# What's Keeping Motor Carriers from Purchasing Non-Diesel-Powered Trucks or Using Renewable Diesel?

Sorin Garber and Keith Wilson 1/8/2022

Major changes have been occurring in the motor carrier (aka trucking) industry during the global pandemic including historically high delivery traffic volume, driver shortages, increasing fuel costs, and delays at port terminals. One revolutionary change in the trucking trade that is going unnoticed is growth in the purchase of non-petroleum-fueled trucks, in particular, electric powered trucks, which produce zero emissions. In addition to electrically powered trucks is the dramatic growth in conventional trucks substituting petroleum diesel fuel for renewable diesel[1] (a second-generation renewable fuel and not to be confused with biodiesel), which is created from renewable sources and produces 60% fewer greenhouse gas emissions than diesel.

We believe that the motor carrier industry will convert to alternative fueled fleets – including battery electric, renewable diesel (R99), and hydrogen - much faster than the passenger fleet because the economics of doing so are so compelling.

Many carriers will wait until they need to replace their fleets or when batteries are less expensive and have longer range, or when there is an adequate local supply of R99, or when hydrogen technology is proven to be feasible and practical. But, as fuel and maintenance represent nearly 30% of their total costs, there is a positive business case for switching to an alternative to petroleum diesel fuel in the next few years for every type of carrier – big and small companies, national and local operations, and Class 5 to Class 8 truck types.

Evidence of this comes from Titan Freight, a regional motor carrier in Portland that operates both petroleum diesel and non-petroleum fueled trucks. They rely almost entirely on renewable diesel for diesel engine trucks and report that:

- "We have reduced petroleum diesel use 93% which has reduced our overall emissions output by 69% over this past decade. "
- "We haven't had to change one DPF (Diesel Particulate Filter). Oil costs are down as well, from less soot entering the crankcase."
- "Overall, Titan Freight has saved 1.9 cents per mile. After running on renewable diesel for one million miles, total savings have been $19,000 and its carbon reduction has been 1,294 metric tons."

First, some background facts about motor carriers and the information used in their decision-making about the fuels they consume and the equipment they use.

[1] Also known as R99 and is a mixture of animal fats, feedstocks, used cooking oils

## Truck Facts: Equipment, Miles, Trip Types, Costs, and Fuels

Much of the information described below was gathered from the most recent survey of motor carriers nationwide conducted annually by the American Transportation Research Institute (ATRI)[2]. The survey included carriers in all fifty states of respondents with a total of "138,930 truck tractors and 418,520 trailers of varying types, representing over 12 billion vehicle miles traveled."

***Type of Carrier Equipment in Use.*** As shown in Table 1, the average age of the 138,930 truck tractors owned by those surveyed have an average age of 5.3 years and they drove an average of 89,358 miles in 2020, which is a drop from the 93,956 miles driven in pre-pandemic 2019. Typically, Class 8 tractors (the largest truck tractors most commonly in use) are replaced after 5 to 8 years, or 500,000 – 650,000 miles.

**Table 1. Respondent Equipment Characteristics 2020 – Class 8 Trucks Only**

| Equipment Type | Number of Trucks/ Trailers | Average Age (Years) | Average Miles Driven per Year per Truck |
|---|---|---|---|
| Truck-Tractors | 138,930 | 5.3 | 89,358 |
| Trailers | | | |
| 28' Trailers | 160,380 | 8.5 | |
| 33' Trailers | 905 | 7.4 | |
| 45' Trailers | 4,859 | 7.7 | |
| 48' Trailers | 23,906 | 9.1 | |
| 53' Trailers | 165,691 | 6.7 | |
| Tank Trailer | 20,828 | 16.4 | |
| Flatbed Trailer | 9,797 | 7.0 | |
| Refrigerated Trailers | 21,127 | 4.0 | |
| Intermodal Trailers | 4,413 | 5.5 | |
| Auto Transporters | 106 | 4.6 | |
| Other Trailers | 9,753 | 11.0 | |
| **Total Trailers** | **348,088** | | |

The information in Table 1 is related to Class 8 trucks which carry most of the heavy loads on our roadways. This paper, however, is based on the truck types shown in Table 2:

**Table 2. Medium- Duty and Heavy-Duty Trucks Considered for this Analysis**

| | Weight Class | Total Weight Range(a) |
|---|---|---|
| ***Medium Duty Trucks*** | | |
| Step Van, Bucket Truck, City Delivery Truck | Class 5 | 16,001 to 19,500 lbs. |
| Beverage Truck, Single-Axle, Rack Truck | Class 6 | 19,501 to 26,000 lbs. |
| ***Heavy Duty Trucks*** | | |
| Truck Tractor, Refuse Truck, Furniture Delivery | Class 7 | 26,001 to 33,000 lbs. |
| Semi-Truck ("Sleeper"), Cement Truck, Dump Truck | Class 8 | 33,001 lbs. & over |

[2] See *An Analysis of the Operational Costs of Trucking: 2021 Update* (truckingresearch.org)

*Examples of Medium-Duty and Heavy-Duty Trucks*

| | | |
|---|---|---|
| Class 5 Medium-Duty Trucks |  |  |
| Class 6 Medium-Duty Trucks |  |  |
| Class 7 Heavy-Duty Trucks |  |  |
| Class 8 Heavy-Duty Trucks |  | |

***Type of Truck Trip.*** The rise of E-commerce sales has dramatically changed the types of deliveries trucks are making. For example, as shown in Table 3, local deliveries jumped by 52% between 2016 and 2020, while national trips over 1,000 miles dropped by 25%. Overall, average trip lengths for all truck trips shifted from 800 miles/trip to 500 miles/trip between 2016 and 2020. As documented in ATRI's report, "*E-Commerce Impacts on the Trucking Industry,*" intra-regional and last-mile truck trips have decreased the overall average trip

**Table 3. Respondent Trip Types, 2016 to 2020**

| | 2016 | 2018 | 2020 | % Change 2016 to 2020 |
|---|---|---|---|---|
| Local pick-ups and deliveries (less than 100 miles) | 21% | 26% | 32% | +52% |
| Regional pick-ups and deliveries (100-500 miles) | 40% | 37% | 37% | -8% |
| Inter-regional pick-ups and deliveries (500-1,000 miles) | 23% | 21% | 19% | -21% |
| National (over 1,000 miles) | 16% | 16% | 12% | -25% |

length by 37 percent from 2000 to 2018, and these trip lengths have continued to decrease in 2019[3].

***Total Motor Carrier Costs.*** According to the ATRI survey, vehicle-based and driver-based expenses changed dramatically from 2019 to 2020. For example, fuel costs declined by 26% for small carriers and 21% for large carriers. In contrast, truck insurance premiums rose by 14% for small carriers and by 13% for large carriers.

As shown in Table 4, vehicle-based costs (i.e., not including employee wages and benefits) in 2020 were estimated to be $1.04/mile and $0.82/mile for small carriers and large carriers, respectively, while driver-based costs are $0.70/mile and $$0.77/mile for small carriers and large carriers, respectively.

- Fuel - 24%-35%
- Vehicle maintenance - 8-10%
- Vehicle/trailer purchase and/or lease payments - 24%-35%

**Table 4. Average Costs per Mile, 2019-2020 Motor Carrier Costs**

| | Small Carriers(a) | | | Large Carriers(b) | | |
|---|---|---|---|---|---|---|
| | 2019 | 2020 | % Change | 2019 | 2020 | % Change |
| *Vehicle-based* | | | | | | |
| Fuel Costs | $0.439 | $0.326 | -26% | $0.370 | $0.293 | -21% |
| Lease/Purchase Payments | $0.278 | $0.307 | 10% | $0.262 | $0.248 | -5% |
| Repair & Maintenance | $0.195 | $0.174 | -11% | $0.133 | $0.128 | -4% |
| Truck Insurance Premiums | $0.107 | $0.122 | 14% | $0.060 | $0.068 | 13% |
| Permits and Licenses | $0.024 | $0.020 | -17% | $0.016 | $0.015 | -6% |
| Tires | $0.043 | $0.055 | 28% | $0.036 | $0.035 | -3% |
| Tolls | $0.037 | $0.037 | 0% | $0.032 | $0.036 | 13% |
| *Driver-based* | | | | | | |
| Driver Wages | $0.534 | $0.580 | 9% | $0.543 | $0.556 | 2% |
| Driver Benefits | $0.138 | $0.117 | -15% | $0.166 | $0.196 | 18% |
| **TOTAL** | **$1.794** | **$1.738** | **-3%** | **$1.618** | **$1.570** | **-3%** |

**Source:** American Transportation Research Institute, Minneapolis, MN, November 2021, An Analysis of the Operational Costs of Trucking: 2021 Update (truckingresearch.org)

(a) Small carriers are defined as having 100 or fewer power units.
(b) Large carriers are defined as having more than 100 power units.

[3] *Labor lags in long-distance freight as truck drivers prioritize home time*, S. L. Fuller and Shefali Kapadia, Transport Dive, Jan. 19, 2021, https://www.transportdive.com/news/trucking-employment-labor-driversbls/593487/.

***Alternative Fuels.*** Approximately ten percent of the ATRI survey respondents reported that their fleets used some form of alternative fuel in 2020, which was a decrease from 15 percent in 2019. Compressed natural gas (CNG) continued to have the highest adoption with 6.1 percent of carriers having at least one truck which utilizes CNG (Table 5). In addition, the survey found that natural gas-fueled truck sales fell by 9 percent from 2019 to 2020.[4] The second highest alternative fuel type was battery electric power, with 3.8 percent of carriers reporting at least one battery-powered truck in their fleet. Liquefied natural gas (LNG) usage fell from 5 percent in 2019 to 2.3 percent of carriers in 2020.

**Table 5. Use of Alternative Fuel Vehicles Alternative Fuel Type**

| Alternative Fuel Type | Percent of ATRI Surveyed Operators Using Alternative Fuels |
|---|---|
| Compressed Natural Gas (CNG) | 6.1% |
| Electric Battery | 3.8% |
| Liquid Natural Gas (LNG) | 2.3% |
| Liquefied Propane Gas (LPG) | 0.8% |
| Hybrid | 0.8% |
| **TOTAL** | **13.8%** |

**Source:** American Transportation Research Institute, Minneapolis, MN, 11/ 2021, An Analysis of the Operational Costs of Trucking: 2021 Update (truckingresearch.org)

While nearly 14% of carriers reported owning at least one truck using alternative fuels, the actual number of trucks using alternative fuels is just 0.4% of the 348,048 trucks owned by survey respondents. This figure has remained constant over the past five years. According to the ATRI authors, this low adoption rate may be due to a number of factors including the lack of available public electric charging stations, limited supply of CNG, LNG and LPG, and the excessive cost of equipment replacement.

## Which Alternative Fueled Truck Tractor Engines have the Greatest Promise.

Battery electric powered tractor configurations are expected to represent 20% of the market by 2040[5].

Other literature indicates that natural gas (either CNG, LPG or LNG) fueled trucks have lesser power and significant additional equipment acquisition costs. In addition, there are only four public natural gas fueling locations in Oregon, and it takes a significant amount of time to fuel a truck. And while there are no such trucks on the road these days, there is a lot of interest in hydrogen-powered trucks, but their advancement is at least a decade away and they will require a very unique and costly fueling infrastructure.

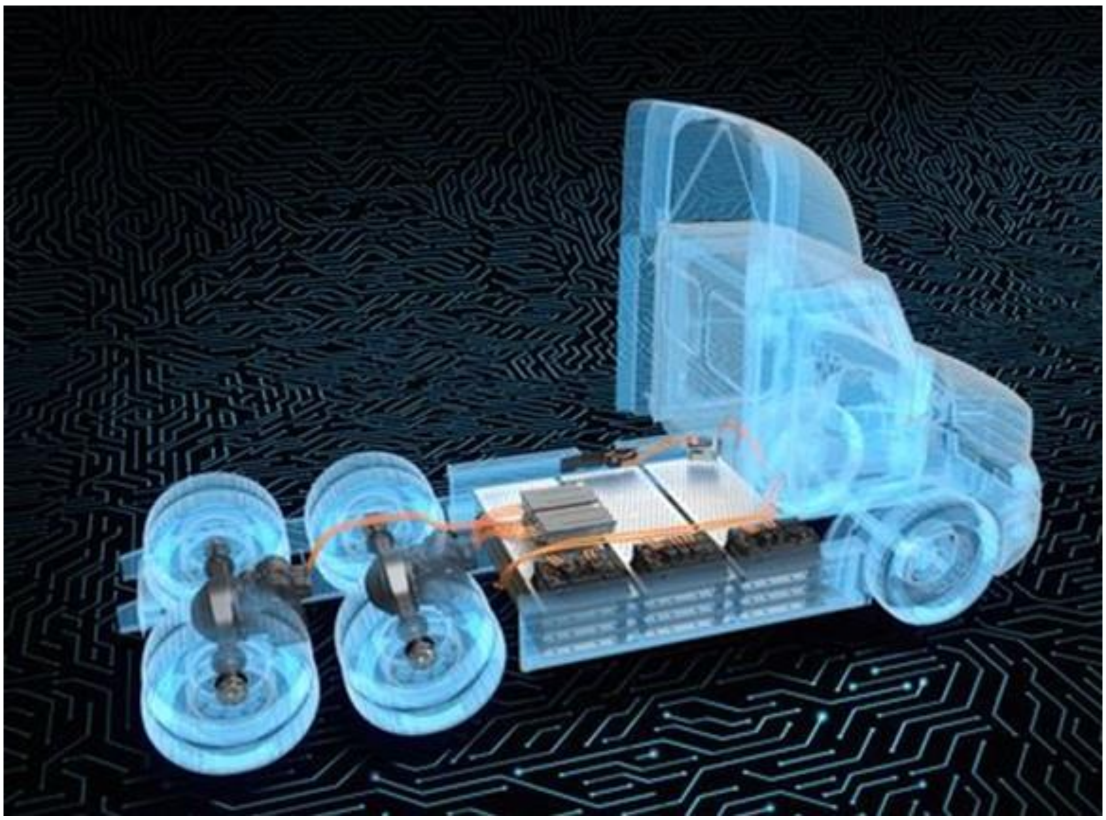
In the meantime, carriers can effortlessly switch to renewable diesel which emits 30% less black carbon and 60% less GHG than petroleum diesel. Renewable diesel can be pumped into

[4] *ACT Research: Class 8 Natural Gas Truck Retail Sales Contracted 9% YTD 2020 through November*. McNealy, Jennifer, ACT Research, Jan. 29, 2021, https://content.actresearch.net/blog/act-research-afqclass-8-natural-gas-truck-retail-sales-contracted-9-ytd-2020-through-november/.

[5] BloombergNEF's global EV outlook 2021: Commercial vehicles | Bloomberg Professional Services

diesel tanks at fueling stations and provides the same level of power as diesel at the same cost.

***Total Cost of Ownership of Electric vs Diesel Truck Tractors.*** A comparative analysis of the total annual costs of owning a diesel truck and a battery electric truck was prepared using PGE's Fleet Total Cost of Ownership Tool. The tool considers the cost of truck equipment (for electric trucks it also includes the cost of the EV charger and the EV charger installation), cost of fuel (i.e., assumes diesel fuel cost $3.70/gallon and the standard 2021 electricity rate for Schedule 83) and maintenance. It does not include insurance, labor, depreciation, or other accessory costs and credits.



Courtesy, Freightliner. Schematic of the all-electric Detroit ePowertrain designed for the Freightliner eM2 and Cascadia models

For the purposes of this analysis the tool was used to estimate costs from year 1 to year 10 for medium-duty trucks (both Class 5 and Class 6) traveling 100 miles/day, and heavy-duty trucks (both Class 7 and Class 8) traveling 150 miles/day[6]. Cost estimates include one EV charger when purchasing one vehicle, and two EV chargers when purchasing ten vehicles.

As shown in Table 6, the Year 1 costs for a single conventional diesel engine medium and heavy-duty truck is far less than the initial cost for a battery electric powered truck, but in year 5 those annual costs are more than two to three times lower for the battery electric truck. By Year 10, the savings are even greater and the 10-year cost savings ranges from $74,200 to $239,726.

**Table 6. Total Cost with Purchase of 1 Truck**

| | | Year 1 | | Year 5 | | Year 10 | | |
|---|---|---|---|---|---|---|---|---|
| | Assumed Daily Mi. | Diesel | BEV* | Diesel | BEV* | Diesel | BEV* | Cumulative 10-Yr Savings with BEV* |
| Medium Duty Class 5 Truck | 100 | $75,426 | $134,889 | $22,214 | $7,275 | $24,670 | $8,079 | $74,200 |
| Medium Duty Class 6 Truck | 100 | $113,148 | $262,693 | $25,174 | $10,324 | $27,958 | $11,465 | $151,343 |
| Heavy Duty Class 7 Truck | 150 | $120,184 | $296,098 | $32,826 | $11,526 | $34,456 | $12,800 | $195,500 |
| Heavy Duty Class 8 Truck | 150 | $167,733 | $356,500 | $46,473 | $22,838 | $51.613 | $25,364 | $239,726 |

**Source:** Cost estimates prepared using PGE's Fleet Total Cost of Ownership Tool. See Appendix A
*Battery Electric Vehicle

Most carriers purchase multiple trucks for their fleet at any one time. The findings of a purchase of ten new vehicles using the Fleet Total Cost of Ownership Tool is shown in Table 7. As expected, the costs in Year 1 for ten new vehicles is substantial, and between 97% to as much as 144% higher for a battery electric truck. However, by Year 5, the annual costs for battery electric trucks are just 29% to 47% of the annual cost of diesel engine trucks of the same type and traveling the same miles. By Year 10, battery electric vehicles are as much as three times lower than the annual cost than diesel engine trucks, with a cumulative 10-year savings of between $1,777,500 for ten Class 7 trucks, and $2,017,500 for ten Class 7 trucks.

Not considered in the above cost savings comparisons are the financial incentives offered by states and municipalities for purchase and use of electrically powered trucks. For example, some states (California, New York, Oregon, and Utah) offer generous subsidies and/or grants for the purchase of qualified electric heavy-duty trucks, and others provide carbon credits for the reduction in emissions produced by a company's trucks. Further, public EV charging

[6] Each of these truck types travel differently with varying daily mileage. The actual driving time and mileage is based on the delivery geography rather than the truck type. In particular, any Class 7 and Class 8 vehicles travel as much as 650 miles/day when they are moving goods through multiple states, however, the analysis is considering a 150-mile/day average as that is about 60% of the range published by EV manufacturers – with 60% being an average that some truck EV fleet holders are comfortable with.

**Table 7. Total Cost with Purchase of 10 Trucks**

| | Assumed Daily Mi. | Year 1 | | Year 5 | | Year 10 | | Cumulative 10-Yr Savings with BEV* |
|---|---|---|---|---|---|---|---|---|
| | | Diesel | BEV* | Diesel | BEV* | Diesel | BEV* | |
| Medium Duty Class 5 Truck | 100 | $754,256 | $1,486,935 | $222,135 | $64,637 | $246,701 | $71,785 | **$1,594,479** |
| Medium Duty Class 6 Truck | 100 | $1,131,477 | $2,764,507 | $251,739 | $94,623 | $279,579 | $105,087 | **$1,590,614** |
| Heavy Duty Class 7 Truck | 150 | $1,201,480 | $2,779,400 | $328,262 | $110,819 | $364,565 | $123,075 | **$1,777,500** |
| Heavy Duty Class 8 Truck | 150 | $1,677,328 | $3,466,798 | $464,734 | $216,744 | $516,129 | $240,713 | **$2,017,500** |

**Source:** Cost estimates prepared using PGE's Fleet Total Cost of Ownership Tool. See Appendix A
*Battery Electric Vehicle

stations such as the one built by PGE and Daimler Trucks of North America in Portland's Swan Island industrial district can reduce the cost of installing electric charging stations on a motor carrier's site or reduce their downtime for charging their batteries. This charging station is part of a project by West Coast electric utilities and two government agencies to provide publicly available charging for freight and delivery trucks on 1,300 miles of I-5 across the three West Coast states.

Finally, another cost savings for electrically powered trucks is related to their occasional restricted access and mobility on public roadways. That is, where highway corridors and bridges and central business districts are priced (either through tolls or variable pricing mechanisms), electric trucks are sometimes allowed to enter free of charge. In other cases, convenient on-street parking facilities may be reserved for electrically powered trucks.

## Emissions produced by Motor Vehicles

According to the Environmental Protection Agency (EPA), transportation emissions represent 28% of all greenhouse gas emissions[7] produced in the U.S., followed by the electric power industry, manufacturing, agriculture, commercial enterprises, and residential uses. As shown in Table 8, medium- and heavy-duty trucks, which represent just 5% of the vehicle fleet on U.S. roadways, generate nearly a quarter (i.e., 23.7%) of all transportation-related GHG emissions (in comparison to passenger vehicles and light-duty trucks which generate 57.8% of all transportation GHG emissions).

Greenhouse gases absorb radiation from the sun and emit infrared radiation through the atmosphere. Without them the earth would be too cold for human life as we know it to exist. When we add too much greenhouse gas to the atmosphere we trap more heat and the planet becomes warmer, which is commonly referred to as climate change. Since 1990, we have produced 23% more GHG in the U.S.

[7] Including carbon dioxide ($CO_2$), methane *(CH2)*, nitrous oxide *(N2O)*, chlorofluorocarbons *(CFCs)*

**Table 8. U.S. Transportation GHG Emissions, 2019 (Tg CO2 Equivalent) - i.e., GHG emissions/1 million metric tons**

| | 1990 | 2005 | 2015 | 2016 | 2017 | 2018 | 2019 | | 2019 % |
|---|---|---|---|---|---|---|---|---|---|
| **On Road Vehicles** | **1,206.8** | **1,647.4** | **1,510.6** | **1,534.6** | **1,540.7** | **1,563.9** | **1,555.6** | | **82.9%** |
| Cars | 639.6 | 691.7 | 752.5 | 763.5 | 760.6 | 770.3 | 762.3 | | 40.6% |
| Light-duty Trucks | 326.7 | 537.7 | 320.9 | 330.2 | 324.3 | 325.7 | 323.1 | | 17.2% |
| Motorcycles | 1.7 | 1.6 | 3.7 | 3.9 | 3.8 | 3.8 | 3.6 | | 0.2% |
| Buses | 8.5 | 12.3 | 19.6 | 19.1 | 20.6 | 22.0 | 22.2 | | 1.2% |
| Med/Heavy Duty Trucks | 230.3 | 404.1 | 413.9 | 417.9 | 431.4 | 442.1 | 444.4 | | 23.7% |
| **Aircraft** | **189.1** | **193.6** | **160.5** | **169.0** | **174.8** | **175.5** | **181.1** | | **9.6%** |
| Commercial Air | 110.9 | 134.0 | 120.1 | 121.5 | 129.2 | 130.8 | 135.4 | | 7.2% |
| Military Air | 35.3 | 19.5 | 13.6 | 12.4 | 12.3 | 11.9 | 12.0 | | 0.6% |
| General Aviation | 42.9 | 40.1 | 26.8 | 35.1 | 33.3 | 32.8 | 33.7 | | 1.8% |
| **Ships and Boats** | **47.0** | **45.4** | **33.8** | **40.8** | **43.9** | **41.2** | **40.4** | | **2.2%** |
| **Rail** | **35.8** | **46.6** | **40.3** | **36.8** | **38.1** | **39.9** | **37.8** | | **2.0%** |
| **Pipelines** | **36.0** | **32.4** | **38.5** | **39.2** | **41.3** | **49.9** | **53.7** | | **2.9%** |
| **Lubricants** | **11.8** | **10.2** | **11.0** | **10.4** | **9.6** | **9.2** | **8.9** | | **0.5%** |
| **Transportation Total** | **1,526.5** | **1,975.6** | **1,794.7** | **1,830.8** | **1,848.4** | **18,79.6** | **1,877.5** | | |

**Source:** Fast Facts: U.S. Transportation Sector Greenhouse Gas Emissions, 1990-2019 (EPA-420-F-21-049, June 2021)

Carbon dioxide is the most troubling greenhouse gas being emitted today as it represents, by far, the largest volume of emission tonnage and because it lasts a long time in our atmosphere. As shown in Table 9, carbon dioxide represented almost 97% of the greenhouse gases released into our atmosphere in 2019 with medium- and heavy- duty trucks generating 24% of all transportation-related carbon dioxide emissions.

**Table 9. U.S. Transportation Emissions by GHG Gas, 2019 (Tg CO2 Equivalent) - i.e., GHG emissions/1 million metric tons**

| | Carbon Dioxide *(CO2)* | Methane *(CH2)* | Nitrogen Oxide *(N2O)* | Chlorofluoro-carbons *(CFCs)* | Total | | Percent |
|---|---|---|---|---|---|---|---|
| **On Road Vehicles** | **1,512.7** | **0.9** | **9.3** | **32.7** | **1,555.7** | | **74.5%** |
| Cars | 748.3 | 0.4 | 4.4 | 9.3 | 762.3 | | 36.5% |
| Light-duty Trucks | 304.3 | 0.2 | 1.7 | 16.9 | 323.1 | | 15.5% |
| Motorcycles | 3.6 | 0.0 | 0.0 | 0.0 | 3.6 | | 0.2% |
| Buses | 21.4 | 0.2 | 0.1 | 0.4 | 22.2 | | 1.1% |
| Med/Heavy Duty Trucks | 435.2 | 0.1 | 3.0 | 3.5 | 441.8 | | 21.1% |
| **Aircraft** | **179.4** | **0.0** | **1.6** | **0.0** | **181.1** | | **8.7%** |
| Commercial Air | 134.2 | 0.0 | 1.2 | 0.0 | 135.4 | | 6.5% |
| Military Air | 11.9 | 0.0 | 0.1 | 0.0 | 12.0 | | 0.6% |
| General Aviation | 33.3 | 0.0 | 0.3 | 0.0 | 33.7 | | 1.6% |
| **Ships and Boats** | **35.9** | **0.4** | **0.2** | **3.9** | **40.4** | | **1.9%** |
| **Rail** | **37.1** | **0.1** | **0.3** | **0.1** | **37.6** | | **1.8%** |
| **Pipelines** | **53.7** | **0.0** | **0.0** | **0.0** | **53.7** | | **2.6%** |
| **Lubricants** | **8.9** | **0.0** | **0.0** | **0.0** | **8.9** | | **0.4%** |
| **Transportation Total** | **1,827.8** | **1.4** | **11.5** | **36.7** | **1,883.9** | | **89.9%** |

**Source:** Fast Facts: U.S. Transportation Sector Greenhouse Gas Emissions, 1990-2019 (EPA-420-F-21-049, June 2021)

In addition, diesel exhaust (from trucks, buses, construction equipment, etc.) produces fine particulate soot or particulate matter. According to the Occupational Safety and Health Administration (OSHA) "Short term exposure to high concentrations of diesel exhaust/diesel particulate matter can cause headache, dizziness, and irritation of the eye, nose and throat severe enough to distract or disable miners and other workers. Prolonged DE/DPM exposure can increase the risk of cardiovascular, cardiopulmonary and respiratory disease and lung cancer."

## So, What's Keeping Motor Carriers from Purchasing Electric Semi-Trucks?

In general, there are five principal reasons why many carriers are not replacing their fleets with electrically powered tractors:

1. High Purchase Price - The purchase price of a medium- or heavy-duty tractor is between 79% and 314% higher for an electric powered tractor vs a conventional diesel tractor (see Table 6).
2. Battery Cost is Declining - The cost of an electric battery for a Class 8 truck is expected to decrease by more than 50% by 2030.[8]
3. Range Anxiety - The distance range of an electrically powered Class 8 tractor is currently maxed at 250 miles for a fully loaded Class 8 truck on a single charge (see Table 10 below) and for many carriers their rigs travel longer distances.
4. Lack of Charging Stations - As of the date of this newsletter, there is only one publicly accessible fast charging station for electric semi-trucks.
5. Battery Weight Reduces Potential Payload – Batteries can weigh as much as 4,000 lbs. which reduces the amount of cargo weight that can be carried by a rig equipped to carry a total of 80,000 to 105,000 lbs. (i.e., combined weight of truck tractor, chassis, trailer, and cargo).

**Table 10. Distance Range of Class 8 Tractors Available in 2021/2022**

| Manufacturer | Range of fully loaded truck* | Top Speed | Maximum Power | Availability |
|---|---|---|---|---|
| BYD - *BYD 8TT* | 125 miles | 74 mph | 483 hp | 2022 |
| Lion – *Lion 8T* | 170 miles | 65 mph | 350hp - 470hp | 2020 |
| Freightliner- *e-Cascadia* | 250 miles | 65 mph | 360hp – 500 hp | 2022 |
| Volvo - *VNR Electric* | 150 miles | 65 mph | 340hp - 455 hp | 2021 |
| Kenworth - *T680E* | 150 miles | 70 mph | 536hp – 670 hp | 2021 |

*Based on a single charge

As discussed earlier, the total cost (fuel and maintenance) of owning an electric powered Class 5-8 truck falls below that of a conventional diesel-powered Class 5 – 8 truck in the

[8] "A 375-mile range truck with the current battery price of $135/kWh is expected to cost 75% more than a diesel counterpart, but upfront costs will continue falling as batteries keep getting cheaper – average battery prices are expected to hit $60/kWh between 2025 and 2030." Cheap Batteries Could Soon Make Electric Freight Trucks 50% Cheaper to Own Than Diesel (forbes.com), 3/16/2021

second year of ownership and are between 210% and 325% lower for electric powered tractors by the fifth year. By the 10th year of ownership, electric powered trucks accumulate between $151,343 and $320,916 in savings per truck.

With the increase in production volume and the declining cost of batteries, their purchase price should begin to fall later in this decade. The improved batteries, which will continue to offer superior power and performance will also get lighter and more compact, allowing for larger volumes of cargo.

Finally, while most carriers will install fast-charging electric chargers at their facilities, there will also be a significant increase of public EV chargers. The West Coast Clean Transportation Corridor, aims to construct and maintain 27 high-power DC fast-chargers along 1,300 miles of I-5 plus other connecting highways in California, Oregon, and Washington. These charging stations may be installed as early as 2025, and the expectation is that they will be available on several other highways with heavy truck volumes.

Courtesy, Freightliner. Electric Island – Daimler Trucks North America and PGE, Portland, OR

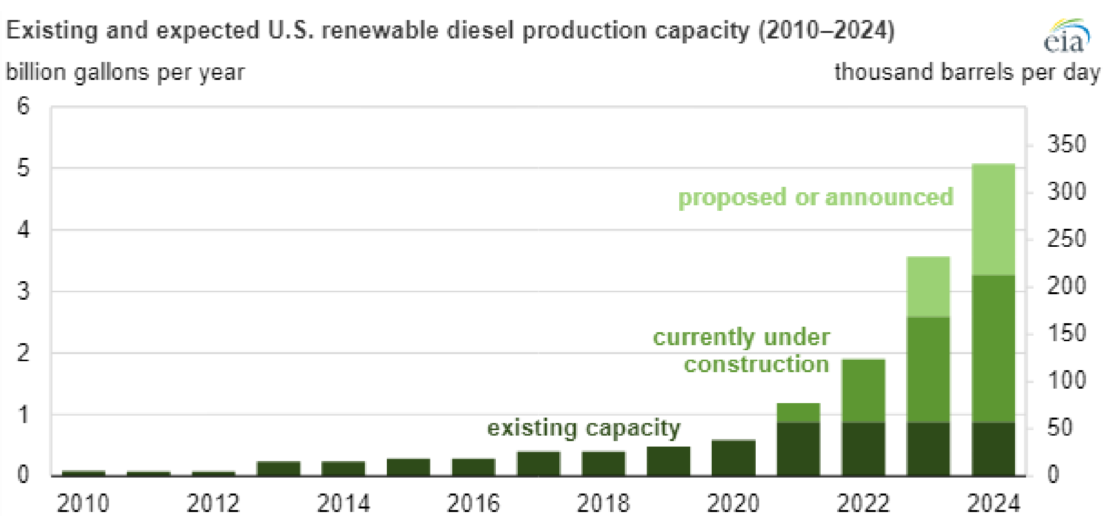
## Case for Renewable Diesel

Titan Freight describes renewable diesel as a "bridge fuel solution," because it is an immediate and available substitute for petroleum diesel that can be pumped and otherwise used in the same manner as conventional diesel: however, it produces 60%-75% less greenhouse gas emissions than petroleum diesel without sacrificing engine performance. Its cost is competitive with petroleum diesel, but importantly, as it produces less black carbon (i.e., particulate emissions), it requires fewer oil changes and less exhaust system maintenance which Titan Freight estimates saves them about two cents/mile.

Renewable diesel is produced from a broad range of renewable raw materials, including residues and vegetable oils, livestock tallow and cooking grease, and repurposing it into clean energy. Up to 1% of its content is petroleum diesel which helps lubricate engines and allows carriers to pocket the $1.00/gallon federal tax credit for use of blended fuels.

Renewable diesel is also a "bridge fuel solution" because it will take decades before the electrification of heavy vehicles takes place in any significant manner, and renewable diesel provides immediate significant reductions in greenhouse gas emissions produced by medium- and heavy-duty trucks.

A drawback to renewable diesel in Oregon currently is the lack of available supply. Currently, renewable diesel is only available in bulk delivery and there are no retail locations. However, according to the U.S. Energy Information Administration, availability of renewable diesel is estimated to increase from 0.6 billion gallons/year in 2020 to 5.1 billion gallons/year by the year 2024 (see figure below)[9].




Courtesy U.S. Energy Information Administration

[9] U.S. renewable diesel capacity could increase due to announced and developing projects, U.S. Energy Information Administration, July 29, 2021

## Other Alternative Fuels Powering Medium- and Heavy-Duty Trucks

In addition  to renewable diesel, other alternatives to conventional diesel are growing in popularity in the U.S.

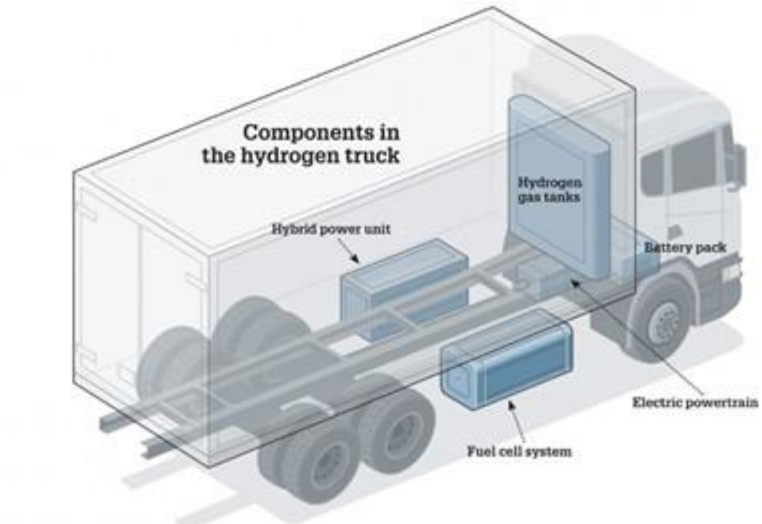
***Biodiesel.*** There are two forms of biodiesel – B20 and B100 - that are available for use by medium- and heavy-duty trucks. They are both made from the same organic waste streams – including animal and seed fats – with the content of B20 fuel being 20% of that organic matter and 80% petroleum diesel, and B100 being 100% composed on organic matter.

The cost of B20 is competitive with conventional and renewable diesel and can be pumped directly into truck fuel tanks without the need for special equipment. B100 has limited use and in some cases requires additional equipment to reduce gelling in cold weather.

***Compressed natural gas (CNG***) can also be used as a substitute for petroleum diesel and is often less costly as there is an abundant supply in the U.S. leading to less price volatility. However, they do require extensive retrofits to existing equipment and the fuel produces decreased power. Moreover, there is only one public natural gas fuel station in Oregon, though with the forecasted increase in production of vehicles that will use natural gas in the next 25 years, there will be an increase in their number.

Because CNG is refined from natural gas which is drilled and extracted from the earth it is not especially beneficial from an environmental perspective. Burning natural gas is cleaner than other fossil fuels, but it does produce higher levels of nitrogen oxides and hazardous pollutants are produced at drilling sites.

***Hydrogen-fueled Cells.*** An emerging fuel source that has many advantages is hydrogen fuel cell technology which is often linked with electric motors to produce quick acceleration and high torque. In 2021, two companies delivered eleven hydrogen fueled trucks in Europe, with plans to deliver up to 1,000 more by the year 2025.
Like electric powered engines, hydrogen fueled trucks do not burn fuel like combustion engines and so produce zero emissions and low noise levels. A major advantage over electric power is that a hydrogen-fueled trucks can be refueled within 15 minutes. The benefits of hydrogen fuel cell technology include zero local emissions, low noise levels, high torque from the electric motor, and, unlike all-electric powertrains, quick refuel times, assuming access to a hydrogen fuel source. They also can travel longer distances before refueling than electric-powered trucks.




Courtesy of Scania Norwegian wholesaler ASKO puts hydrogen powered fuel cell electric Scania trucks on the road

They will require a completely different engine, fuel storage and other equipment unique to their operation, and hydrogen-fuel stations will need to be established. While there are clearly many advantages to this technology, it is in its infancy and until mass production is accomplished the truck tractors will remain extremely costly.

## Frequently Asked Questions

- Does the federal government or the state of Oregon offer any financial incentives toward the purchase of an electric-powered medium- or heavy-duty truck?

  There are no state sponsored incentives to defray the purchase cost of a battery electric vehicle. Oregon DEQ offers limited mitigation grants that can cover up to 75% after qualification.

- Do medium- and heavy-duty trucks need a different kind of EV charging station?

  Yes, in some cases, PGE customers can qualify for a "Make Ready" program that will cover part or all the charging infrastructure (not including dispensers).

- How long does it take to fully power an electric medium- or heavy-duty truck?

  Depending on the EV charger and the truck manufacturer, it takes between one and eight hours to fully recharge their batteries.

- What is the cost for a fast-charging EV charging station that can quickly charge a medium- or heavy-duty truck?

  Average cost to purchase and install a commercial grade, level 2 **EV** charging station is between $6,000 and $13,000.

## What does this all mean?

***Benefits Outweigh the Costs of Electric-Powered Trucks by as much as a 3:1 Margin***

As we mentioned at the top of this article, both the economics for carriers and the regulations requiring and/or encouraging low-emission and zero-emission trucks will encourage the purchase of non-petroleum-fueled trucks, in particular, electric powered trucks. In Oregon, as well as California and potentially Washington State, the number of diesel petroleum fueled trucks that can be sold is now limited (in the Portland metropolitan area as early as 2024).

Carriers have multiple critical financial, concerns when it comes to replacing their fleets – most notably, that the cost of diesel fuel and the maintenance required for use of diesel represents 30% of their total expenses. And this is for an industry that is highly competitive and operates on a low profit margin. Any cost savings is significant.

As truck manufacturers provider a wider array of electric powered truck options, and carriers continue reporting highly positive experiences with them, there has been an extremely strong uptick in the purchase of electric-powered trucks.

Moreover, with the recently passed federal infrastructure bill, there are financial incentives for both the replacement of older diesel-powered trucks and for alternative fueling facilities to further sway carriers into purchasing electric trucks.

***Renewable Diesel is an Immediate Solution to Significantly Reducing Diesel Exhaust***

In the meantime, renewable diesel represents an immediate and significant solution to our climate crisis with respect to our need to reduce diesel exhaust from medium- and heavy-duty trucks. Renewable diesel costs similar to petroleum diesel and reduces maintenance costs by as much as 15%. In California, where renewable diesel represents 10% of truck fuel consumption, it is also measurably reducing the amount of greenhouse gases produced by trucks.

It is a solution available to Oregon now and is a win-win for the carrier and for cleaner air.

There is a wide range of data about truck equipment and regulations, technological solutions, and logistics strategies to reduce truck emissions, and there are advances in each of them on a near weekly basis.

If you are interested in learning more about these and other trends, or have questions or comments, please contact either of us.

Sorin Garber is Owner of Sorin Garber & Associates, an independent transportation program management and planning practice in Portland, OR. Mr. Garber works with state DOTs, MPOs, transit districts, cities, port districts, and their partners throughout the U.S. as their spokesperson and leader in preparation of multimodal passenger and freight system/corridor plans, feasibility studies, and infrastructure project business plans. He has analyzed and forecast bi-state conditions on I-5 and I-205, the BNSF and UPRR systems, the Columbia/Snake River system, and corresponding ports and transportation systems for the Washington and Oregon Legislatures, ODOT, WSDOT, Port of Portland, Metro, and the City of Portland. He advises and consults with legislative bodies, state and local agencies, business leaders and non-profit organizations, on transportation investments. In 2019, he prepared the *E-Commerce and Emerging Logistics Technology* for the City of Portland and has independently been producing quarterly updates of that study's initial findings.

Keith Wilson is an expert and practitioner on the economics of renewable fuels for the motor carrier industry. He is president of TITAN Freight Systems, a regional transportation company with operations throughout OR, WA and ID, and is the lowest carbon footprint carrier in the Pacific Northwest using Renewable Diesel for the majority of its operations. This second-generation renewable reduces GHG emissions up to 60%. In 2023, he will have six heavy-duty electric truck tractors added to his fleet. Keith is a Vision Zero expert who utilizes artificial intelligence resulting in millions of miles traveled with zero accidents. He is also a US High Speed Rail advisory board member where he works with city, state, and federal officials to advance this extraordinary technology to put the "RAPID" back in rapid transit. Keith grew up in one of the poorest neighborhoods in Portland, his home wedged between factories, junk yards, landfills, and freeways. He has witnessed firsthand how segregation creates an improper functioning society and is focused on ensuring outcomes are fair and equitable for all communities, always.

# Appendix