BENEFITS AND BARRIERS TO ELECTRIFICATION OF THE FREIGHT SYSTEM IN MINNESOTA

White Paper

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MINNESOTA FREIGHT ADVISORY COMMITTEE

MFAC

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Introduction

In the 2007 Next Generation Energy Act signed by Governor Tim Pawlenty, Minnesota set a goal of reducing greenhouse gas emissions 80% below 2005 levels by 2050. The goal includes benchmarks of a 15% reduction by 2015 and a 30% reduction by 2025. Since then, Minnesota has successfully changed the trajectory of its emissions profile, so it is no longer increasing. Minnesota State published its Climate Solutions and Economic Opportunities in 2015, which is in line with the state's NGEA goals. Based on this guideline, developing mass transit, improving the fuel efficiency of vehicles, enhancing the renewable electricity standard, and eliminating coal plants are the principal aspects of this plan (Minnesota Environmental Quality Board 2015). Furthermore, in March 2021, the Minnesota Legislature introduced legislation that aims to establish a clean fuels standard. This legislation would entail a 20% reduction in the carbon emissions of the transportation sector within the state by 2035 when compared to a 2018 baseline.

Minnesota's freight transportation system plays a critical role in supporting the region's economic competitiveness and quality of life (Metropolitan Council 2020). However, concerns over GHGs have led state government authorities to create a plan for electric freight vehicles to replace conventional diesel trucks, which produce approximately 12% of GHG emissions in the state.

This white paper provides a brief overview of benefits and barriers to the electrification of freight vehicles in Minnesota.

Truck Classification

The Federal Highway Administration Vehicle Inventory and Use Survey classifies trucks by gross vehicle weight. As shown in Figure 1, this classification system includes eight classes ranging from 1 to 8.

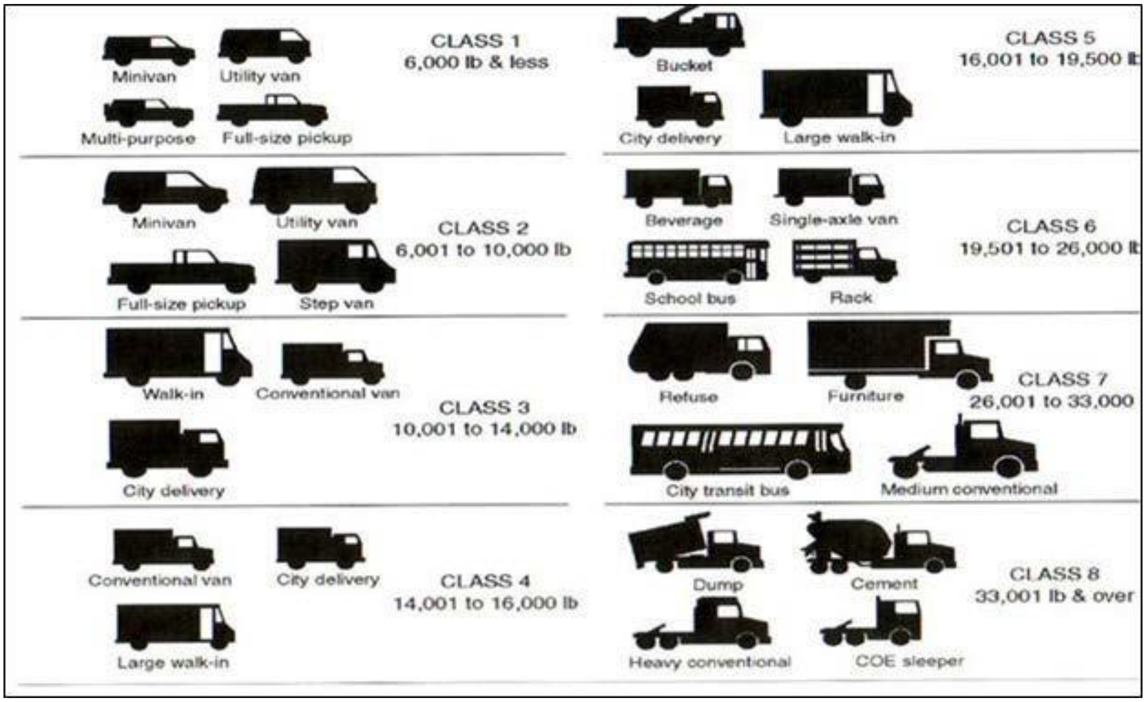

Figure 1: **Truck classifications by gross vehicle weight**

Truck Operation Models

"Trucks make money when they move" is the key concept in truck operation.

There are three main models for truck operation:

One truck, one driver

In this model, the driver's goal is to maximize driving hours (typically 11 to 14 hours) — anytime sitting and waiting to load and unload counts against maximum allowed duty hours. However, with rising equipment costs, regulatory mandates, and customer demand for faster shipment times, fleet managers are turning to other operational models of driving to keep their operations viable.

One truck, two drivers as a team

Team driving is defined as a team of two or more drivers who ride together and drive the same truck in shifts. This essentially allows the truck to remain in motion almost constantly and is used primarily for time-sensitive freight.

Slip seating

Slip seating refers to drivers not assigned to a specific truck. Instead, drivers get into a truck once another driver returns it from an assigned route. In this model, vehicles rarely sit idle.

Environmental Impact Assessment of Electric Trucks

Minnesota has a diverse economy, comprised of several different industries, including farming, manufacturing, health care, trade, utilities, and mining. It currently hosts the headquarters of 16 Fortune 500 companies. Because of its diversity, the Minnesota economy is more resilient than those of other Midwestern states (Minnesota Frieght Advisory Committee 2020). To receive raw materials and to distribute products to customers, companies rely on the freight transportation network. The safety, efficiency, reliability, and robustness of freight transportation are vital for urban residents to access materials and goods for living, working, and recreation. Trucking is the most important part of this system, and it is important to all industries. Even goods moving via other modes of transportation often use trucks for the first- and last-mile of the trip (Minnesota Department of Transportation 2018). As an example, for freight movement from the Twin Cities metro area to rural areas, about 86% of freight by weight and 82% by value is carried by trucks (Minnesota Frieght Advisory Committee 2020). The trunk highway system in Minnesota consists of nearly 12,000 miles of roadway, and many of these highways average more than 5,000 truck trips per day (Minnesota Department of Transportation 2018).

A U.S. Environmental Protection Agency 2019 report reveals that the transportation sector has the highest share in greenhouse gas emissions in the country (U.S. Environmental Protection Agency 2019) (*see* Figure 2). This problem becomes even more critical when considering that pollution in the transportation sector is more concentrated in urban areas (Emami, Song and Khani 2021). Accordingly, enhancement in the transportation sector, such as improving vehicle energy efficiency and promoting the use of public transportation, could lead to emissions reduction. In Minnesota, trucking produces about 13% of the total pollutants in the state, or about 21 million out of 161 million carbon dioxide-equivalent[1] tons (Minnesota Pollution Control Agency 2018).

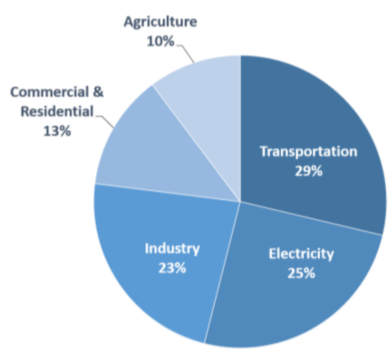

Figure 2: **Total U.S. greenhouse gas emissions by economic sector in 2019**

[1] Carbon dioxide equivalent: CO2-eq is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide.

Market Penetration

The electric truck market size has had remarkable growth in recent years, due to its low maintenance costs, initiatives of governments and regulations, and diminishing battery prices. **Error! Reference source not found.** shows the historic and projected sales of medium- and heavy-duty trucks in the United States (West Coast Clean Transit Corridor Initiative 2020). The global electric truck market is predicted to reach 1,508.1 thousand units, in terms of volume, by the end of 2025, with a compound annual growth rate of 18.5% during the forecast period (Market Research Future 2021).

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
US sales class 3-8	311,390	369,144	501,478	569,200	605,508	670,589	732,092	605,343	583,155	635,452	673,658
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
US sales class 3-8	682,153	665,998	691,909	694,823	677,059	669,774	676,652	689,043	707,251	724,444	737,480

Table 1: **U.S. historic and projected sales of medium- and heavy-duty trucks**

Based on a Prescient & Strategic Intelligence 2020 report[2], the U.S. electric truck market, valued at $211.5 million in 2019, is expected to witness robust growth of 51.6% CAGR during the forecast period (2020-2030). The U.S. electric truck market is divided on the basis of vehicle type into heavy-duty, medium-duty, and light-duty trucks. Out of these, the LTDs are predicted to account for the largest share of the market in 2030, owing to the increasing demand for pickup trucks in the country. In the United States, LDTs accounted for more than 85% of the sales of commercial vehicles. Other than this, the HDT division is predicted to grow at the fastest pace during the forecast period. Electric trucks falling under the HDT category are expected to witness the highest demand in the market. The major factor driving the market for these HDTs is the fast-growing demand for freight transport due to massive growth in the e-commerce industry. Thus, trucking companies are focusing on adding HDTs to their fleets in view of the strong freight demand and federal government financial incentive schemes encouraging the adoption of electric vehicles.

[2] U.S. Electric Truck Market Research Report: By Vehicle Type, Propulsion, Range, Battery Capacity, Application — Industry Analysis and Growth Forecast to 2030

Implementation of Electric Freight Vehicles

Implementation of electric freight vehicles is not a new phenomenon. Over the last decades, several trials have been undertaken to implement this system in city logistics. Today's EFVs have a greater range and improved loading capacity, and they are fast becoming a viable alternative for short- and medium-haul goods distribution. Nevertheless, actual implementation of EFVs in city logistics operations is still limited.

Barriers to Adoption of EFVs

Technical performance

Infrastructure: Infrastructure (such as charging and repair stations) continues to be one of the biggest industry barriers to the adoption of electric trucks. Challenges such as infrastructure lead time, costly upgrades, and demand charges are examples of barriers that impede a fleet's ability to successfully deploy electric trucks. As fleets explore the benefits of transitioning to electric vehicles, there is a significant knowledge gap about necessary planning and development requirements of implementing infrastructure. For decades, conventional fuels (diesel and gasoline) have been the norm, and the practices for fleet deployment have been consistent. With electrification, terminology and practices will be different. Depending on the fleet size, its vocation, and its duty cycle, infrastructure needs will vary, and there is no single solution.

Range: A primary issue with electric trucks is their driving range. This problem is exacerbated by considering the long charging time and insufficient charging infrastructure. For example, the typical run of current trucks is about 750 miles. A truck carrying 200 gallons of fuel at 7 mpg can predictably travel up to 1,400 miles before refueling and serve multiple customers without stopping. By contrast, the best electric trucks carrying comparable loads only have a range of about 200 miles between charges. Another problem with the implementation of electric trucks in terms of driving range is that the harsh winter weather conditions in Minnesota will draw between 25% and 40% of the energy from of the battery. This issue can highly affect the driving range of these vehicles.

Battery: The most expensive part of EFVs is their rechargeable batteries (about half of their retail cost). Today, battery companies are trying to improve battery weight, recharging time, and energy storage. Battery life is dependent on several operational factors, such as operating profile and charging strategy. Vehicles require battery management systems to actively monitor the batteries, charging, discharging, and thermal profiles. Based on current estimations, EFV batteries last somewhere between three and seven years, and the replacement price of these batteries ranges between $80,000 and $175,000.

Charging: EFV charging time is too long in comparison with conventional diesel trucks. Long electric charging times cut into vehicle productivity. Unlike the typical commuter, truck drivers are limited to 14 hours on duty any given day — thus, recharging time matters. It typically takes 15 minutes to fuel a truck with diesel. However, using fast chargers requires 90 to 120 minutes to recharge an electric truck completely. This cuts into precious driver hours, thereby reducing a driver's wage-earning capacity since drivers are usually paid by delivery and not by time. Using a regular charger, a class 7 or 8 truck may take 15 to 20 hours to recharge. That's a long time for a truck to idle without making money. Also, federal hours-of-service rules require trucks to stop for eight to 10 hours. Trucks cannot get fully charged during a service break, so it reduces its revenue.

Operational performance

Charging pattern: Based on past and ongoing experiences (Freight Electric Vehicles in Urban Europe (FREVUE) 2017) (Pelletier, Jabali and Laporte 2018), overnight depot charging with several shorter charging sessions during the day is the most frequently reported charging scheme. However, this pattern is not applicable for all trucks as mentioned by operators because some trucks don't get home to terminals for weeks, and they may be unable to recharge every night. These models may make more sense for some companies such as FedEx and Walmart since their trucks return to distribution centers every night.

Loading capacity: Vehicles that carry a large volume but a limited weight, such as Amazon an UPS urban delivery trucks, are well-suited to EV requirements. But EFVs have not been a viable alternative to replace heavy-duty trucks, and past cases indicate that EFVs are more suitable for light and medium-duty trucks (Davis and Figliozzi 2012). Moreover, battery weight significantly reduces truck payload hauling capacity. For instance, loaded truck weights are capped at 80,000 pounds, which usually equates to about 40,000 pounds of cargo. However, electric trucks require 5,000 to 7,000 pounds of batteries. That weight displaces 12 to 17% of paying cargo, thereby increasing the number of trucks on the road.

Repair facilities and technicians: Lack of enough repair facilities and technicians equipped to service electric vehicles is critical and can be considered as another barrier to electrifying the truck sector. Typically, diesel truck drivers have some knowledge and experience in maintaining and repairing their vehicles, but, with EFVs, drivers would not be able to do this by themselves.

Economics

Although electric truck technologies are emerging in the market, production volumes are not at the levels needed to drive down technology costs. The purchasing cost of electric trucks continues to be the biggest barrier to adoption of electric trucks, especially for independent operators and small businesses. The problem becomes even more critical for small businesses, which form most truck fleets, especially knowing they may need to spend more for battery replacement in three to five years. A typical heavy-duty commercial truck costs around $150,000, without a trailer. According to a California Air Resource Board estimate, electrified trucks will cost an additional $86,000. That is a 57% increase in the cost of a truck.

Energy storage prices also continue to remain expensive. Though battery prices continue to drop at the cell level, they remain high at the customized, low-volume pack level. Customer experience with battery pack sizing in earlier fleet trials also has led customers to ask for larger battery pack sizes to overcome range and cold-weather battery degradation concerns, further increasing the cost of the battery system.

Utility perspective

Cost: Utility companies need a huge investment to build the charging infrastructure and upgrade the grid network across the state. Representatives of the trucking sector believe this cost will be paid indirectly by truck companies and other consumers through an automatic surcharge to the price of electricity so that electric companies can build out the grid to accommodate charging stations. But trucking companies will not be able to increase rate-per-mile costs because shippers do not pay more based on the type of fuel or equipment a company uses. As a result, these companies may not be able to pass on any significant portion of these costs to shippers.

Grid capacity: Today, about 300 million vehicles are registered in the United States. Electrification of all the vehicles will have a massive impact on the electrical grid. Do we have enough electricity to cover this demand? According to past experiences, some medium-sized cities have had a serious issue supplying the electrical demand of a truck charging station with only 20 charging piles. Therefore, grid capacity can be a severe barrier against large-scale adoption of electric trucks.

Business-model issue: Aside from the issues related to the power supply and infrastructure deployment, truck operators also are anxious about a new and unsolved business model that may affect their relationship with utility companies. This issue has not yet been addressed by the government or experts.

EFV Benefits and Opportunities

Operational performance

Higher operational efficiency: In some cases, there are some restrictions for using conventional trucks in urban areas. For example, local authorities may implement a low-emission zone for their cities, limiting the operation of large trucks. However, zero or low-emission EFVs could be permitted in these zones. Therefore, the route choice of these vehicles can be a more efficient option for operators. In addition, the experience of using these vehicles in the Netherlands has shown that EFVs are noiseless, which makes possible a more extended operating time window (such as operating longer into the night and/or early morning).

Positive impacts on congestion and extended time window: EFVs have higher maneuverability and smaller size, which could help reduce congestion. Furthermore, since EVs emit no engine noise, they could benefit from an extended operational time-window regulation for freight deliveries (out of peak periods, like early morning and late evening or night).

Economic benefits

Lower total cost of ownership: Based on an International Energy Analysis Department report, at the current global average battery pack price of $135 per kilowatt-hour (realizable when procured at scale), a Class 8 electric truck with a 375-mile range and operated 300 miles per day, offers about 13% lower total cost of ownership per mile when compared to a diesel truck. This is about a 3-year payback and net present savings of about $200,000 over a 15-year lifetime. This is achieved with only a 3% reduction in payload capacity. Moreover, battery prices are projected to decline to about $60 per kWh by 2030, accompanied by further improvement in energy density and efficiency. These advances, combined with state and federal policies to monetize pollution-reduction benefits, could make the cost of owning an electric truck more than 40% lower than a diesel truck.

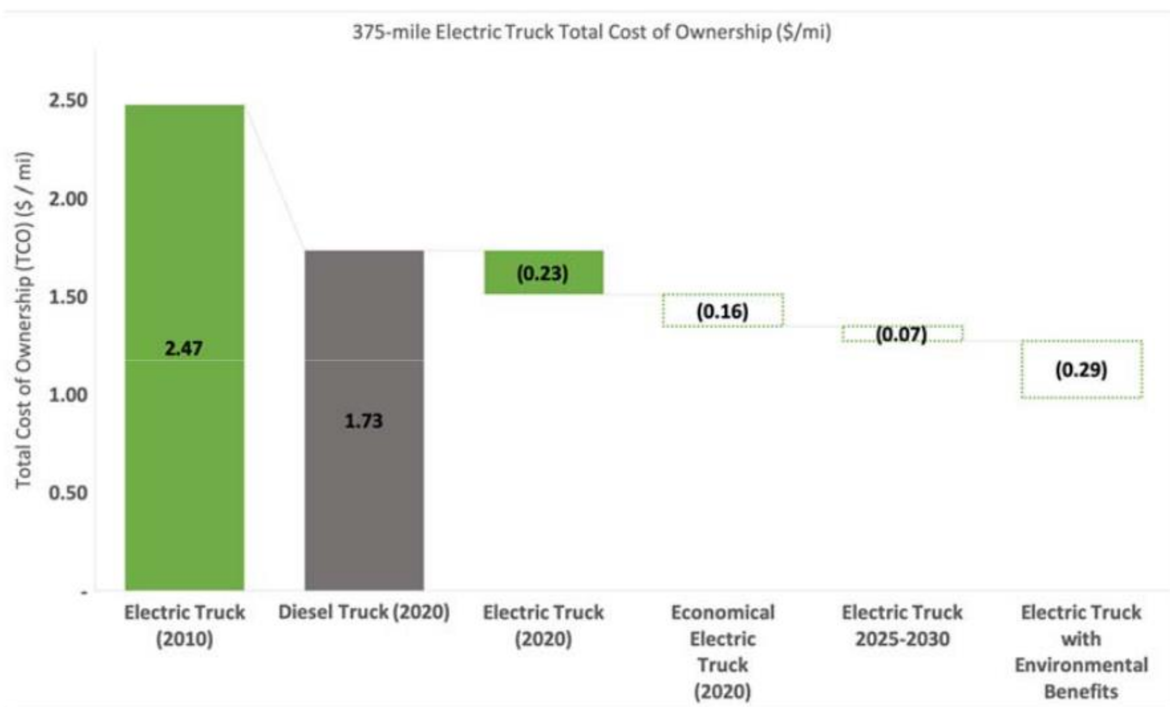

Figure 3: **TCO comparison for 375-mile (797 kWh battery pack truck) operated 300 miles per day for 260 days per year.**

Environmental benefits

Using EFVs can reduce local emissions, improving the health and livability of vulnerable communities, according to findings reported by all U.S. and EU demonstration projects and private operators. But are we just moving from mobile source pollution to fixed-site pollution, or is the energy source going to change? Is there enough potential in the state to exploit clean, renewable energy sources such as solar and wind to supply the power demand?

Opportunities for policies and incentives

In the context of the high initial purchase cost of EFVs and remaining uncertainties about their long-term performance, favorable government policy often is deemed essential to support the massive adoption of electric trucks. A combination of financial support subsidies and government policy promoting the implementation of EFVs are seen as key factors to their success. In other words, if trucking companies invest large amounts of money on the electrification of their fleets, they need to be sure they can recover the extra costs. For instance, there is a $60,000 gap between the cost of an electric truck, estimated at $200,000, and an existing freightliner, which costs $135,000 to $140,000.

Social and attitudinal impact

Electric vehicles are being accepted well by the public because they are less noisy and more environmentally friendly than conventional vehicles, and they are receiving positive feedback from drivers in most initiatives.

Noise: EVs emit no engine noise and, therefore, may benefit from an extended operational time-window regulation for freight deliveries (out of peak periods, like early morning and late evening or night). However, tire noise from EVs is comparable to conventional vehicles and there is still a problem with noise from driver activities, loading and unloading personnel, and from loading and unloading equipment when operated within extended time windows. (To address the latter issue, silent electric pallet movers can be used.)

Driver acceptance: Overall, most drivers are happy with electric freight vehicles because of improved technological features that make maneuvering and parking easier in urban areas. EFVs also stand out for their appearance.

Positive corporate image: Implementation of electric vehicles has helped some transport operators to improve the image of their company. For example, according to Tesco (UK), “our customers want to know that we are caring for the environment, and we are working hard to reduce our CO_2 emissions.” The admirable thing about an EFV is that it is a very visible solution of improved sustainability in urban logistics, while other sustainability solutions (such as better bundling or planning) are not visible at all in city streets.

Steps Towards Electrification of the Freight Fleet in Minnesota

In November 2021, the bipartisan Infrastructure Investment and Jobs Act (IIJA) became the single largest infrastructure investment in American history. The bill includes significant funding at the federal and state levels for electric vehicles and the infrastructure needed to support EV deployment. As state and local governments look to increase transportation electrification, this bill provides investment in several critical areas needed for deployment.

Minnesota also is committed by statute to do its part for the climate by meeting its Next Generation Energy Act goals. This 2007 law requires the state to cut its annual emissions of greenhouse gases by 80% between 2005 and 2050. While much progress has been made, the 2050 goal will require policies well beyond what already is in place at the federal or state level. EFVs offer numerous benefits to Minnesotans, including less emissions and cleaner air. They are part of a comprehensive strategy to reduce carbon pollution. Because EFVs emit zero tailpipe emissions, they are cleaner to operate compared to diesel trucks. Charging EFVs with clean energy makes them even cleaner. As electricity generation shifts to lower-cost renewable energy, EFVs effectively will get cleaner over time.

However, implementation of an electric freight system so far has faced serious barriers such as the lack of infrastructure, and government support has traditionally been focused on light-duty charging because light-duty EVs were introduced to the market first. Retailers, workplaces, and municipalities also have focused on installing light-duty chargers because these entities mostly encounter light-duty EVs. But now, governments, utilities, and other relevant actors have noted the growing market for medium- and heavy-duty EVs and have started taking action to fill the infrastructure gap. The IIJA authorizes funding for the Congestion Mitigation and Air Quality Improvement Program. The law also includes medium- and heavy-duty vehicles and infrastructure spending through the Advanced Technology Vehicles Manufacturing Loan Program of the U.S. Department of Energy Loan Programs Office.

Minnesota also formed the Regional Electric Vehicle Midwest Coalition (“REV Midwest”) with Indiana, Illinois, Michigan, and Wisconsin to create a regional framework for accelerating vehicle electrification in the Midwest. REV Midwest provides the foundation for cooperation on fleet electrification along key commercial corridors to safeguard economic security, reduce harmful emissions, improve public health, and advance innovation. REV Midwest will future-proof the region’s manufacturing, logistics, and transportation leadership and position the region to realize the additional economic opportunity in clean energy manufacturing and deployment.

Conclusion

In this evaluation of EFVs, we identify strengths and weaknesses in relation to current and future implementation (barriers and success factors) of EFVs in city logistics when compared to vehicles with internal combustion engines.

Strengths of EFVs compared to ICE vehicles

Economic/operational performance

- Lower maintenance and fuel cost
- Higher efficiency in operation, in the case of government support (for example, larger time windows, environmental zones, and free parking)

Social and environmental impact

- Zero emission
- No noise from vehicles — only from loading equipment and driver behavior
- Drivers are happy with vehicles, and its acute turning range is helpful on city streets
- Positive general acceptance from the public
- Contribution to the positive image of transportation operators and shippers

Weaknesses of EFVs compared to ICE vehicles

Technical and operational performance

- Limited range and lack of infrastructure
- Battery and charging issues
- Loading capacity

Economic and power supply

- Higher purchasing cost
- Grid capacity and new business models

When added together, these many issues together create a huge barrier for the implementation of electric freight vehicles. But aggressively moving toward electrification before addressing the barriers can negatively impact the grid and impose too much pressure on trucking companies, particularly smaller ones.

About MFAC

The Minnesota Freight Advisory Committee (MFAC) was established in 1998 to advise the Minnesota Department of Transportation (MnDOT) and other public agencies and officials on the performance and importance of Minnesota's freight transportation system to support the state's economic competitiveness.

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