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A road map for successful conversion to a fully electric fleet

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Electric utilities and transit agencies may not know how to complete an efficient conversion when it comes to electrifying their vehicle fleets. Following a comprehensive road map allows them to identify challenges and quantify benefits while still meeting their business needs.

Many utilities and transit agencies will soon need to electrify their vehicle fleets to remain compliant with various state regulations, meet market demands or both. Yet many organizations may not know how to determine if electrification makes sense for them or how they could feasibly transition their fleet to 100% electric.

A pilot program is essential when considering the conversion of medium-duty (MD) and heavy-duty (HD) fleets of vehicles powered by gas, diesel or compressed natural gas (CNG) to plug-in hybrid or battery electric vehicles (EVs). Pilots can help determine if plug-in electric vehicles can support critical operations, define upfront equipment costs, calculate savings on maintenance and fuel costs, and gather feedback from staff regarding operating and maintaining EVs.

Additionally, it is important to calculate the impact fleet electrification can have on meeting carbon emission reduction benchmarks in a given market. Rapidly increasing regulatory focus on the reduction of greenhouse gas carbon emission requirements in various states is a key player in the move toward fleet electrification. Utilities will need independent third-party consultants to provide that verifiable analysis for rate filings to support capital budgets, compliance and stakeholder groups.

Overall, a successful pilot program allows an organization to evaluate the true benefits of fleet vehicle electrification for its business and provides a foundation for determining how a full electric conversion might be approached. However, even the most effective pilot program cannot address all the challenges associated with converting large quantities of vehicles to electric.

Before beginning a 100% conversion from existing fleet vehicles to electric fleet vehicles, it is important to identify challenges and understand potential benefits by building a comprehensive electrification road map. Nine critical areas (Figure 1), as laid out in the following, must be carefully evaluated in order to plan an EV conversion that meets a business' needs and is completed as efficiently and cost-effectively as possible.

Operational assessment

A thorough operational assessment will help an organization understand how to operate and maintain a fleet every day. It may seem rudimentary, but this is the first step on the electrification road map, and it serves as the foundation for every other stage.

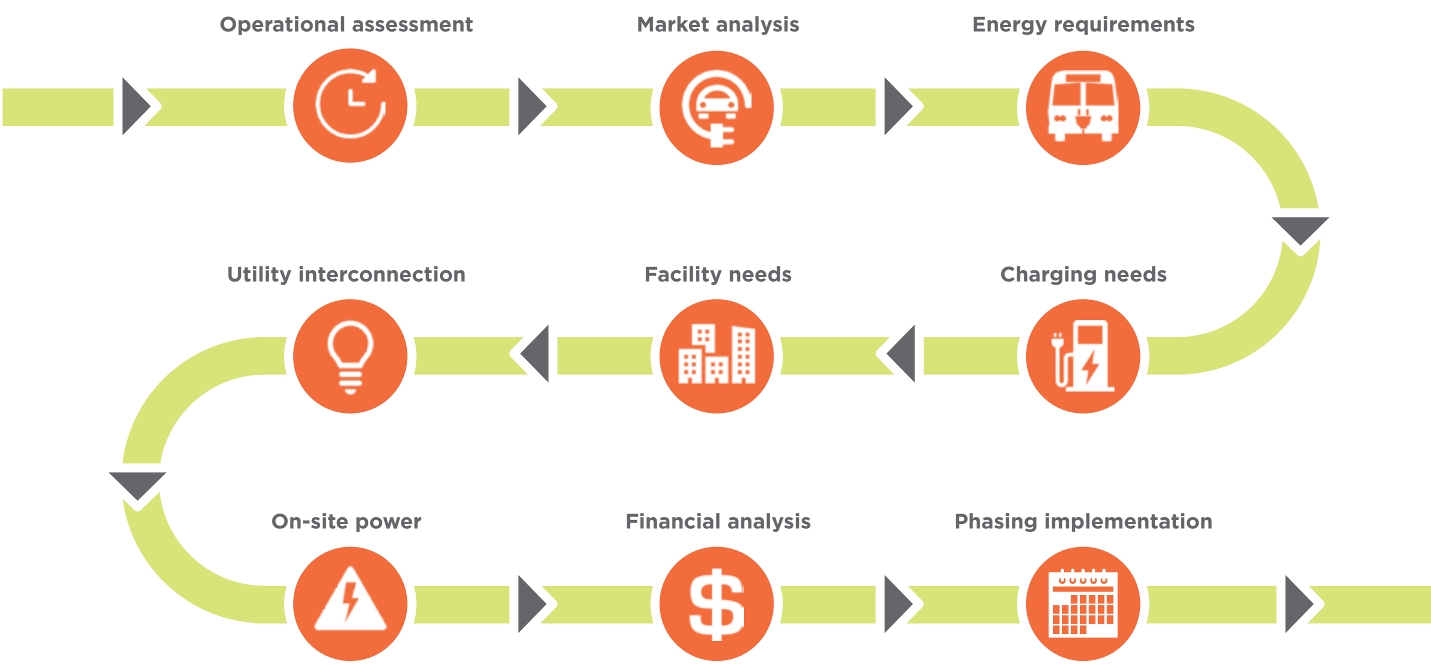

Figure 1: *Electrification road map. Follow this road map and the stops along the way to reach a successful destination.*

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At this point, an organization will need to answer some critical questions regarding its infrastructure needs, climate challenges, procurement schedule, etc., in order to move forward with an effective program. Answers to these questions will determine how an organization ultimately phases and places electric vehicles into service. For example, if operating a fleet of 100 buses in a climate where temperatures rarely drop below freezing, an organization can expect minimal efficiency decreases due to weather. If operating the same fleet in an area with extreme temperatures, an organization will need to anticipate decreased efficiencies and formulate plans to support routes. Based on the existence of short routes, long routes or a combination of both, organizations can start to develop energy profiles and select electric buses that will serve its routes.

It is also important to consider scheduling. With short downtime windows, high-powered chargers are needed. If there are longer downtime windows that extend through the late night and early morning, slower chargers to replenish energy stores can be used.

Market analysis

The next step is for an organization to conduct market research on the type of vehicles and equipment needed to successfully convert to an all-electric fleet. Understanding the availability and specifications of EVs, including charge rates, driving distance and the manufacturer's stated vehicle efficiencies, is critical to matching appropriate EVs to operations. This knowledge then informs the selection of appropriate electric vehicle supply equipment (EVSE) and the supporting infrastructure needed at facilities.

One of the biggest challenges in selecting charging infrastructure is the lack of agreed-upon charging standards. When converting a fleet to electric, becoming burdened with equipment that cannot grow with an organization's needs or that ties it to a proprietary solution or specific vendor is a real concern. Accordingly, researching current and forthcoming standards is critical when selecting charging infrastructure. Timely, in-depth market research can be gathered from industry research institutions, such as EPRI and universities, to monitor impending changes to industry standards. As the market matures, vendors develop new equipment, and both EVSE vendors and EV manufacturers move toward standardization, organizations need to understand how these developments will impact their investments in order to decide which EVs to purchase.

Completing state of the market research for vehicle electrification enables the identification of developments that may impact future procurement plans. Potential developments include a decrease in vehicle costs, greater vehicle selection and breakthroughs in battery technology that would allow vehicles to travel further per charge. For example, increased adoption of EVs in a market could drive increased production and selection, and reduced costs. Knowing when these developments may happen strengthens an organization's electrification road map as the organization moves into more detailed analysis of equipment and infrastructure needs.

Energy requirements

Once an understanding is gained on multiple metrics — including miles driven daily, number of routes, vehicle quantities, types, retirement schedule, weather and terrain conditions — an organization can evaluate how much energy will be consumed by any EVs added to its fleet. The calculations to analyze energy consumption can be simple or complicated, depending on operations.

For example, if an organization operates heavy-duty cargo handling equipment at a port, specific vehicle types will perform the same tasks with a similar, if not the same, duty cycle. Then the routes, operation and mileage for the same vehicle classes can be aggregated to determine total energy consumption based on vehicle type and quantity.

On the other hand, if a transit agency operates a fleet of buses, each predetermined route will have different mileage requirements, start and stop times, and terrain. Then analysis

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of the individual energy consumption on a route-by-route basis will be required to see that an electric bus will have enough capacity to service a given route.

Charging needs

An organization will then need to evaluate its charging requirements. Once again, data obtained during the operational assessment — specifically, when vehicles operate, when they have downtime and how much energy they need to perform their duties — will be used. Peak power levels required from EVSE are determined by combining the daily schedule of downtime with how much energy is required.

Chargers must have enough output to replenish the vehicle's battery in the available downtimes. When charging time is limited, high-powered chargers are needed. When more time is available for charging, an organization may choose to select EVSE with lower power levels. Utilizing lower-power chargers will reduce infrastructure costs, but it also may create the need for a lower-cost charge port for each vehicle. Additionally, even with long charge windows, lower-power chargers may not provide enough energy to meet operational requirements.

Understanding a fleet's energy consumption and charge times allows organizations to optimize charger selection based on operational needs. For example, if a bus fleet is operated from a single depot, it may be advantageous to install a high-powered DC pantograph system and rotate multiple buses through a charging cycle. This would prepare buses for routes faster, thereby providing greater operational flexibility. Alternatively, if a delivery fleet is operated with overnight downtime, using Level 2 AC chargers for a slow charge might better fit that organization's needs.

Another consideration is whether there is a large centralized depot where all charging will occur, or smaller facilities spread across a service territory. While the same principles for charging can be applied to both scenarios, peak power outputs will vary and can impact the overall costs of the facility upgrades necessary to accommodate charging EVs.

Reviewing the information collected during market research will help an organization anticipate what future developments in battery technology may look like and whether the EVSE that is required today will service future vehicles in terms of power output and standards. Carefully selecting more future-proofed equipment is critical for avoiding investments in equipment that would become obsolete before it could be fully utilized.

Facility needs

Once a charging infrastructure is selected based on energy requirements and schedule, the type and quantity of EVSE can be optimized against operation schedules. Everything from peak power requirements to equipment footprints and vehicle flow through facilities can be evaluated and planned.

By reviewing existing electrical infrastructure on-site, including utility assets, it can be determined if a given facility has enough capacity to support the charging required for a full conversion to electric fleet vehicles or if upgrades will be needed. Then, estimates for the final-state costs of a facility, including necessary utility upgrades, can be established.

It is important to remember that a conversion to EVs will occur over time. The infrastructure needed to support a full conversion to EVs should be built based on vehicle retirement schedules and expected procurement schedules for purchasing EVs. A phased buildup allows for the identification of milestones and to understand when major infrastructure upgrades will be required throughout an entire conversion schedule.

Utility interconnection

Once both the load and equipment types required to charge a fleet during the different phases of an EV purchasing schedule are known, the power requirements of a facility can be discussed with the local electric utility. During this stage of the road map, an organization should investigate what programs the utility has in place to assist with meeting the power requirements of a facility as EVs are implemented.

The electric utility will then assess the grid capacity of the facility as is and consider future requirements, such as additional transformation capacity and upgraded or additional circuits. The utility also will assess the costs involved in meeting the needs of the facility and discuss charging times and peak power demands to evaluate if impacts from charging the electric fleet will coincide with peak operations. Then the operation schedule can be adjusted to avoid charging at peak times. This can significantly lower electricity costs if time of use (TOU) energy metering is available.

Working with the utility to optimize charging patterns is critical for reducing fuel costs and maximizing savings when compared to usage of diesel, CNG or gasoline. One of the biggest items to discuss with the utility will be the demand charges that will be applied to a facility. It may be possible to work with the utility to have these charges reduced or waived based on the additional energy consumption that the facility will use.

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On-site power

When implementing EVs it is important that an organization maintain the level of service already provided by internal-combustion engine vehicles. Accordingly, an organization must have plans in place to provide electricity to its fleet even when grid outages occur.

As part of this assessment, the minimal critical needs of a fleet will be evaluated. First, it must be determined which vehicles must operate and which, if any, are nonessential. Then, power requirements and size of a suitable backup system can be calculated.

Backup generation options range from diesel generation sets to batteries and solar. The financial impacts of traditional generation versus renewable integration can be evaluated to determine the most cost-effective solutions for the area. For example, there may be rebates and policies supporting the installation of batteries and solar.

When selecting backup power, consideration must also be made on how the system will grow based on the EV procurement implementation schedule. Answering questions such as, "How will the system change with EV growth?" and "What technology has the most flexibility to meet changing needs?" will help an organization select a backup power option that can grow with its system.

Financial analysis

Before spending millions of dollars procuring vehicles, purchasing equipment and upgrading facility infrastructure, it is important to assess the financial viability, impacts, savings and programs available for implementing EVs. This financial analysis relies on the information collected and analyzed throughout the road map and assesses the specific financial impacts to a business based on how it will purchase and operate EVs.

The total cost of ownership (TCO) of an electric vehicle will be determined by comparing the initial cost of the vehicle against fuel and maintenance savings. While the initial purchase price of EVs currently is higher than traditional vehicles, market projections estimate that the price of EVs and traditional vehicles will reach parity within the next five to 10 years. At that point, the economics for purchasing EVs will change due to the savings generated from lower fuel and maintenance costs being realized immediately.

In addition to comparing initial costs versus fuel and maintenance savings, an organization also must consider the cost of charging infrastructure for powering its fleet. Whether utilizing a large centralized depot or operating small and dispersed depots, this could greatly impact how much will be spent on installing this infrastructure.

When conducting the financial analysis, it's important to evaluate the TCO over time. While the EV implementation schedule is a key factor, other factors that will impact the financial analysis include understanding the available tax incentives that may lower overall costs, and evaluating utility incentives that may assist in the installation of charging infrastructure.

Phasing implementation

In this last step of the road map, organizations will finalize the implementation plans for converting its fleet to 100% EVs. The phasing implementation plan uses the analysis already conducted to map how EV infrastructure will be installed against the timeline of EV procurement.

Because most conversions take place over five to 10 years, it is important to clearly define every stage of the process and identify exactly when and how each stage will be completed. The phasing plan provides stage gates, allowing organizations to pivot the implementation to take advantage of technology advancements as they come. It also shows how the fleet conversion fits into a business plan, scheduled facility upgrades, grid capacity and the need for backup power.

Final thoughts

Converting a fleet to 100% EVs requires a large investment in new equipment and infrastructure. Before spending millions of dollars, it is essential to invest time, money and resources in developing a comprehensive plan that will help achieve a 100% EV conversion as efficiently as possible.

While a pilot program can introduce the basic requirements of owning and operating EVs, organizations also need to understand how EVs will benefit the company over time and how to avoid investing in assets that will become obsolete before the end of their useful lifetime. Completing the electrification road map outlined here will provide organizations with critical information for confidently moving forward with a complete implementation of electric vehicles.

Biographies

Joshua Loyd is a grid modernization and distribution planning consultant at 1898 & and Co., part of Burns & McDonnell, specializing in vehicle electrification and grid modernization. He has worked on engineering design projects for EVSE and electric utility communication systems. Josh also is involved with developing EV strategies and has provided analysis and guidance on charging and load growth impacts that can be caused by electrification of light-, medium- and heavy-duty vehicles. He holds a Bachelor of Science in electrical engineering from Kansas State University.

Adam Young is a director of financial analysis and rate design at 1898 & Co. He has more than 17 years of experience in financial modeling, resource planning, pro forma model development, market analysis, project financing, cost-of-service analysis and rate design. Adam works closely with investor-owned, municipal and cooperative utilities — as well as independent power producers and transit agencies — to solve their complex business challenges. Adam holds a Bachelor of Science in mechanical engineering from the University of Missouri in Columbia and a Master of Business Administration in finance from the University of Missouri-Kansas City. Throughout the past several years, Adam has been supporting both utility clients and fleet owners with planning for fleet electrification.

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