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Battery Electric Vehicles in Light- & Medium-Duty and Specialty Truck Commercial Applications

Developed by the Technology & Maintenance Council's (TMC)
S.14 Light- & Medium-Duty and Specialty Truck Study Group

ABSTRACT

A Class 1-6 commercial motor vehicle (CMV) powered solely by electricity is much different than a CMV powered by an internal combustion engine (ICE) or by hybrid electric vehicle (HEV) design. A battery electric vehicle (BEV) design includes storage only for its onboard battery capacity, not fossil fuel. The battery capacity has a direct impact on vehicle range and powered features. The electrical propulsion system requires a high voltage supply and significant current draw that dictates the capability and therefore the battery capacity. Unlike electric cars that can transport a relatively light load within a limited range, a commercial application relates to the operator's ability to fulfill a customer's expectations.

Commercial BEVs have balanced design considerations that involve total vehicle cost, weight, energy storage capability, and lifecycle value. The primary consideration is the battery in which lithium-ion (Li-ion) technology has grown to be most popular for its design. Other considerations rely on the unloaded weight amount the CMV has compared to its maximum load weight amount dependent on distance, geographical terrain, duty cycle and any other specific industry segments that test its capabilities. End users must understand their own applications before changing from ICE design or HEV fleet units to fully electric.

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INTRODUCTION

Global trucking manufacturers are accelerating their efforts to produce more vehicles utilizing electric drivetrains. Many factors are contributing to this trend, including newly enacted fuel economy standards, greater confidence in electric-powered vehicles, and advances in battery technology. In the past 10 years, there have been many OEMs taking up BEV development for many operations in fleet markets, municipalities, universities, and state and federal government.

An estimated average CMV range and payload would dictate industry segmented applications where a BEV would be acceptable. For deliveries that are limited to slower speeds, lighter loads and shorter trips, BEVs would have a more conducive capability. A delivery schedule that accommodates short operation time and significant recharging time would be preferred since currently the charging of such a large battery can range to between five and eight hours of downtime. Accordingly, faster and more convenient charging capabilities are under development. A wireless inductive charging standard, for example, has been in development by the Society of Automotive Engineers (SAE) since 2010.

Battery

The shift from well-established nickel-metal hydride (NiMH) batteries (mostly used in HEV applications) to Li-ion represented a major endorsement of the ability of this chemistry to perform consistently in a trucking environment. This style of battery has the highest energy density (Wh/kg) and life span (cycles), lowest discharge rate and fastest recharge time commercially available.

The life and warranty of a battery pack is determined by the number of charge / discharge cycles. An electric vehicle that is used in normal daily operation would have a single charge cycle which would equate to:

240 work days per year x 10 years

= 2,400 charge cycles

A battery that is projected to have a 2,400 charge cycle life should have an estimated service life of approximately 10 years in this type of operation. A calculation such as this would be helpful when evaluating a battery warranty. Several factors in estimating the operating cost of a commercial BEV include:

- useful life,
- percent of degradation over its projected life span,
- replacement cost, and;
- salvage value of the original battery.

Charging

Level 1 charging is the technical term for plugging an electric car into an ordinary household outlet. At 120V (in the US), charging a BEV may take the longest time in recharging a large battery for commercial applications. At the other end of the spectrum is DC Fast Charging, the fastest type of charging currently available. Between the relatively cheap Level 1 and expensive DC Fast Charging stations sits Level 2 charging. Level 2 supplies 240V, which supplies a household oven or shop welder. It goes through a box and a cord that improves safety by waiting to send power to the plug until it's plugged into the BEV. These charging stations are being developed all over the United States depending on state programs, government funding, fleet use, consumer locations, etc.

Other than switching from a fuel nozzle to a plug, BEVs are also equipped with self-charging capabilities. Currently regenerative braking, solar power, and kinetic energies are most popular for BEVs. New charging methods have been influenced by wireless testing. Inductive charging allows a BEV to park over or be near a transmission unit that feeds power over-the-air by the magnetic field created from the unit and the BEVs receiver unit.

Safety
The safety criteria for BEV batteries may be viewed from different perspectives, and each OEM will have a unique safety approach tailored for its vehicle platform. Fundamental to all efforts though is that the battery cell failure rate can never lead to thermal runaway resulting in battery explosion. Other safety aspects for an industry approach include, but not limited to, equipment sensibility to fire, emergency responder training, hazard representation, equipment alarms, etc. How a fleet decides its equipment purchasing should rely on its existing safety plan first and alter if necessary for BEV consideration.

CONSIDERATIONS

The following topics are suggested for fleets to consider when planning to transition ICE equipment assets to BEV assets:

a. ***Economics/Return on Investment***—In many areas there are substantial savings as a consequence of government incentives for reduced carbon emissions from CMV comprising grants, reduced and, in some circumstances, zero taxation. This can include purchase and import taxes, capital concessions and the avoidance of road and fuel taxes and concessions relating to parking, congestion charging and other road use especially in city centers.

b. *Maintenance Reduction*—Reduced energy consumption, lowered maintenance costs from fewer moving parts in electric drivetrains as compared to ICEs and more efficient operations are benefits. Avoidance of fluctuating costs from the fossil fuel market also become associated disincentives to using ICEs.

c. ***Emissions—***BEVs ensure compliance with increasing legal requirements for reduced exhaust emissions. More and more cities across the world will continue to set up environmental zones requiring increasingly stringent reductions in exhaust emissions – leading eventually to zero emissions.

d. Public Image—BEVs are 'clean.' They have a reduced carbon footprint as emissions are virtually non-existent, making for cleaner air in the communities where the vehicles are driven. Many BEV charging station networks can also be associated with renewable energy generation sources. Early BEV adoption will be perceived as pioneering, progressive, and as caring for the environment and the well-being and quality of life for people in the community.

e. ***Operator and Customer Acceptance—***Pride, commitment, job satisfaction are some intangible factors. BEVs encourage a shift in spending to local and domestic sources of energy and the use of company infrastructure to charge personal BEVs. They are also generally considered to be extremely pleasant to drive. They are quiet, smooth and relaxing as, for instance, they don't require gear changing and commonly win over drivers from conventional ICE-powered vehicles.

f. ***Performance—***Just as an HEV drives, but without the ICE ever activating because there is none. If the performance expected from the CMV is light loading, short routes, low speeds and extended downtime for charging then performance standards will be met. Plus the operating comfort of a 'low-noise' emission free CMV. Also, they won't violate quiet zones in and around hospitals, for example, and provide quiet deliveries and other road usage during the night.

FACTORS TO EVALUATE

The following factors are to be evaluated by fleet sector specifics:

Vehicle Ownership and Operation Costs

For this report, conventional BEV ownership costs are assumed to be higher than an average CMV, and annual mileage is estimated to be lower. Operating costs, including fixed and variable costs, and direct and indirect maintenance costs are all impacted with transitioning from conventional CMV to BEV.

Financial Subsidies

It seems reasonable to estimate that commercial BEV sales are subsidized at least 10¢ per mile, based on $10,000 averaged over a 100,000 average operating life for an electric CMV. This represents the lower bound of subsidies, since it ignores development costs, uses the lower bound of estimated subsidies, and ignores the time value of money (since this cost occurs before benefits).

Travel Time

BEVs have no incremental travel time costs. Limited distance use BEVs are likely to have actual travel time incremental costs greater than zero. Given viable choices for longer distance trips, actual incremental time costs should be low.

Accident Costs

Commercial BEVs are assumed to have higher accident costs than conventional CMVs only when operated as such. Limited distance use BEVs probably bear somewhat reduced accident costs and impose much lower costs on others due to their lower speeds.

Parking

Commercial BEVs will accumulate the same costs as a conventional CMV in pay per parking areas. Although the design of a BEV is smaller than a CMV, if parking is by lot space then less costs will account. Finding a charging spot and one that is open to vehicles larger than a car will be difficult too.

Roadway Costs

Electric CMVs impose roadway use costs comparable to conventional CMVs but pay no user fees. As a result, this can be considered an external payment to electric CMVs.

Equity and Option Value

Commercial BEVs have the same equity and option value cost as conventional CMVs, although tax return value with BEVs may be more generous with emission excise tax. BEVs are also more acceptable to impaired users by ease of use and may be an option to receive excise incentives for that.

Air Pollution

Electric CMVs produce zero emissions as ICE CMVs produce DOT standardized emission limits. Although, pollution is made during manufacturing of both types of CMVs.

Noise

Commercial BEVs can be heard even at very low speeds (e.g., tires rolling, brakes, generator hum) but are extremely quieter than conventional CMVs. Very easy to operate in areas of low noise areas.

Resource Consumption Externalities

Electric CMVs significantly reduce resource consumption externalities by reducing total energy consumption and by allowing greater flexibility in the primary “fuel” used compared with petroleum fueled CMVs.

Barrier Effect

The barrier effect refers to the degradation of the pedestrian and bicycling environment by motor vehicle traffic. BEVs that are routed in regular traffic patterns give no benefit the barrier effect unless they are in limited distance use.

Waste Production
Electric CMVs reduce some types of waste and increase others. One cost to carefully monitor are those tied to heavy metals associated with battery production and disposal, which represents an uncertain but potentially hefty outlay for users. After the useful life of a BEV has ended, recycling costs tied to these heavy metals could be significant, especially in relation to those associated with conventional CMVs.

CONCLUSION
Electrically propelled Class 1 to 6 CMVs are not of new technology, but will continue to evolve as related technologies improve. The overall system of vehicle capability and charging infrastructure must be evaluated to determine the applicability of fully electric CMVs in an operation. The performance requirements and duty cycle are key to determining the applicability of an all-electric CMV to specific operations.