



Electric Commercial Vehicles: What To Look For



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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. Reasons for this include state or local mandates, environmental sustainability goals and customer demand. 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.

Contents

1. Differences Between Electric and Internal Combustion Engine Vehicles.....	1
2. Electric Conversions vs. Purpose-Built Vehicles	2
3. Repowering Ageing Vehicles	3
4. Battery Quality: Performance, Longevity and Safety	4
5. Range Estimates and Realities	4
6. Integration Quality	5
7. Regenerative Braking, Creep and Hill-Hold.....	5
8. Analytics.....	6
9. Charging Solutions	6
10. Pollution and Sustainability Considerations	7
11. Financial Considerations	8
12. Planning for Electrification	9

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). 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.
- **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 to \$8,000 saved in annual fuel costs, per vehicle.
- **Quiet:** Electric vehicles are notoriously quiet – so much so, that some countries are requiring EVs to make an artificial sound as a safety feature to alert pedestrians.

- **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.
- **Maintenance:** Electric vehicles have far fewer moving parts and require less maintenance than vehicles with internal combustion engines and multi-speed transmissions. EV operators will enjoy not having to perform frequent oil changes, air filter changes, DPF purges, etc. Regenerative braking (where the vehicle is slowed by using the motor as a generator) dramatically reduces brake wear.

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. However, there are many applications where the vehicle's daily route falls comfortably within that range. For example, many urban delivery routes are 50 miles or less per day.
- **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".
- **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.
- **Weather:** Battery-electric vehicles are more affected by ambient temperature than ICE vehicles. The batteries themselves operate best in a relatively narrow temperature range. **Look for vehicles which have actively thermally managed batteries.** In addition, the weather affects the need to heat or cool the passenger cabin for comfort, which requires energy and will reduce the on-road range.



A diesel engine and transmission removed from a bus, and the electric motor and transmission that replaces it.

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

Vehicles which are completely new from the ground up have some 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. (However, this level of quality is not guaranteed just because it's a ground-up design.)
- The custom body design can provide an aerodynamic advantage which may improve the vehicle's range.

However, these advantages are typically not significant:

- A high quality electric drivetrain integration into an existing vehicle can be just as

polished and has the additional advantage of being entirely familiar to drivers.

- For urban cargo and passenger duties, aerodynamic styling is a very small contributor to efficiency because vehicle speeds are relatively low.

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

- Existing, well-established vehicles enjoy nationwide parts and service infrastructure, whereas a new design from a niche manufacturer may not. Obtaining replacement mirrors, windshield glass, body panels and mechanical parts may be difficult to impossible for such vehicles, especially for large fleets.
- This problem extends to accessories and up-fits, such as shelving and lifts. For ground-up designs, these accessories may be hard or even impossible to obtain.
- Fleets are very familiar with the dimensions and operational characteristics of existing vehicle models, whereas a new design is an unknown quantity.
- Established vehicles may enjoy warranties from major OEMs. Conversions of Ford vehicles retain their Ford warranty if the EV vendor is a member of Ford's eQVM program.
- 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 development and financial burden which may prove commercially unsustainable for a niche manufacturer.



A familiar, tried and trusted vehicle; but this one's electric.

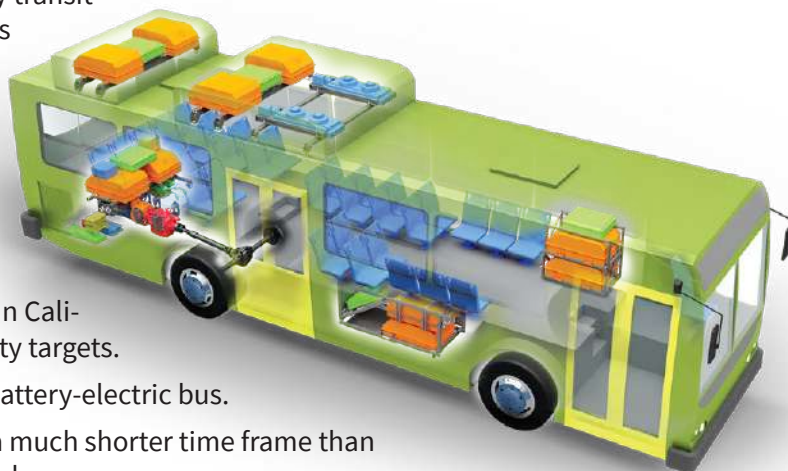
Look for a vendor with a credible business model and low risk for fleets.

3. Repowering Ageing Vehicles

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, which have engines nearing end-of-life, typically leading to scrapping the entire bus.

Converting old diesel buses to battery-electric vehicles 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.



4. Battery Quality: Performance, Longevity and Safety

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: lower-cost batteries may exhibit problems relatively quickly.

The basic building block of an EV battery pack is the cell. **Look for commercial EV vendors who use the same premium cells as are used by major passenger EV OEMs.** Many vendors use cells sourced from China, which may exhibit higher failure rates and shorter lifetimes.

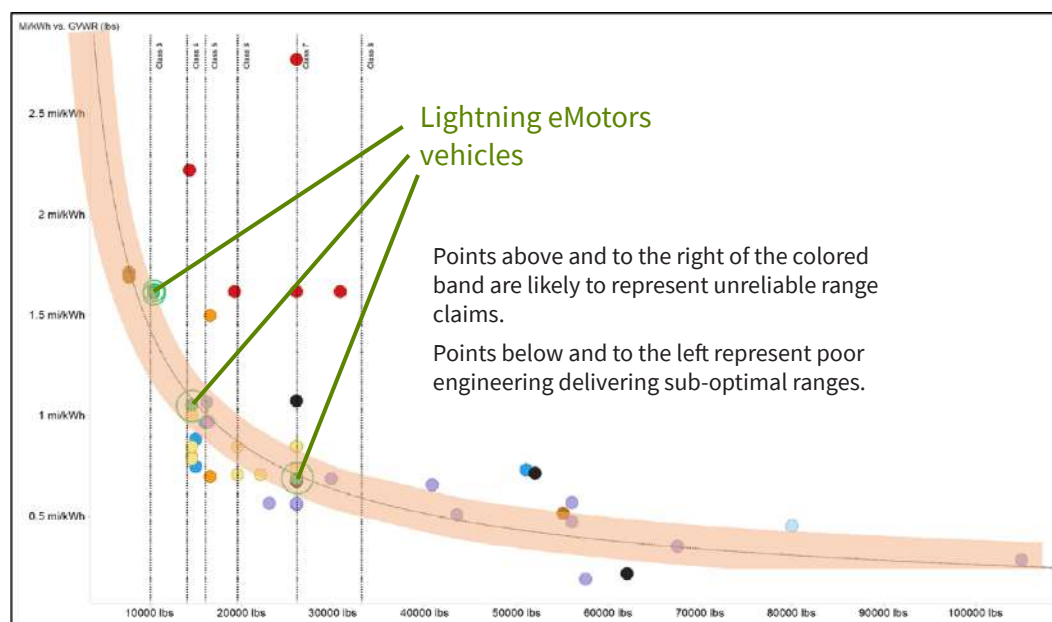
A key feature of high quality EV implementations is active thermal management for the batteries. The cells operate best within a particular temperature range, delivering the best performance, range and efficiency, and lifetime. Batteries that are not thermally managed typically last as little as one 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.

Battery safety is an important consideration. **Look for implementations that include 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!

Therefore, if a commercial electric vehicle manufacturer advertises a range or efficiency more than 10% different from the theoretical line in the chart below, you should **Look 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. In fact, they had run the test with zero payload and at a steady 28 mph, which is unrepresentative of real-world use.

6. Integration Quality

Commercial EV vendors must make many engineering decisions when designing a vehicle conversion, which affect the quality of the integration, including the driver experience, the on-road performance, and reliability. **Look for high quality integration features:**

- All components throughout the EV kit should be selected for high quality and high reliability, and are proven in similar automotive applications.
- Drivetrain components should use existing engine and transmission mounts for easy installation and mechanical robustness.
- Controls should be integrated with the vehicle's CAN bus for deep integration with vehicle functions, but should not use the OBD-II port, which remains available for service use.
- There should be no unfamiliar switches, pedals or buttons. Operating an electric bus, van or truck should be entirely intuitive for drivers.
- Regenerative braking, creep and hill-hold should be implemented.

7. Regenerative Braking, Creep and Hill-Hold

Look for a high quality EV drivetrain design which implements 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. This recaptures 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.

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.

Regenerative braking, 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.



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

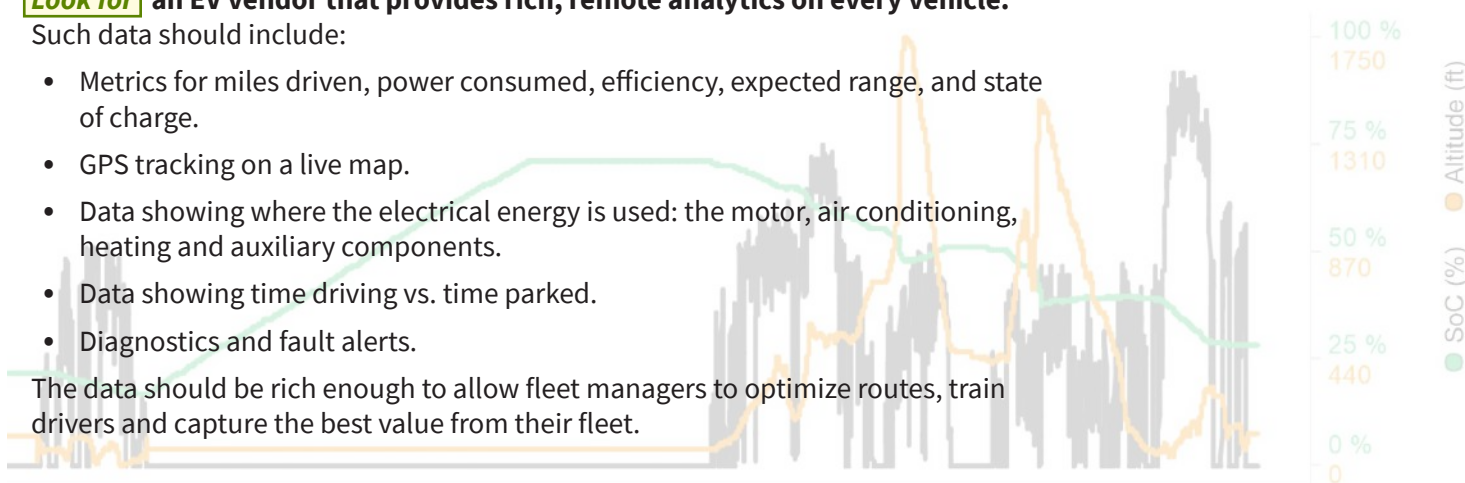
8. Analytics

Look for an EV vendor that provides rich, remote analytics on every vehicle.

Such data should include:

- Metrics for miles driven, power consumed, efficiency, expected range, and state of charge.
- GPS tracking on a live map.
- Data showing where the electrical energy is used: the motor, air conditioning, heating and auxiliary components.
- Data showing time driving vs. time parked.
- Diagnostics and fault alerts.

The data should be rich enough to allow fleet managers to optimize routes, train drivers and capture the best value from their fleet.



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.

Look for EV vendors whose vehicles support DC Fast Charge.

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).

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. **Look for** a commercial EV vendor who can manage the project or connect you with a company that can.



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 eMotors 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 CO₂ (carbon dioxide), which is the main product of all fossil fuel combustion.

A battery-electric vehicle emits no CO₂. 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 CO₂ 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, CO₂ may be emitted:

- Coal, natural gas, oil-fired and biomass power plants emit CO₂ as a product of combustion.
- Nuclear, solar, wind, geothermal, hydro and tidal do not emit CO₂.

So how do an EV's CO₂ emissions compare with gasoline and diesel when we take the grid into account?

For coal-fired power stations, which are the most CO₂-intensive, the emissions are approximately 1.9 lbs of CO₂ 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 CO₂ per 100 miles traveled. This is similar to the CO₂ 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 CO₂ 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 CO₂. With this mix, CO₂ emissions for a battery-electric commercial vehicle driving 100 miles in California are about 29 lbs of CO₂. That's 9.7x less than an equivalent diesel vehicle.



What about raw materials and manufacturing?

In the case of a used vehicle (“repower”), that vehicle is kept out of the landfill, and the impact of manufacturing a new vehicle is avoided. This is clearly the most sustainable option. For conversions of new vehicles, 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, cobalt and other materials, so there’s a materials and energy footprint associated with that too, as well as the environmental impact of 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.

The EV industry is young and this situation will improve over time. For example, as the world’s mix of power generation sources becomes increasingly clean, the CO₂ impact of manufacturing and operating EVs will decrease.

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. 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. **Look for** a CEV vendor who 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 that can finance a vehicle (or at least the batteries) for 7 to 10 years.**

12. Planning for Electrification

There's a lot to think about when planning to electrify your fleet. Here is a suggested list of questions to consider:

- 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 re-power, food truck)
- How many vehicles?
- Will electric vehicles work for your proposed routes? (range, charging time, payload capacity)
- Are there any financial incentives 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. 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 electric charging projects.

Look for a partner who can help you with all of this. **Lightning eMotors.**

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