitable for HDV return-to-base operations, due to the limited availability of refueling infrastructure at present. As demand grows and fueling infrastructure develops in the future, long haul operations will benefit from this lightweight energy storage technology. This is particularly important for HDV fleets, where long-distance driving is common and ample fuel is required. Hydrogen allows for lighter weight energy storage onboard the vehicle, as compared to an electric truck of a similar size. FCEVs contain a higher amount of energy-per-unit mass than a battery storage setup or conventional diesel. Therefore, the vehicle can get a higher amount of energy, without significantly increasing the overall weight. This is an important consideration for long-haul trucks that often need to adhere to strict regulations on weight. Furthermore, hydrogen can be a suitable technology for long-distance and 24/7 commercial operations, as the refueling times are short and comparable to diesel vehicle refueling[xxix].

Infrastructure: The selection of refueling infrastructure depends on the technology used for storing hydrogen onboard vehicles. Hydrogen is not energy dense and therefore needs to be stored at high pressure to provide adequate driving range and reduce refueling frequency. Onboard a vehicle, it is typically stored at either 350 bar or 700 bar pressure[xxx]. It is less expensive to deliver hydrogen at lower pressures, which is why it is important to determine the optimal pressure when deploying refueling infrastructure and to minimize costs[xxxi]. When it comes to heavy duty transport, 700 bar pressure is considered the most suitable for long haul driving.

Hydrogen refueling stations comprise of storage, compression, and dispensing equipment. These stations do not come in standard sizes and are available in several different configurations, ranging from smaller on-site stations to large stations for retail applications[xxxii]. While smaller stations meant for a lower pressure fill offer a lower operating cost, the larger fueling stations may be required to meet the needs of high volume. In addition to this, fueling stations could be designed for slow or fast fills. The 'slow-fill' configuration offers lower capital and operating costs but requires a 6–8-hour time window. On the other hand, a 'fast-fill' is preferred if the fleet of vehicles is to be refueled in back-to-back succession. Fleet managers must consider their fleet's duty cycle to decide on their refueling infrastructure needs[xxxiii].

The Canadian Hydrogen Association's ***Hydrogen Production Database*** *features a map of hydrogen production facilities, contributed voluntarily by Canadian producers.*

Vehicle Availability & Timelines: Hydrogen may be seen as an emerging fuel type by most commercial fleets, as the domestic supply chain for hydrogen is still under development. Fleet managers may need more time to evaluate their options and identify Original Equipment Manufacturers (OEMs) and fueling providers to begin piloting this technology. Acquiring FCEVs typically has longer wait times than conventional vehicles. Additionally, a long lead time for acquiring fueling equipment, based on the required pressure, can be expected.

The North American Council For Freight Efficiency (NACFE) has outlined trends that could hasten hydrogen adoption in their ***Guidance Report***

Safety: Hydrogen has no color or odor, but it can have very high leakage and dissipation rates due to its light molecular weight, which requires specialized equipment for detection of leaks. Within a confined space, hydrogen may leak and accumulate to a flammable concentration. Therefore, adequate ventilation is required, and the use of advanced hydrogen detection sensors is recommended. Drivers and operators also need to be trained in the appropriate methods to extinguish hydrogen fires and equipped with protective gear.

Efforts are underway to harmonize international safety regulations for FCEVs. The National Renewable Energy Laboratory in the US is developing compliance verification tools. The Canadian Hydrogen Installation Code (CHIC) is the standard which establishes the installation requirements for hydrogen generating equipment, transport, storage, and maintenance.

Maintenance: Effective thermal management is key to maintaining optimal operating conditions for hydrogen fuel cells[xxxiv]. Extremely high or low temperatures can be detrimental to vehicle performance and reduce durability in the long run. To ensure that FCEVs operate efficiently and have a long lifespan, a thermal management system specific to the technology type may be required[xxxv]. Fleet managers can refer to the CSA Group Codes and Standards for Canadian Infrastructure such as CSA B401.1 (and the soon to be released CSA

B401.3) for general maintenance facility requirements. It is also important to keep note of OEM recommended preventative maintenance schedules for fuel cell vehicles.

Economics: Understanding the fleet's duty cycle can help determine the cost effectiveness of adopting FCEVs. As several interconnected factors add to the overall operational cost, a hydrogen fueling station must be sized to meet specific needs of the fleet. The cost of a fueling station is heavily dependent on the type of operation and could range from thousands of dollars for a small station up to multi-million-dollar projects for larger stations. The cost of infrastructure projects ultimately depends on the type of station and overall capacity required, since these projects are typically customized to suit specific fleet needs. As Hydrogen fueling technology becomes more widespread in the market, associated costs are expected to come down in the future, following similar trends with other clean technologies.

*The **Hydrogen Village** offers educational training programs on Hydrogen fuel technology.*

IV. Renewable Diesel

Renewable Diesel (RD) presents a significant advancement in sustainable fuel technology as it is produced from recycled cooking oils, used vegetable oil and animal fats. It is important to note that RD is not the same fuel as biodiesel, as it undergoes a different production process called hydrotreating, and has a distinct molecular structure. Both fuel types have very different production pathways, which in turn impacts their operational characteristics and suitability for different types of fleets[xxxvi].

- **Renewable Diesel**: It is chemically similar to conventional diesel and can be used directly in diesel engines. There are no special handling, blending or storing requirements, as it meets the international standards (ASTM D975) for petroleum diesel and can be used as is. RD has no blending limits, as compared to biodiesel.
- **Biodiesel:** It requires blending with petroleum diesel and has different chemical properties, storage and handling requirements. Typically, 20% biodiesel is blended with petroleum diesel and it must meet prescribed quality standards as specified by ASTM D7467 International Standards[xxxvii].

RD presents the opportunity to achieve significant reduction in emissions, even though its tailpipe emissions are comparable to conventional diesel. This is because the production process for renewable diesel typically results in lower GHG emissions compared to conventional diesel, over its lifecycle[xxxviii]. To make this assessment, it is important to take into account all the lifecycle stages from feedstock cultivation to processing and transportation of the fuel[xxxix]. If RD is produced from local organic waste, it can help reduce waste and promote a circular economy[xl].

KEY CONSIDERATIONS:

Application and Market Outlook: RD can be used in existing diesel engines without modification as it meets the conventional petroleum ASTM D975 specification and international standards. As it is approved as a direct replacement for petroleum diesel, it can be used with existing infrastructure and vehicles. RD replicates the Petroleum Diesel molecule but has a 2.2% higher energy content and lower carbon intensity (CI), allowing for a longer range for the same volume and weight of fuel. Therefore, RD is suitable for any HDV application, which is currently operated by conventional diesel vehicles. However, the fuel supply and availability at public fueling stations will ultimately determine its usage and uptake.

Infrastructure: Limited infrastructural upgrades are needed for delivery and storage of RD. However, there is currently a low market supply for RD in Canada. Its availability depends on feedstock sources and production facilities. Several new renewable diesel facilities are planned, or are under construction in Canada[xli], in addition to a RD refinery which is under development in the Toronto region.

Vehicle Availability & Timelines: Fleet managers do not need to acquire new vehicles or upgrade existing vehicles to operate on RD. This allows fleets to switch to RD with no upfront cost, other than the investments in the fueling and storage infrastructure. However, the overall timeline for making the switch to RD can vary and range from a few weeks to several months, depending on the scale of operations, vehicle type and the availability of refueling infrastructure.

Safety: As outlined above, RD is approved as diesel fuel by the ASTM D975 specification and international standards. Safety practices and procedures related to conventional diesel are well-documented and easier to mitigate, as most operators and drivers are familiar with this fuel. Any potential threat to the fleet operator's health may primarily come from mechanical failures or fire related incidents. RD should be handled with care to prevent fires, as it is flammable above 60 degrees Celsius (comparable with conventional diesel). The Canadian government has established several safety and regulatory requirements for RD under the Clean Fuel Standard and Renewable Fuels Regulations.

Maintenance: Fleet vehicles using RD should undergo regular maintenance checks to ensure that the fuel systems are clean and functioning properly. This includes checking for leaks and ensuring that fuel filters are in good condition. Vehicle operators should comply with regulations regarding the handling and storage of RD.

Economics: A significant benefit of transitioning to RD is that there is no upfront cost to acquiring a new fleet of vehicles or fueling stations. It is considered as a "drop-in" fuel, meaning that it can be used in currently available vehicles. However, in terms of the operational costs, the market price of RD could vary depending on the production method and availability of feedstock. While publicly available information on RD is limited, fleet managers can understand its price trends by following indices like the US based Chicago Board of Trade (CBOT) - CME group, which provides a fact sheet on pricing Renewable Diesel[xlii]. The RD pricing index is often linked to conventional petroleum prices. But it is important to note that they are independent markets and the price trends for RD can be better understood when linked to its feedstock supply and demand.

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*The **Alternative Fuels** Data Center offers additional insights on how RD is priced.*

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3. Conclusion – Gearing up for the Transition

Transitioning heavy-duty vehicle fleets to low carbon and zero emission vehicle technologies requires comprehensive planning. Each technology option will have its unique challenges and opportunities. Factoring these into the planning and fleet assessments stages can help with the successful transition to alternative fuel technologies. Guidance can be sought at each step of the way in developing fleet management plans and assessing the pros and cons of each technology.

With a rapidly changing regulatory environment, most companies are now reporting on their sustainability metrics and publishing their decarbonization plans. Therefore, GHG emissions reduction potential of available technology options must be considered. Establishing protocols, managing costs, monitoring progress and training staff are key to achieving success.

The adoption timeline for different ZEV technology varies with the vehicle type and fuel system and is highly dependent on the duty cycle of the fleet. Infrastructure development is also a significant factor, with charging and refueling stations taking several years to be fully operational. The total cost of ownership (TCO) analysis is applicable to all technologies, as the overall cost is dependent upon the upfront cost as well as the utilization of vehicles and access to affordable fuel and infrastructure. The widespread adoption of all the technologies discussed in this guide is dependent on the development of reliable charging/fueling stations.

To help meet the goals set by Canada's Emissions Reduction Plan and to steer their fleets towards these alternatives, managers should look out for financial incentives and infrastructure support. The Canadian government has implemented policies and launched programs, such as NRCan's Green Freight Program and Transport Canada's Incentives for Medium- and Heavy-Duty Zero-Emission Vehicles (canada.ca), which are aimed at helping businesses to make the switch to ZEVs.

Visit the Futureproof Your Fleet Resource Hub by Partners in Project Green (PPG): A growing library of informational resources on fleet decarbonization which features case studies, research reports, reference guides and tools to guide fleet managers and transportation sector professionals.

*The **Fleet Manager Readiness Checklist** is available on the Resource Hub to offer tangible guidance to fleet managers and owners looking to decarbonize their fleets.*

Glossary

- BEV: Battery Electric Vehicle
- CNG: Compressed Natural Gas
- EV: Electric Vehicle
- GHG: Greenhouse Gas
- GVWR: Gross Vehicle Weight Rating
- HDV: Heavy-duty Vehicle
- kW: Kilowatt
- LNG: Liquefied Natural Gas
- MDV: Medium-duty Vehicle
- MVI: Manufacturers' Vehicle Inventory
- NOx: Nitrogen Oxide
- OEM: Original Equipment Manufacturer
- PHEV: Plug-in Hybrid Electric Vehicle
- PM: Particulate Matter
- RD: Renewable Diesel
- RNG: Renewable Natural Gas
- SOx: Sulfur Oxide
- TCO: Total Cost of Ownership
- ZEV: Zero Emission Vehicle

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