Electric Commercial Vehicles: What You Need To Know

Introduction

Many fleets are looking at electrifying at least some of their vehicles. Reasons for this include state or local mandates, environmental sustainability policies and customer demand. As electric drivetrain technologies and components move into the mainstream market, fleet electrification is increasingly on the radar for many government, municipal, commercial and non-profit fleets. This guide aims to provide some insight into the many facets of electrification, and to help fleet managers to understand what to look for when selecting a vendor of commercial EVs.

Lightning Systems produces electric commercial vehicles by designing and manufacturing electric drivetrains and managing their installation into established vehicles from major OEMs such as Ford and GM. By using the best available components and by embodying sophisticated mechanical, electrical and controls engineering into our designs, we offer premium commercial EVs which deliver the market's best reliability, performance, driver experience and longevity.

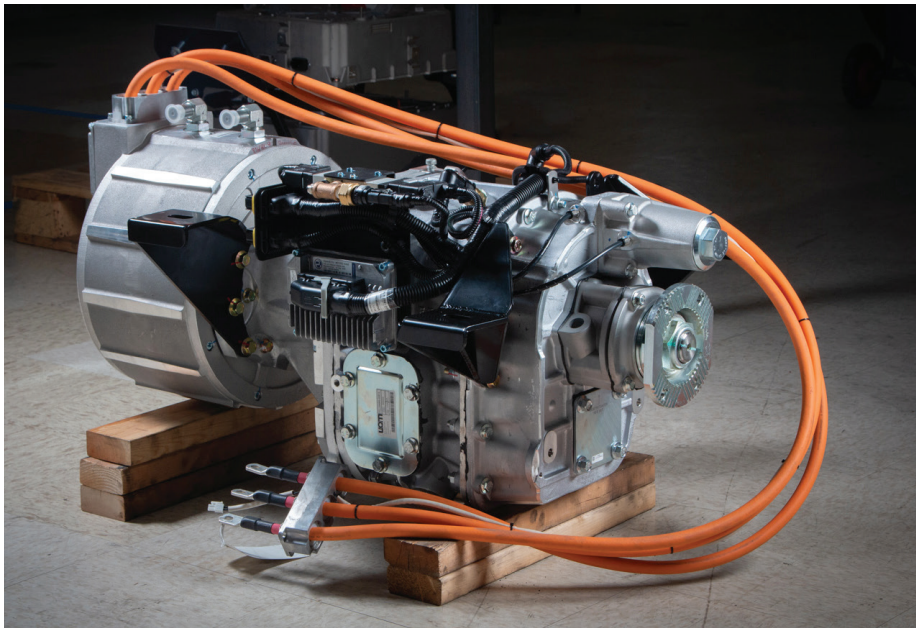
Contents

1. Differences Between Electric and Internal Combustion Engine Vehicles

An electric commercial vehicle may look different from a traditional vehicle – or it may not, depending on whether it is "purpose-built" or a conversion (see the next section). A well-integrated conversion, such as those from Lightning Systems, is hard to spot visually, with just a few clues such as a different dashboard graphic. From a driver, passenger and cargo perspective an EV should behave very like its internal combustion engine (ICE) counterpart.

However, there are some significant distinctions. On the positive side:

- **Zero emissions:** This is probably the primary driving force for fleet electrification. See the section *Pollution and Sustainability Considerations* later in this guide for a deeper look at this topic.
- **Low fuel costs:** Electricity use in an EV costs 10-35% of gasoline costs per mile, depending on gasoline and electricity costs. For a vehicle covering 25,000 miles per year, this amounts to $5,000–8,000 saved in annual fuel costs, per vehicle.
- **Quiet:** Electric vehicles are notoriously quiet – so much so, in fact, that some countries are requiring EVs to make an artificial sound as a safety feature to alert pedestrians. Some of our EVs are indeed silent at low speeds; others emit some sound and are not completely quiet. However, compared to, say, a diesel truck, EVs are very quiet.
- **Driver experience:** As long as the EV integration is of high quality (see the *Integration Quality* section), the driver's experience is always strongly positive. The vehicle usually accelerates faster than its ICE equivalent, and is smoother and quieter to operate. Vehicles which employ regenerative braking (see the section *Regenerative Braking, Creep and Hill-Hold*) may behave in an unfamiliar manner when the driver takes his or her foot off the accelerator pedal; but drivers become used to this very quickly.
- **Maintenance:** Electric vehicles have far fewer moving parts and require less maintenance than vehicles with internal combustion engines and multi-speed transmissions. The electric motor is maintenance free, and the simple one-speed or two-speed gearbox uses a small amount of fluid which should be changed every 150,000 miles. The batteries' thermal management system uses coolant fluid which should be checked for leaks and topped off if needed, and replaced every 150,000 miles. Additionally, regular inspections of the high-voltage system should be carried out by certified technicians. However, EV operators will enjoy not having to perform frequent oil changes, air filter changes, DPF purges, spark plug replacement, etc. Additionally, regenerative braking (where the vehicle is slowed by using the motor as a generator) dramatically reduces brake wear. With all of these differences, EVs deliver large savings in maintenance costs and time.



An electric traction motor coupled with a gearbox, as used in our Ford Transit electric drivetrain.

However, electric vehicles do present some operational challenges not experienced

with internal combustion engine vehicles:

- **Range:** Electric vehicles have significantly shorter on-road ranges than ICE vehicles. For some uses, such as inter-city transport, this may make EVs inapplicable; however, there are many uses where the relatively limited range is not a concern because the vehicle's daily route falls comfortably within that range. For example, many urban delivery routes are 50 miles or less per day. Lightning Systems offers a choice of ranges for most vehicles, depending on the number of battery packs installed. A typical maximum range is 110 to 120 miles.
- **Charging time:** Unlike ICE vehicles which can be refueled in a few minutes, EVs take longer to charge. Suitable charging infrastructure can reduce charging times to as little as one or two hours, but four hours may be more typical for a full charge from "empty" to "full". Therefore, most operational models would expect the vehicles to be charged during the night, say.
- **Payload / passenger capacity:** Battery packs are heavy, which impacts payload or passenger capacity for a given GVWR limit. This needs to be factored into the operational planning for the vehicle. Aside from pricing, payload is one reason why Lightning Systems offers different numbers of battery packs. For example, if a vehicle's route is relatively short, a configuration with fewer battery packs will suffice, with the advantage of increased payload capacity.
- **Weather:** Battery-electric vehicles are more affected by ambient temperature than ICE vehicles. The batteries themselves operate best in a relatively narrow temperature range. On Lightning Systems' vehicles, the batteries are actively thermally managed, which takes care of this requirement automatically (see the section Battery Quality: Efficiency, Performance and Longevity). In addition, the weather affects the need to heat or cool the passenger cabin for comfort. Heating and cooling both require energy and will reduce the on-road range of an EV.

Payload capacity is affected by the weight of the batteries.

2. Electric Conversions vs. Purpose-Built Vehicles

There are two primary routes that EV manufacturers can take to bring commercial EVs to market:

1. New, purpose-built vehicles
2. Conversions of established existing vehicles

Several commercial vehicle manufacturers are adopting the first approach by entering the market with vehicles which are completely new from the ground up. These are typically recognizable by their aerodynamic, modern or even futuristic styling.

Vehicles in this category have a few advantages:

- A ground-up design can provide the most sophisticated integration of an electric drivetrain into a vehicle, including the driver's controls and driving experience.
- The custom body design can provide an aerodynamic advantage which may improve the vehicle's range, along with additional enhancements such as low rolling resistance tires.

- Such vehicles are potentially recognizable by the public as electric, which may assist fleets with PR and marketing.

However, these advantages are typically not significant:

- Although a ground-up vehicle's electric drivetrain integration can be sophisticated, Lightning Systems' integration into existing vehicles is just as polished and has the additional advantage of being entirely familiar to drivers.
- For urban cargo and passenger duties, aerodynamic styling and low rolling resistance tires are very small contributors to efficiency because vehicle speeds are relatively low, since air resistance increases as the square of the vehicle's speed.

In addition, purpose-built vehicles have major disadvantages relative to conversions of existing vehicles:

- Existing, well-established, popular vehicles enjoy nationwide and international parts and service infrastructure, whereas a new design from a niche manufacturer does not. Obtaining replacement mirrors, windshield glass, body panels and mechanical parts may be difficult to impossible for such vehicles, especially for the support needs of large fleets.
- This problem of the lack of an established ecosystem extends to accessories and upfits, such as shelving and lifts. For established vehicles, these can usually be ordered and installed through the OEM's dealership network. For ground-up designs, these accessories may be hard or even impossible to obtain.
- Fleets are very familiar with the dimensions, payloads and operational characteristics of existing vehicle models, whereas a new design is an unknown quantity.
- Established vehicles enjoy warranties from major OEMs. Lightning Systems' conversions of Ford vehicles (such as Transit, E-450 and F-59) retain their Ford warranty through our membership of Ford's eQVM program. Purpose-built vehicles are warranted by the EV manufacturer, who may not have the resources or geographic reach to fulfill warranty needs.
- EV manufacturers who bring purpose-built new vehicles to the roads are responsible for the design, simulation, analysis and proving of their designs, as well as regulatory compliance. Then comes component sourcing, manufacturing and commissioning for all systems on every vehicle. These amount to a heavy operational and financial burden which may prove commercially unsustainable for a niche manufacturer.

For these reasons, Lightning Systems believes the more successful approach is to convert established vehicle models from major OEMs to electric.

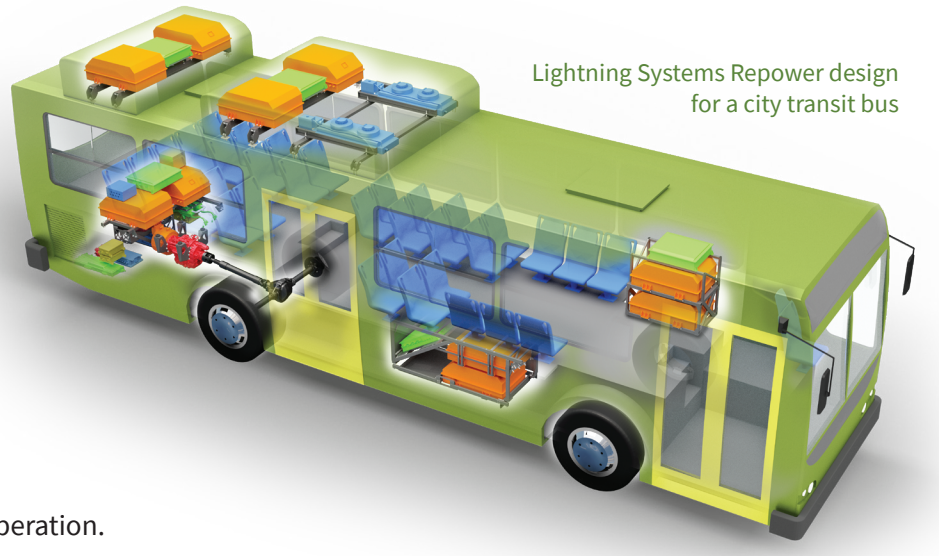
A purpose-built vehicle from Smith Electric, a company that's no longer in business.

Image: Jan Kubík Wikimedia Commons CC BY-SA 3.0

3. Repowering Ageing Vehicles

In most cases, our conversions are performed on new vehicles before they are delivered to the fleet or dealership, which means that they are legally regarded as new electric vehicles at the time of registration.

For some markets, it makes economic and environmental sense to convert an older vehicle to electric. This is especially true for diesel city transit buses which are over 10 years old. Many of these buses have engines which are nearing end-of-life, typically leading to scrappage of the entire bus.



Lightning Systems Repower design for a city transit bus

Lightning Systems offers a solution for converting old diesel buses to battery-electric vehicles. This has several advantages:

- It keeps a perfectly good bus body in operation.
- It provides a path to electrification, which is increasingly becoming either mandated (such as in California) or desirable for organizational sustainability targets.
- It is *much* less expensive than purchasing a new battery-electric bus.
- The conversion can be designed and installed in a much shorter time frame than the typical delivery time for a new battery-electric bus.
- In addition, considerations for battery quality (covered next in this paper) apply.

4. Battery Quality: Efficiency, Performance and Longevity

Probably the greatest differentiator between EV vendors is the quality of the batteries used and whether or not they are thermally managed. This has a direct effect on performance, efficiency and – importantly – battery lifetime. As you might expect, high quality generally comes at a higher price; and lower-cost batteries may exhibit problems relatively quickly. Lightning Systems has chosen to equip our electric drivetrains with the highest quality batteries available, and to implement thermal management to ensure that the batteries deliver the best performance and longest life.

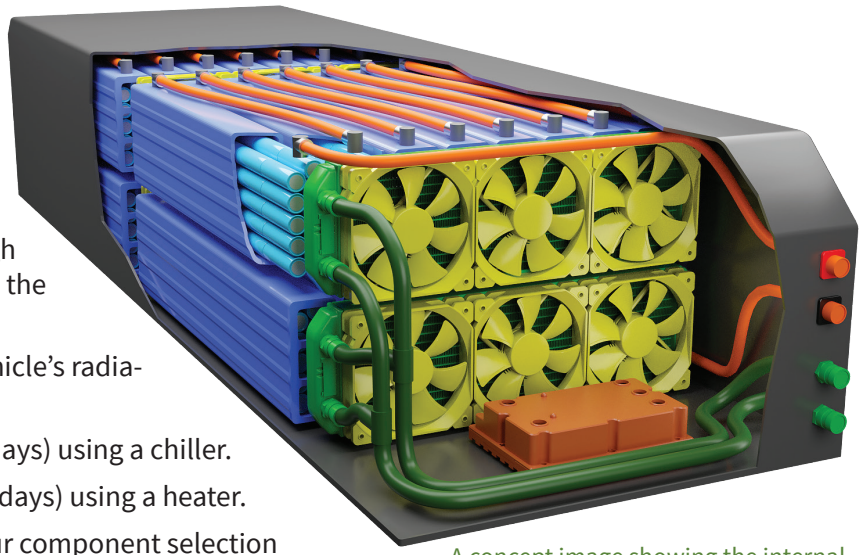
The basic building block of an EV battery pack is the cell. We use the same premium cells from South Korean manufacturers as are used by major passenger EV OEMs. Several of our competitors use cells sourced from China, which may exhibit higher failure rates and shorter lifetimes.

The technology used in our cells is “NMC” – Nickel Magnesium Cobalt, which is type of lithium ion battery that is widely used in the electric vehicle industry because of its good performance with respect to energy density, power density, longevity and safety.

The cells are combined in units called modules which are connected together within the battery pack to deliver the required electrical characteristics to drive our EVs. Most of our EV offerings have more than one battery pack, with as many as ten packs employed in a city transit bus Repower.

An important feature of all Lightning Systems EV implementations is thermal management for the batteries. The cells operate best within a particular temperature range, delivering the best performance, range and efficiency, and lifetime. Batteries that are not thermally managed typically last as little as one or two years before they stop taking enough charge to be usable on the road. With thermal management, this lifetime extends to between seven and ten years. Our thermal management consists of a coolant fluid loop which runs through the batteries. The fluid is treated automatically in the following ways:

- Cooled to ambient temperature using the vehicle's radiator.
- Cooled below ambient temperature (on hot days) using a chiller.
- Heated above ambient temperature (on cold days) using a heater.



A concept image showing the internal components of a battery pack

Battery safety is an important consideration in our component selection choices. There are safety features at the cell level, the module level and at the battery pack level. These include fire and explosion risk reduction to safe levels and reducing the risk of personnel electrocution during servicing or accident situations.

5. Range Estimates and Realities

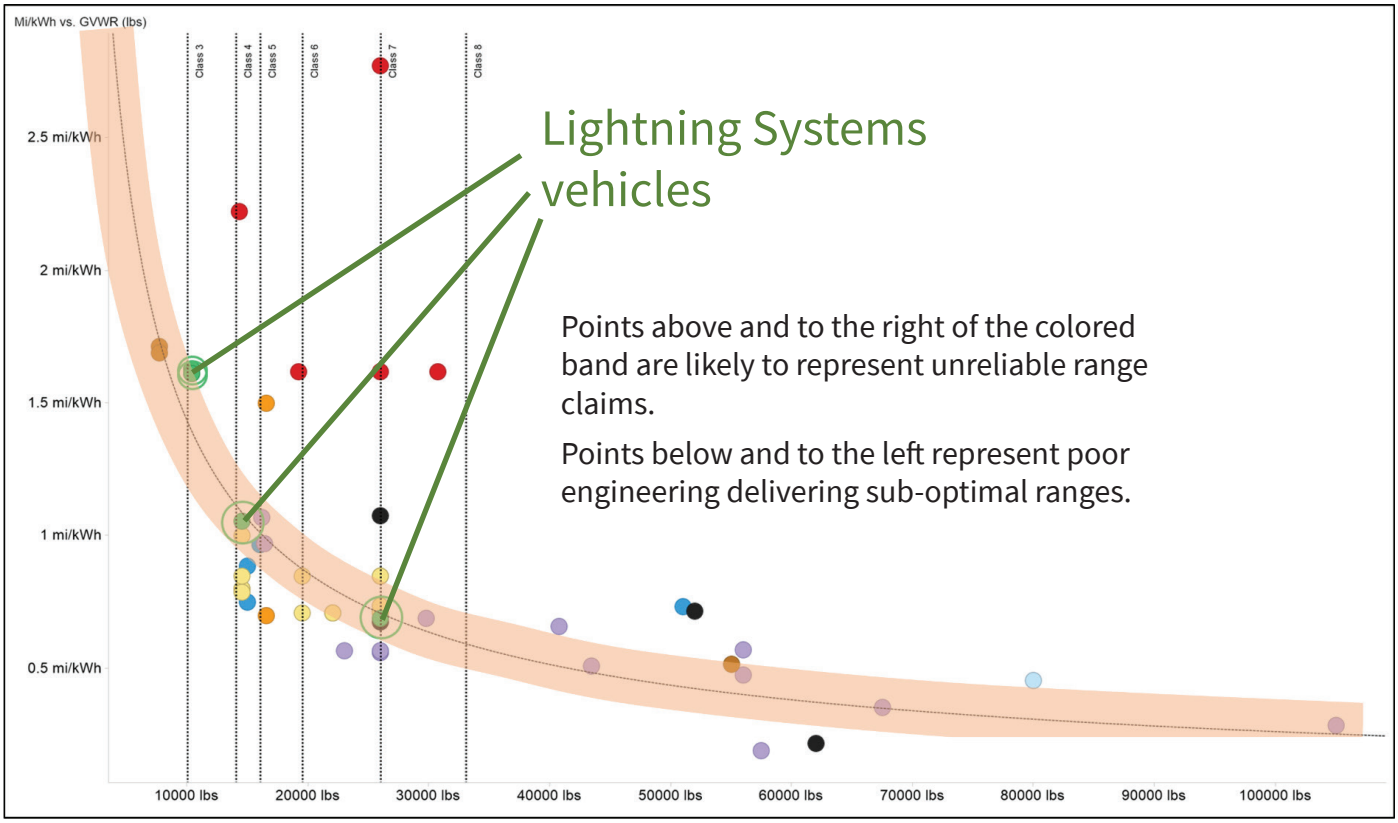
The range of a commercial electric vehicle depends primarily on its weight, drive cycle and battery capacity. This is down to physics, and one would expect similar vehicles to have similar ranges. However, the ranges claimed by some of the vendors in the industry make one wonder if they're somehow in a parallel universe where physics is different!

The benefits of a "ground-up" or purpose-built vehicle design (see the section Electric Conversions vs. Purpose-Built Vehicles) have very little impact given that the laden mass and drive cycle are the same.

Therefore, if a commercial electric vehicle manufacturer advertises a range or efficiency more than 10% different from the industry fit-line in the chart on the next page, you should ask for their dyno and track results and their test criteria.

In one recent case, a vendor advertised 50% higher range/efficiency than the industry average. After searching we discovered that they had run the test at zero payload and a steady 28 mph. No customer will see those results in real-world driving, so this kind of manipulation is not helpful to anyone.

Lightning Systems has CARB-certified dyno range and efficiency test results for all of our Class 3 (Ford Transit) vehicles. Our results are industry-leading because our control algorithms for brake regeneration are the best in the business, and we use the very best battery, motor and accessory technologies. These advantages put us a little above the fit-line in the chart; but not by an amount that bends the laws of physics.



Lightning's Class 3 results are the only data points on the chart based on certified EPA City/Hwy dynamometer testing. All other data points are based on each OEM's self-reported modeling, or on-road testing using whatever algorithm they chose.

We are now working to test all of our other platforms on dynamometers. In the meantime, we will use standard road testing that is representative of customers' real drive cycles to provide range and efficiency data. We believe every EV manufacturer should be forced to the same standard — and if the certifying agencies do not enforce it, we believe that customers should and will.

6. Integration Quality

Commercial EV vendors must make many engineering decisions when designing a vehicle conversion. These decisions affect the quality of the integration, including the driver experience, the on-road performance, and reliability. Lightning's approach is always to opt for the best quality and most elegant choices, which results in a premium experience for the driver and passengers, and the most reliable platform for fleet operators. Examples of high quality integration features include:

The dashboard of a Lightning Systems Ford Transit van, showing the power meter on the left, and the battery charge level indicator instead of the fuel gauge.

- All components throughout the EV kit are selected for high quality and high reliability. They have been proven in similar automotive applications.
- Drivetrain components use existing engine and transmission mounts for easy installation and mechanical robustness.
- Controls are integrated with the vehicle's CAN bus for deep integration with

vehicle functions. This integration does not use the OBD-II port, which remains available for service use.

- The dashboard labeling is replaced with our custom graphic which shows information that's relevant to the EV. For example, instead of showing engine RPM, the dashboard shows electrical power-draw/regeneration.
- There are no unfamiliar switches, pedals or buttons. Operating a Lightning EV is entirely intuitive for drivers.
- Creep and hill-hold are implemented (see the next section).

Our design philosophy is that everything should be done the right way; nothing should be "cludgy" or half-baked.

7. Regenerative Braking, Creep and Hill-Hold

Lightning Systems' EV technology provides regenerative braking, creep and hill-hold.

Regenerative braking occurs when the driver removes his or her foot from the accelerator pedal. The vehicle is slowed down by using the electric motor as a generator, which charges the batteries. The purpose of this is to recapture some of the kinetic energy (the "motion energy") of a moving vehicle and to store it as charge in the batteries. This contributes to the overall efficiency of the vehicle, and extends its on-road range by a small amount. A valuable side-effect of regenerative braking is that the vehicle's wheel brakes are used much less, which reduces brake wear and its associated maintenance costs.

Lightning Systems' experience with hydraulic parallel hybrid systems, which were regenerative braking devices, means that our implementation of regenerative braking in our EVs is the most sophisticated in the industry. In fact, some of our competitors do not implement regenerative braking at all.

A street where hill-hold is a good thing...

Creep is the behavior of automatic transmissions where a vehicle will move slowly forwards (or backwards, if in reverse) when the driver takes his or her foot off the pedals. This is very useful for maneuvering and parking and is much appreciated by drivers.

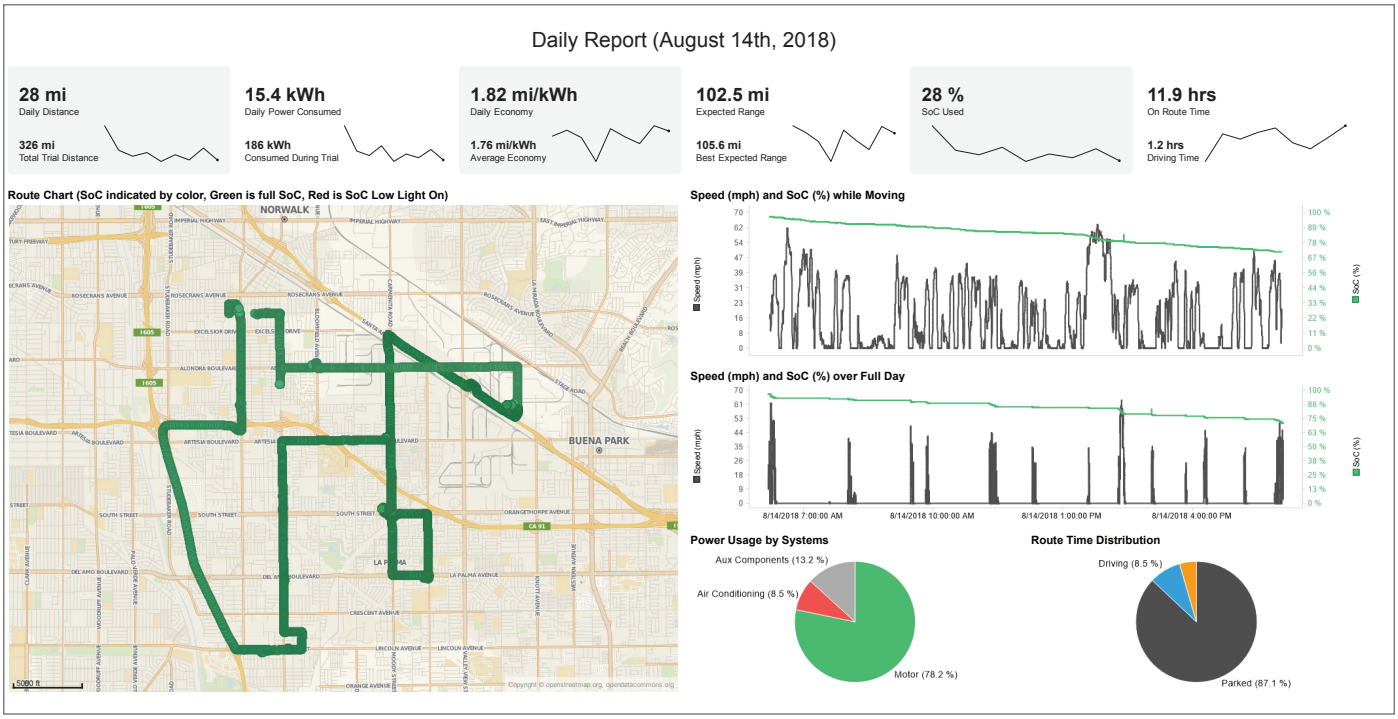
Hill-hold is a related behavior where a vehicle that's on an uphill slope will not roll backwards when the driver removes his or her foot from the pedals.

Creep and hill-hold are not by-default behaviors of electric motors. They have to be specifically implemented in the control software so that the electric traction motor is powered in just the right way. Lightning Systems implements both creep and hill-hold in all our EVs.

8. Lightning Analytics

Every vehicle is equipped with a telematics controller which interfaces with the CAN bus and connects to our data servers over an encrypted 4G connection. This allows Lightning Systems to monitor the health of every EV; but it also forms the basis of the valuable Lightning Analytics service for our customers.

Lightning Analytics goes much deeper than many commercial telematics solutions. By reporting GPS location and as many as 70 vehicle parameters every second, a rich set of data on every vehicle's activities is collected. Using sophisticated analysis tools, we generate reports for our customers. Here is an example of a daily report for a single vehicle:



- Along the top, there are at-a-glance metrics for miles driven, power consumed, economy (miles per kWh, which you can think of as the BEV version of miles per gallon), expected range, State of Charge used, and time spent on the route.
- The map on the left shows the vehicle's route. If the batteries' state of charge gets low, the route line turns red.
- On the right, there are two versions of the "speed and state of charge" graph; the lower one includes the times where the vehicle was parked; the upper one doesn't. The green line shows the state of charge in the batteries.

- The left-hand pie-chart shows where the electrical power went. In this case, the motor used most of it, as expected, with air conditioning and auxiliary components accounting for about 22% of the energy used.
- The right-hand pie-chart shows how much time was spent parked or driving during the route.

We also generate reports which summarize the metrics across an entire fleet.

Lightning Analytics is a powerful tool for gaining insight into almost every aspect of a vehicle's operation and performance. Fleet managers can take advantage of it to optimize routes, train drivers and capture the best value from their fleet of Lightning Systems EVs. Lightning Systems' analytics experts can provide custom reporting, custom data analysis and interpretation, and training.

9. Charging Solutions

Because commercial vehicles have higher battery capacities than passenger vehicles, the charging infrastructure at a fleet depot will likely require substantial planning and investment. Additionally, operational planning will be required to ensure that all EVs in your fleet can access charging stations when they need them, which will depend on the number of vehicles, the daily distances driven, the capacity of the batteries, the time taken to charge, and the number of stations.

Charging stations for commercial EVs fall into two categories: Level 2 AC charging and DC Fast Charge.

Level 2 AC charging: AC power is delivered to the vehicle, where it is converted to DC power for charging the batteries. This class of charger is lower cost and easier to connect to your building's existing electrical infrastructure. However, charging times for a commercial EV will be long due to the high capacity of the batteries.

DC Fast Charge: The charging station converts AC electricity to DC power which is delivered to the vehicle and is used to charge the batteries. Although more expensive, DC Fast Charge is much faster than Level 2. The high current levels needed for DC Fast Charge may require additional planning and permitting for installation.

All of Lightning Systems' commercial EVs support DC Fast Charge. Level 2 charging is also supported on our lighter vehicles such as the Ford Transit 350 HD and the Ford E-450. Check the specifications of the vehicles to see which charging types are supported.

The U.S. Department of Energy has published a Plug-In Electric Vehicle Handbook for Fleet Managers (https://afdc.energy.gov/files/pdfs/pev_handbook.pdf) which, while somewhat focused on passenger vehicles, covers many of the considerations to navigate when provisioning EVSE (electric vehicle supply equipment). Considerations include (but are not limited to):

- Power requirements to support the fleet now and in the future
- Number of charging stations to be operationally successful
- Electrical provision from the grid to the building (may need to be upgraded, which will require working with your utility company)
- Placement of charging stations
  - Can the cables reach the vehicles' charging ports?
  - For EVSEs with two cables, can you park two vehicles close enough?

- Permitting, building regulations, zoning requirements, etc.
- Electrical provisions inside the building
  - Voltages, current capacities, single-phase or three-phase, locations
  - Installation by certified electricians
- Running electrical provision to the charging stations
  - Trenches
- Safety considerations
  - Electrical, trip hazard, flood risk, cable damage, etc.
- Charging management
  - Billing, monitoring, smart charging (off-peak rates)
  - Metrics and analysis
- Microgrid options
  - On-site solar or natural gas generation
- Financial incentives
  - Some jurisdictions and utility companies offer financial assistance with fleet electrification projects.

Implementing electric vehicle charging, especially at fleet scale, is a complex and potentially expensive undertaking. A project like this requires committed project management. This can be provided within the fleet's management team; or it can be outsourced to companies which specialize in designing and deploying charging services for fleets. Lightning Systems can connect you with companies offering these services.

Additionally, Lightning Systems sells Level 2 AC and DC Fast Charge charging stations, without installation or management services. Visit our website or contact us for more details.

10. Pollution and Sustainability Considerations

This topic is complex and nuanced, depending on whether one looks at just the on-road emissions, or instead considers the entire raw materials, manufacturing, operation and end-of-life impacts of electric vehicles. The location where the vehicles are operated has a large impact too, due to different mixes of power generation types.

Our paper *Lightning Systems electric vehicles: Sustainability* goes deeper into some of these considerations. It is summarized here.

Automotive pollutants fall into two main categories:

Air quality pollutants – These degrade the air quality in a region. Poor air quality impacts human health and leads to hospitalizations and deaths. Air quality pollutants include NO_x (oxides of nitrogen), CO (carbon monoxide), VOCs (volatile organic compounds) and PM (particulate matter), which includes diesel soot, brake dust, tire dust and road dust.

Greenhouse gases – These capture heat in the atmosphere and are contributing to man-made global warming. The primary gas in this category is CO_2 (carbon dioxide), which is the main product of all fossil fuel combustion.

A battery-electric vehicle emits no CO_2. There's no fossil fuel combustion, so there's no carbon dioxide. There are also no NO_X, CO or VOCs. The emissions of particulate matter (PM) are also reduced: no diesel soot; and brake dust is reduced due to the use of regenerative braking.

At first glance, this appears to make it easy to calculate how many pounds of CO_2 you'll save each year if you replace your conventional vehicles with EVs. However, for a more complete picture, we need to take a look at where your electricity comes from.

The electricity used to charge a battery-electric vehicle usually comes from the grid, which is the infrastructure which delivers electricity from one or more power stations to the end user. Depending on the type of power station, CO_2 may be emitted:

- Coal, natural gas, oil-fired and biomass power plants emit CO_2 as a product of combustion.
- Nuclear, solar, wind, geothermal, hydro and tidal do not emit CO_2.

So how do an EV's CO_2 emissions compare with gasoline and diesel when we take the grid into account?

For coal-fired power stations, which are the most CO_2-intensive, the emissions are approximately 1.9 lbs of CO_2 per kilowatt-hour (kWh) of electricity generated. Since a commercial EV travels about 1 mile per kWh (say for class 5), that's 190 lbs of coal-generated CO_2 per 100 miles of range. This is similar to the CO_2 emissions of an equivalent gasoline vehicle.

However, natural gas power stations are taking over from coal in most US markets. They emit 35% of the CO_2 that coal emits for the same electricity output, so if your local grid is 100% natural gas powered, your EV's carbon emissions are 4.3x less than an equivalent diesel vehicle.

Most regional grids have a mix of power generation types which include nuclear and renewable sources. For example, California's mix has 43.8% natural gas and almost no coal; the rest comes from solar, hydro, nuclear, wind and geothermal, none of which emit CO_2. With this mix, CO_2 emissions for a battery-electric commercial vehicle driving 100 miles in California are about 29 lbs of CO_2. That's 9.7x less than an equivalent diesel vehicle.

What about raw materials and manufacturing?

Lightning currently supports two vehicle scenarios: a used vehicle and a new vehicle. In the case of a used vehicle ("repower"), we are keeping that vehicle out of the landfill and avoiding the impact of manufacturing a new vehicle. This is clearly the most sustainable option. However, most Lightning Systems EVs are conversions of

new vehicles from major OEMs such as Ford and GM. The stock engines and transmissions are removed, and an electric motor and associated gearbox are installed. This leads to a greater manufacturing footprint, which implies greater use of resources and energy than for a stock OEM vehicle.

In addition, the vehicle's batteries include lithium and other materials, and there's a materials and energy footprint associated with that too, as well as the environmental impact of lithium mining.

Therefore, the end-to-end environmental impact of putting an EV on the road is greater in some cases than for a conventional vehicle and may somewhat offset the EV's on-road advantages.

However, the EV industry is young and the situation will improve over time. For example, as the world's mix of power generation sources becomes increasingly clean, the CO_2 impact of manufacturing will decrease. Ultimately, Lightning Systems is looking beyond lithium-based batteries. This aligns with the EV industry as a whole that sees lithium as an intermediate step to new, greener technologies.

What about end-of-life and recycling?

The electric motor is easy and cost-effective to recycle, as it consists mostly of iron, steel, aluminum and copper.

At this time, lithium-based EV batteries are not cost-effective to recycle, though there is a push in the industry to address this. However, large EV batteries which have reached the end of their useful life in a vehicle can be redeployed in less-demanding applications such as on-site energy storage, for example in mobile charging solutions or at events or in disaster relief situations.

11. Financial Considerations

There are three primary financial considerations to make when purchasing a commercial electric vehicle (CEV):

High quality or lowest cost? Commercial vehicle downtime costs money, and the lowest-price CEVs will have significantly more downtime. Since all CEVs are made in low volumes today, the pricing of components is similar for all manufacturers, large or small. This means that the primary price differences between CEV manufacturers lie in the quality of the components used. The largest quality variable is in the batteries — active thermal management costs about 30% more than passive cooling — but nearly every study shows that actively thermally managed batteries are significantly more efficient, reliable, and last substantially longer. Choose to pay the extra 30% and you will make it up in uptime and longevity. The same holds true for the other components. Choosing a CEV that has high-quality, road-proven components rather than adequate-quality components (usually from Asia) ensures much better ROI and operational success.

Grants or no grants? Although there are a large number of government subsidies available across the US today, they do not cover all customers in all states. In fact, some subsidies, like the FTA Transit bus subsidies, will be stretched thinner as the CEV costs are twice what the diesel costs were, so the FTA grants will now fund about half as many buses. In localities with available grants, Lightning Systems can assist fleets to access those funds.

To lease or to buy? A commercial electric vehicle will always have a larger up-front

cost than a comparable gasoline or diesel vehicle, primarily due to the cost of the batteries. However, the operating costs of a CEV are lower: no oil changes, fewer brake changes, less expensive fuel and longer operating life. Financing a CEV can help level the playing field by lowering the up-front cash requirements and spreading the payments over the life of the vehicle. Look for a partner (such as Lightning Systems) that can finance a vehicle (or at least the batteries) for 7 to 10 years, and you may not need grants to make the CEV a smart purchase.

12. Planning for Electrification

Here is a suggested list of questions to consider when planning to electrify your fleet.

- Clarify your objectives: Why are you electrifying your fleet? (legislative requirements, sustainability goals, customer demand)
- Who are your project leaders and stakeholders? (fleet managers, procurement, vehicle maintenance, facilities management, sustainability director, driver supervisors, etc.)
- What types of vehicles are you looking to purchase? (weight class, platform, cargo, shuttle, bus repower, food truck)
- How many vehicles?
- Will electric vehicles work for your proposed routes? (range, charging time, payload capacity)
- Are there any financial incentives are available in your area? (state, local, utilities)
- Which commercial EV vendor should you select?
  - Does the vendor offer a range of platforms?
  - Does the vendor convert existing established vehicles, or are their vehicles purpose-designed from the ground up?
  - Does the vendor substantiate its range claims?
  - Are the vendor's products certified for legal sale (e.g. California's CARB)?
  - Do their vehicles use high-quality, long-lifetime batteries with active thermal management?
  - Do their vehicles implement regenerative braking, creep and hill-hold?
  - Is their solution elegantly engineered or clunky?
  - Does the vendor offer in-depth analytical telematics reporting?
  - Does the vendor have credible delivery times?
  - Can the vendor assist you with getting those financial incentives?
  - Can you purchase charging equipment directly from the vendor?
  - Does the vendor offer leasing programs as an alternative to purchase?
- Plan your vehicle charging provision: See the Charging Solutions section earlier in this paper

Lightning Systems offers well-conceived and well-engineered electric commercial vehicles, and can assist with all steps of electrification, either directly or by connecting fleets with service providers. Get in touch with us today on 1-800-223-0740 or at info@lightningsystems.com. Learn more at lightningsystems.com.