

Gather, report and analyze with ELECTRIC VEHICLE MONITORING from Clever Devices

In 2017, there were approximately 385,000 electric buses in operation globally. Today that number is nearly 425,000. In early 2018, there were only about 300 battery-electric buses on the roads in the United States, and manufacturers reported a 30% increase electric buses by year's end, a number that will only go up as transit providers work toward building fully electrified fleets.

Building electric considerations into the core

Vehicles will be electric. The question is not if, it's when. There is no question about that as public transportation providers look for ways to reduce costs and adopt environmentally friendly technology solutions to reduce carbon emissions.

The transition to zero-emission buses (ZEBs) is well underway. With the largest fleet in North America, New York City has pledged to be fully electric by 2040 and Los Angeles, the 2nd largest provider has vowed to do so nearly a decade early - by 2030.

China has rapidly embraced electric vehicles and to date, of the almost 425,000 electric buses worldwide, 421,000 were in China. Other countries in Europe and Asia are also building out their fleets and across the globe, public transport providers either have ZEBs on order or have already begun to plan for them in their fleet.

Because adding electrified vehicles into your fleet isn't as easy as swapping a diesel bus out for an electric one, this transformation adds another level of complexity to your planning, scheduling, monitoring, maintenance and management of your fleet. What it doesn't do, is change your number one priority which is to deliver the efficient, costeffective service your riders demand.

This is why Clever Devices is building electric considerations into the core of our offerings to help you plan properly and make the data-driven decisions necessary to quickly begin saving money and realizing the energy efficiencies of a modern, electrified fleet.

Fear of the unknown

Many of the concerns about adding ZEBs into your fleet likely center around how they will actually behave in service. And, truthfully, those fears are valid.

- · Is the manufacturer's miles-per-charge promise accurate?
- · What topographical considerations will impact the range of your vehicle?
- What are the battery-life implications for your climate? Are there sensitivities to extreme heat or cold that you must account for?
- · What role will traffic congestion play in battery-life?
- Will your ZEB indeed have enough charge to complete the work assigned to it? How can you know for sure?
- What impact will individual driver behavior have on the ability of a vehicle to complete its assignment?



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Transportation accounts for approximately 15% of all the greenhouse gas emissions around the world.

Electric buses are expected to make up HALF of city fleets in the 2020's and 80% by 2040.

Electric buses can save an agency about \$400,000 in fuel and maintenance costs over the life of the vehicle.

Electric buses are and 80% by 2040.

-5%

Getting started - key considerations

Whether you are rolling out ZEBs today or considering your options for the future, several variables make injecting electric vehicles into your fleet challenging. These variables fall into four distinct categories:

Power

Ensuring that the power grid can handle the increased capacity and then adapting your depots and garages to meet your increased power requirements should be the first step in your electric mobility strategy. Working with local power companies in the early stages is critical to ensure that the grid can handle your expected increase in capacity. Other factors, such as power consumption costs must be considered. As power costs are lower during certain times, the need to charge during these times could potentially impact your processes considerably.

Charging and Charge Visibility

Ensuring your vehicles are adequately charged at all times and planning for how they will be charged is another consideration. Will you charge them in the depot, overnight, or en route? Where will the charging stations be located, and how do you plan your routes around the need to charge and the time it takes to do so?

As crucial as charging itself is the ability for dispatchers, maintenance crew, and operators to have the visibility into the state of a vehicle's charge. This visibility ensures the vehicle assigned for a piece of work is capable of completing that work and can eliminate the "range anxiety" associated with worrying that a vehicle will run out of power during a route.

Vehicle Assignments

Because an electric vehicle doesn't have near the range as diesel vehicle assignments must be adjusted to accommodate the shorter distance, the electric vehicle can travel before stopping to re-charge. This makes efficient scheduling more complicated than ever before. Additionally, many variables impact range such as topography, weather and passenger load; all factors that need to be considered when scheduling electric vehicles into your fleet.

Maintenance

Your diesel mechanics and supervisors need to transition to working on electric vehicles. They must learn the fundamentals of electric engines and their associated systems, and how they differ from what they are used to. Supervisors will be challenged with implementing new reporting tools and electric-specific maintenance routines that are new and unfamiliar as they analyze the impacts the electric vehicles will have on their processes and adjust their procedures accordingly.



Electric Vehicle Monitoring Solutions- EVMS

Clever Devices has built the management of your electric fleet right into the core of our operations control solutions. Our EVMS technology lets you gather, report and analyze the data you need to run the most efficient electric vehicle operation possible.

•Communicates to all systems, reporting on electric vehicle usage for a completely integrated solution

•Provides visibility to dispatchers and operators of the actual state of charge – eliminates "range anxiety" and avoids inconveniencing passengers

•Collects data from the onboard systems that can be used in reporting for more efficient fleet management and planning purposes

Let data drive your decisions

Data comes from various sources, and Clever Devices' EVMS captures it all. Armed with that data, you can make the adjustments needed to monitor your electric fleet and better align your vehicles with their real-world capabilities.

Charging Data

Evaluate charging behaviors to determine best practices, get visibility into the state of charge of all the vehicles in the fleet, monitor individual vehicle charge levels and their capacity to finish assigned work.

Vehicle Data

Monitor and analyze the real-world range you're achieving vs. the manufacture's range prediction.

Route and Schedule Data

Analyze charge levels throughout a specific route to better understand the vehicle's true battery-life, taking into consideration variables like topography and passenger loads.

Uncontrollable Factor Data

There are many factors that impact range that simply cannot be controlled. Heat and cold extremes and road congestion can severely impact the life of your vehicle's battery. By monitoring these conditions over time, certain conclusions can be made regarding the state of charge to help you more accurately predict range during certain times of year and during certain times of the day.

Driver Behavior Data

Certain driver behaviors such as harsh acceleration and breaking actions can impact battery life. Use driver behavior data to assign drivers according to how they tend to behave or to retrain them promoting practices for conserving battery life.

The basics - the right vehicle for the right route

The EVMS begins with an analysis of your routes and makes recommendations for vehicle assignments accordingly. It helps you understand the performance of an individual vehicle and compares that performance to other vehicles in the fleet. Armed with this information you can make the necessary alterations to create greater efficiencies.



Route Profiles

Creates route profiles based on the energy required to perform the route and provides recommendations to CleverCAD for vehicle assignments based on state of charge.

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Vehicle vs. Route Performance

Tracks route performance of individual vehicles and provides intelligence to understand and compare a particular vehicle's performance to the rest of the fleet.



Alerts

Sends alerts to dispatch when an issue occurs in the field and to maintenance when there is a fault to address.

Electric Bus





Monitoring critical factors that impact performance

There are a number of factors that can impact the performance of a vehicle in your electric fleet. Understanding and monitoring those factors can improve your efficiencies while providing the visibility you need to properly manage your service.



Technology to monitor your entire fleet

As you migrate to an electric fleet that includes a combination of conventional as well as zero-emission vehicles, the technology you use every day to plan and execute your service must evolve to adapt to your changing environment. We're building electric considerations into the core of our solutions, so the same system your end-users use today can be upgraded to manage your mixed vehicle fleet.



Planning and Scheduling

Electric vehicles add a new level of complexity to your planning and scheduling procedures. Our solutions simplify the process by optimizing the creation of your vehicle blocks - taking into account the vehicle autonomy, the time needed to charge and the number of charging stations in the depot or yard to reduce deadheads, improve on-time performance and reduce overtime costs.



Operations Control Center

Dispatchers can hover over any electric vehicle to see its state-ofcharge. Charging stations can be graphically displayed on the map and alerts can be sent when the state of charge reaches critically low levels or when the vehicle's remaining work exceeds miles left on the charge.



On the Vehicle

The onboard system communicates with all the different sub-systems to gather charging data, energy usage and performance data to provide the operator with accurate vehicle status and reduce the likelihood of operators having "range anxiety". The operator can see state-of-charge, miles to complete block and miles to empty.



In the Yard

Our yard management solutions ensure that no vehicle is dispatched without the proper charge to complete its work. Conveniently manage charging schedules to create a more efficient pull in and pull-out to ensure your service stays on schedule.



Maintenance

Our Automated Vehicle Health Monitoring solution provides your maintenance teams with critical information about the health of each electric vehicle and helps you analyze how well it is performing. With customized dashboards you can monitor duty cycles, emissions footprint and battery health status. Customized reports detail state-of charge over time, performance outliers, average miles-to empty, rate of consumption and miles per kilowatt hour as well as daily and reoccurring faults.

Reporting tools provide business intelligence for better decisions

Our reporting tools let you quickly begin capturing the business intelligence needed to make adjustments to your processes and your schedule. Armed with real-world data, you'll gain better insights into your electric fleet's performance to create efficiencies and control costs.



- Customized dashboards help you visualize the data into graphs and charts for easy consumption.
 - o Route Variation Profile Reports
 - o Vehicle/Route Performance Reports
 - o Operator/Route Performance Reports