

FUEL FORCE  EV

Multiforce Systems White Paper Series

Integrated Electric Vehicle Charging Management:

System Design
Considerations

Abstract

The FuelForce/EV product line from Multiforce Systems Corporation allows fleet managers to monitor and control the electrical charging of their entire fleet. FuelForce/EV also allows fleets to deploy low-cost, non-networked chargers, in a sense making “dumb” chargers smart, and secure and minimizing communication costs for fleet and workplace parking. The system can restrict charging to selected times of the day and days of the week, thus avoiding peak demand billing periods. This will reduce the overall cost of the electricity used for EV charging. A study done by Alameda County, CA about 5 years ago showed that avoiding peak demand charges could cut transportation electricity costs by one third.

The FuelForce/EV charging system provides an alert and reservation capability, informing EV drivers by text message when their EV is charged and should be moved to free up the charger for another vehicle. Also, drivers can be alerted by text when a requested charging space becomes available for charging.

FuelForce® users can monitor the total cost of all fuels including electricity anytime, anywhere by cost center, vehicle description, and individual driver or vehicle. Flexible, easy to filter and downloaded data enables management to control, measure, and compare operating costs for all types of transportation energy in the fleet.

Fuelserve.net™ software, the industry’s first and most advanced cloud-based fuel reporting and management platform, is available 24/7 directly to fleet managers and analysts on a desktop, laptop, tablet, or smartphone. This advanced cloud-based software may be integrated with fleet maintenance systems, telematics systems, and other enterprise systems via our open API.

Multiforce fuel advisors can also offer fuel analysis services for customers based on a reservoir of more than 25 million transactions accumulated over the past 15 years.

When Your Parking Lot Becomes Your Fueling Site

EV charging presents a paradigm shift for fleet managers. Standard fueling of an ICE vehicle last roughly 5-10 minutes from normal fuel islands with one to a dozen or more fuel dispensers. ICE vehicles typically can travel 200 to 400 miles between fill-ups. An average ICE fuel transaction for a fleet passenger car is about 10 gallons.

If one considers that a single space is required for each fueling transaction, it is easy to plan a fuel island layout based on the number of vehicles that will fuel there at the peak fueling time, which is often at the beginning or the end of the day.

From data collected at two Princeton University parking garages equipped with ten EV charger each, EVs received an average of 13.1 KWhrs of electricity per transaction. A typical EV receives about 25 miles of travel per hour of charge. This suggests that on average, EVs that charge at these parking lots are parked for an hour and a half, at a minimum.

The University parking authority enforces a policy of moving the EV once the vehicle is charged. Drivers are prompted for a cell phone at time of fueling and are informed by text message when their vehicle is charged.

Also, registered drivers may reserve a charger equipped parking spot and be informed by text when that charger becomes available. Some 300 different drivers are serviced by 20 chargers at these two parking garages.

On average, each EV receives about 38 miles of travel, which is enough to replenish the charge used to get to work. Of course, the amount of mileage received depends on the vehicle being charged and the rate of charge that vehicle can accept.

For a fleet of vehicles that are only used for one shift per day management should figure out the typical usage patterns and include enough chargers to have each EV ready to perform its daily duties. For example, if the range of a fully charged vehicle is 200 miles and the daily usage is 50 miles per day, that vehicle might be charged every other day giving a 100% spare capacity in case of extended need.

The parking garage or lot needs to be sized to hold the expected parking traffic. Engineers have developed formulae for determining the number of parking spaces required for different facilities. The charging infrastructure for a fleet that plans to convert to EVs over time needs to be included in the analysis with growth of EV charging in mind. It is not cost effective to have a charger for every EV so it will be necessary to know when each vehicle is fully charged so it can be moved to make room for another vehicle that must be ready for its next day's duty cycle.

Most parking lots do not have adequate power.

A standard Level 2 charger is like a dryer circuit (208-240V). Five level 2 (40 amp) chargers would require 200 amps, which is the same amount of power of the average home in the United States. When the majority of parking garages or lots were designed and built, the electrical infrastructure incorporated parking lot lighting, possibly a gate control or a manned booth, or perhaps a lit closet with a receptacle. The electrical panels for such power are likely maxed out, with little room for expansion. As a result, adding EV charging will likely require the upgrade of the current electrical panels or the installation of an additional panel.

Most parking lots do not have the right type of power.

To conserve power usage, many parking garages and lots have converted installed lighting to LED that require less power. Some have held that the power freed up by the LED conversion, could be used for EV Charging. The problem with that is many parking lot lighting systems use a 3-phase power source while EV Charging requires single-phase. This might appear to be a technical nit, but there is a cost for adding step-down converters to convert 3-phase power. All of this needs to be considered in system design.

EV Charging Times Additionally Shift the “Fueling” Paradigm

As noted above, an electric vehicle takes a long time to charge using a 40-amp, Level 2 charger depending on battery depletion and the vehicle’s

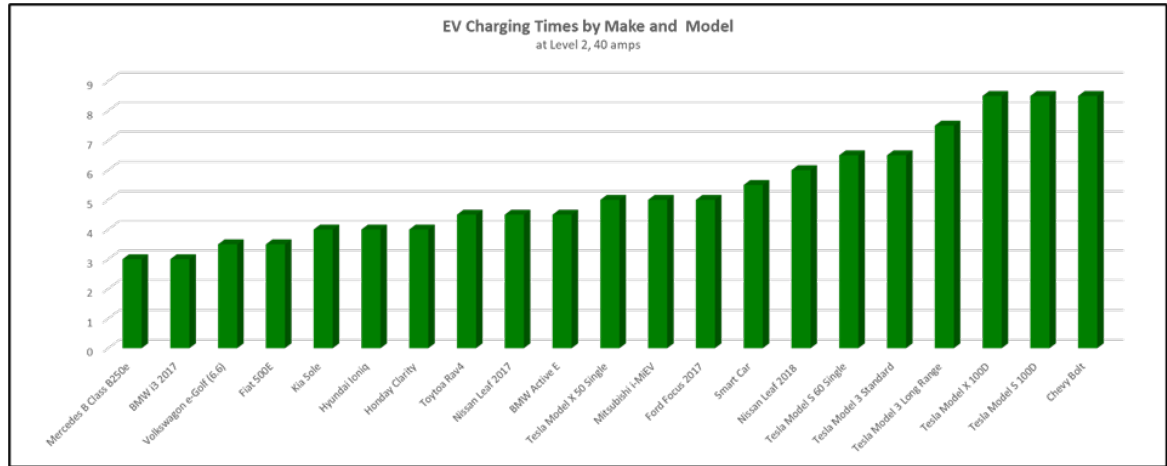


Figure 1. EV Charging Times by Make and Model

charging capability. Not all electric vehicles can take a charge at the same rate. Figure 1 above shows the charging times (assuming near depletion) for a series of vehicle makes and types at 40 amps. This means that the charging times will force an unattended timeframe, perhaps all night. As can be seen, charging times can go from 3-9 hours, again depending on the make. As it is an unattended activity, it is vulnerable to unauthorized use.

Challenges that EV Adoption Present

Electricity Already has a Delivery Infrastructure

One of the major challenges that fleet managers face is that the delivery infrastructure for electricity is well established, and usually beyond the purview of a fleet manager. Kilowatt usage is buried in the electric bill, likely only seen by the accounting department. There are also no transaction details in the electric bill, nor any authorization rules to track usage and cost.

Fleet managers seem to have systems in place that tell them when it’s time to order delivery of standard fuels to their tanks. With electric vehicle charging, there is no periodic delivery to manage. Also, each tank of fuel has a fixed value that can be charged to the equipment. Electricity costs vary by hour of the day and season of the year. Electricity is flowing every minute of every day. What is needed is the ability to manage electricity like any other fuel, including identifying the driver and/or vehicle, authorizing the transaction, then tracking the power used by driver, vehicle, and department.

Infrastructure Needs at Your Site

As noted above, you might not have adequate power at your parking garage or lot. It would be critical to get with either staff electricians or hire one to review your local infrastructure capabilities, specifically at the garage or lot. Building your EV charging site will require not only budget for the wiring and chargers, but also a likely panel upgrade.

Secondarily, you will want to consult with your local utility, as there will likely be a need for a transformer upgrade and other infrastructure changes. This should be done at the earliest stages of your planning, as utility upgrades take time, and you may not be the first on their list of the needed upgrades in your area.

Time of Use Billing

A key challenge for fleet managers is that depending on the time of day, electricity costs can vary dramatically. Most utilities have Time of Use billing tiers, with On-Peak, Partial-Peak, and Off-Peak pricing. For standard fleet usage, electric vehicles will return to the parking garage or lot during the newer peak time periods. Most utilities, especially those in areas with ample solar production, have or are planning to adjust their peak billing to later in the afternoon to early evening. Unfortunately, Fleet and MUD EV charging patterns often have the majority of EVs charging in the same period (the evening). This concentrated power demand could add to the peak assessment and extra fees.

Additionally, most utilities measure peak usage and assess a **Demand Charge** fee. Demand charges can have a significant impact on EV charging costs. The bar graph below in Figure 2 was done by the County of Alameda, CA several years ago. Prior to deploying a significant fleet of electric vehicles, the County had budgeted approximately \$750 annually to “fuel” their EVs. This was based on standard utility fees and their vehicle routes.

What they learned was that if they could avoid charging during the timeframes assessed for demand charges, that budget amount could be reduced to under \$250 annually. However, and this is very important, if they *never* avoided demand charge periods, the total cost will rise to just over \$2,800 annually. Clearly, demand charges have can have a significant impact on EV Charging costs.

As a result, an effective EV charging management solution must include the ability to avoid electrical demand charges and time of use (TOU) billing. The use of an integrated fuel management system that includes electrical power management is a key here.

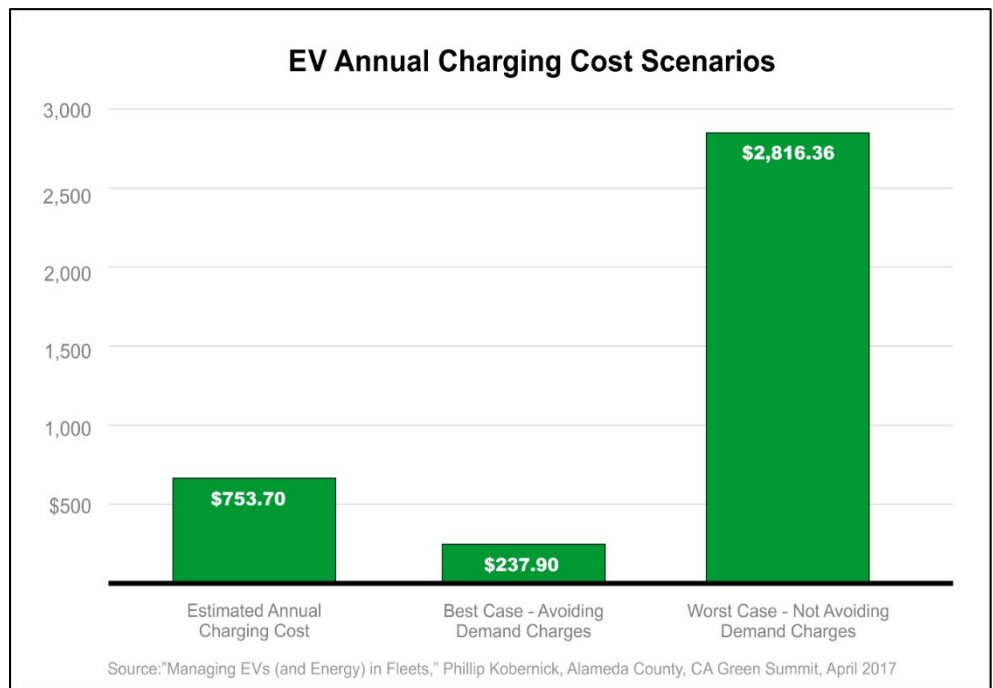


Figure 2. Demand Charges and EV Charging

Charger Choice Overview

A serious consideration for EV Charging is the choice of the EVSE (Electric Vehicle Supply Equipment), or charger. As a point of clarification, the actual charger is embedded in the electric vehicle. What we call a “charger” is a gating and safety device. The charger can identify the maximum rate of electricity flow the vehicle will accept, as well any rate reduction that the vehicle may dictate. As to safety, the charger doesn't allow any electricity to flow if the connection to the vehicle isn't in place.

Chargers come in 3 basic varieties, as noted below:

Level One Charger

- Requires only a standard electrical outlet, suitable for plug-in hybrid vehicles.
- Reduces installation costs by using existing wiring, while fully charging the vehicle overnight.
- Charges an average EV in 12 to 24 hours
- Delivers 120 volts, 8 to 15 amps, supplies power at 1.3 kW to 2.4 kW.

Level Two Charger

- Requires installation of a dedicated, stand-alone electric vehicle charging unit
- Provides faster charging service
- Charges an average EV in 3 to 8 hours
- Delivers 240 volts, 20 to 40 amps, supplies power at 4 kW to 18 kW

DC Fast Charger (Sometimes referred to as Level 3)

- Also requires installation of dedicated, stand-alone electric vehicle charging unit.
- Provides the fastest charging service
- Charges an average EV in .5 to 1 hour
- Most use a 3-phase 480 volt AC electric circuit, supplying 150-250 kW

Most fleet installations should consider deploying Level 2 chargers. This choice balances the electricity costs (including Utility upgrades) as well as the speed of charging. As most fleet scenarios run vehicles during standard business hours, that means that they are parked roughly 14-15 hours a day (during the evening and night). This provides ample time to charge to capacity each day. The exception to this would be scenarios where the vehicle in use needs to be on the road for a much longer time periods, such as transit buses.

Tracking Electricity as a Fleet Fuel

Once the decisions and plans are in place to deploy electric vehicles and the charging infrastructure, a key consideration should be how to manage electricity as a standard fuel. Besides, the power considerations noted above, EV chargers also fall into 2 categories: non-networked, basic chargers and networked chargers. Some EVSE manufacturers also require their chargers to be connected to their own management network for additional fees. A variety of reporting capabilities are offered by the various manufacturers. Most of these systems are independent of the fuel management systems in place by fleet management. This, unfortunately, creates more problems for the fleet management staff.

The Functions of Fuel (Power) Management

The standard fuel management paradigm provides 4 key functions:

- **Identify** - Manually or automatically identify drivers and vehicles, reducing theft and reporting misallocations.
- **Authorize** – Allow that only valid drivers and valid vehicles to receive fuel or a charge from the fuel or power system.
- **Measure** - Accurately measure fuels of all types dispensed, logging transactions with meter-level precision.
- **Report** - View and download standard and customizable reports for fuel usage for multiple vehicles, drivers, departments, and sites.

Multiforce Systems was the first fuel management system provider to give fleet managers a fully integrated EV Charging management. In the fourth quarter of 2017, we introduced the FuelForce/EV platform built around our FF814 fuel controller. The resulting FF814-EV controller provides a patented approach for the full access control and reporting capability of the Fuel Force® system and sophisticated power management and includes the 4 key functions listed above.

Over the ensuing years, the FuelForce/EV platform has been improved and expanded. The FF814-EV can now manage up to 31 charging circuits, providing a cost-effective implementation of a charging management system. The FuelForce/EV platform is currently designed to manage Level 2 chargers. Continued development will add higher capacities soon.

With the use of the FuelForce/EV solution, fleet managers can avoid the costs of the more expensive networked chargers. In a real sense, the FuelForce/EV platform makes “dumb” chargers smart by adding the 4 key functions of fuel management to your EV charging deployment. Later in 2022, we will be adding OCPP (Open Charge Point Protocol) management to our offering. OCPP is a pseudo-standard for management and control of EVSE. The impact of OCPP means that the platform will have the capability of managing a vast array of EVSE systems.



814-EV Controller

The standard layout of the FF814-EV is straightforward. The chargers are deployed normally, with circuits running from the panel and breakers to the EVSE in the parking structure. For management, low voltage control wiring is run from the FF814-EV controller to each charger. Figure 3 shows a standard layout.

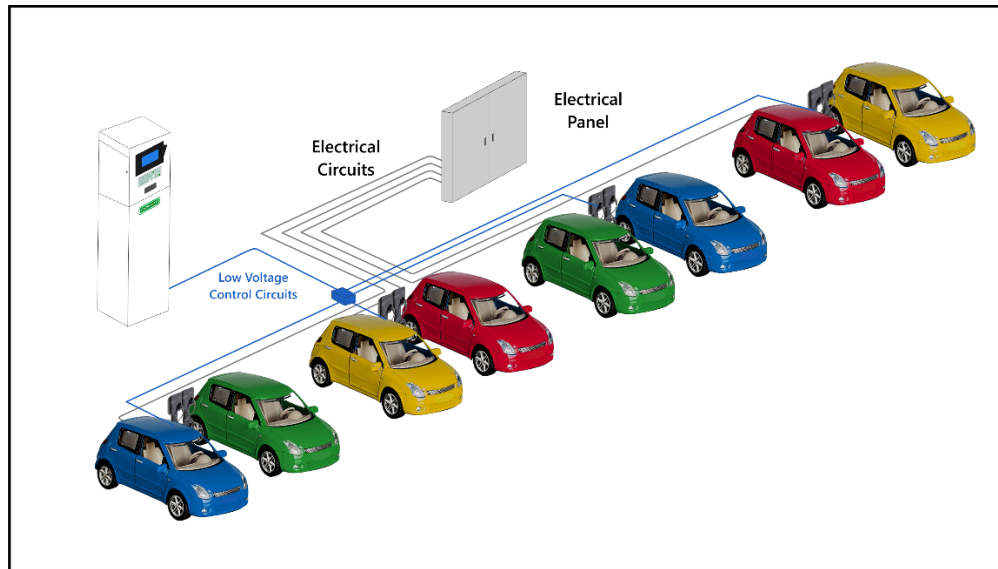


Figure 3. FuelForce 814-EV Installation Example

As to use, the driver of the vehicle parks, goes to the controller kiosk, identifies him/herself, identifies the vehicle, selects the charger space, returns to the vehicle, and connects the charger. The FF814-EV measures the power used for the charging transaction, tying it to the driver and vehicle by date and time.

Alerts and Reservations

An additional benefit offered by the FuelForce/EV solution is a communication with the driver. Alerts can be enabled to let the driver know once the charging transaction is completed. The image to the right shows an initial alert the driver would receive, showing the date and time the transaction started and the specifics of the charging transaction.

12-Sep-17 12:19:33-
FuelForceEV charging started:
Your EV is drawing 24 amps
from charging station 2.

16-Nov-17 17:31:34-
FuelForceEV charging station 1
is now available! Your reservation
will expire in 5 minutes.

The second text communication involves a reservation capability the solution provides. If a driver arrives but no chargers are available, he/she can reserve the next available charger. Once a charger becomes free, the driver would receive a text message like the image to the left. The reservation expiration timeframe is configurable by system management.

Peak Period Lockout

The FuelForce/EV platform allows fleet managers to put a hold on charging during peak billing times. Transactions are put on hold and restarted at the end of the lockout period. Peak Period lockout, when coordinated with facilities, can help reduce the impact of EV charging on the total cost. Peak billing periods as well as assessed demand charge periods can be avoided, ensuring the lowest cost charging. It is vital to work with accounting to identify the demand charge amounts and timeframe. A massive deployment of EV charging

might actually change the peak amount, thus changing the assessment timeframe as well. At the start, it might take some trial and testing to guarantee the maximum cost saving scenario.

Integrated Fuel and Power Management

The FuelForce/EV platform provides fleet managers the unique ability to provide the data for EV charging alongside the fueling data for all other types of fuels. Our patented solution provides a single dashboard to manage all aspects of fleet fueling.

Kilowatt hours can be reported alongside gallons of unleaded, diesel, E-85, as well as CNG, LNG, hydrogen, and other alternative fuels. Costs can be assigned, and reports generated by vehicle, driver, and department including all or selected fuel types.

Integrated Cloud-Based Management

FuelServe.net

Launched in 2006, FuelServe.net (FSN) was the industry's first cloud-based fuel management platform, utilizing the full access, data-backup, and redundancy features of cloud-enabled applications. FSN automates the process of tracking energy use regardless of fuel type. FSN securely manage fleet fueling components anytime, anywhere from any device. With FuelForce® fuel management, you can know with absolute certainty that every kW of electricity and every gallon of fuel is dispensed to the proper vehicle by authorized personnel.

EV Charging Data Integrated with Standard Fuels

Department	Vehicle	Vehicle Desc	Product	Quantity	Controller
50158	867	2015 Force F250 Pickup	UNL	15.5600	001
50125	867	2015 Force F250 Pickup	UNL	17.9460	001
Public	N/A	N/A	KWH	1.8360	002
50158	1315	2017 Mitsubishi i-MiEV	KWH	0.2650	001
50145	1159	2018 Nissan Leaf	KWH	0.4510	002
50158	1077	2014 Chevrolet Malibu	UNL	13.6340	001
Public	N/A	N/A	KWH	0.0894	001
50125	1315	2017 Mitsubishi i-MiEV	KWH	1.2540	001
50145	867	2015 Force F250 Pickup	UNL	16.5760	002
Public	N/A	N/A	KWH	1.2640	001
50125	1159	2018 Nissan Leaf	KWH	1.1650	001
50158	1077	2014 Chevrolet Malibu	UNL	9.6350	001

Figure 3. Sample Report with Integrated EV Charging

Offered as a Software as a Service (SaaS) solution, and being cloud-based, FSN eliminates IT support costs and allows for fleet management staff to get advanced, customizable queries with detailed views of fuel and kwh consumption by driver, vehicle, department, site, and so forth. FSN additionally offers the automatic export of data to fleet management software systems such as RTA, Faster, Assetworks and others.

FuelServe.net allows you to look at your data from a number of perspectives, with easily customizable reports, giving you actionable information to optimize your fleet fueling. Being a cloud-based solution, FuelServe.net allows you to grow your fuel management as dictated by business needs. Manage a handful of sites and vehicles at first and grow with the same platform to hundreds of sites and thousands of vehicles.

With an internet connection and a device with a standard web browser users can securely access fueling data anywhere, at any time. Manage your fuel while in the field, at the office, or even from home. In case of an emergency, fuel and power may be securely authorized to new users at a click of a button.

IT Support

With FSN there is no need for a database, network, or server administrator to provide system administration, maintenance, update and upgrade management, and back-ups. There is no need for additional purchasing of hardware and server licenses and no required ongoing hardware and software support costs. Reports can be generated and bookmarked with ease by system users, thus eliminating the need for IT programmers to create and run reports.

EV Charging Use Models

EV Charging deployments that need management can be found in three scenarios:

Fleet: Company/organization owned vehicles receiving electricity at a company/organization owned facility. The discussion above delineates the features and benefits for fleet management staff.

Workplace: Employees (and others) receiving electricity at the workplace while parked for work. Employing the FuelForce/EV solution in workplace ensures that only authorized employees are allowed to charge and that, if needed, the costs of EV charging can be deducted from the employees pay.

Multi-Family Housing: Landlords and homeowner associations can deploy FuelForce/EV to authorize and assess costs to tenants/condo owners.

Clipper Creek Collaboration

Multiforce has worked very closely with one key leader in EVSE development and manufacture, Clipper Creek. The Clipper Creek products are reliable, robustly designed products provided throughout the US and elsewhere. The FuelForce Galaxy EV Integration module works directly with the Clipper Creek Cosmos board solution as part of the HCS series of chargers to provide intelligent EV management to fleet owners. This integration allows for the complete charging cycle to take place.

As a detail, the onboard charger in the vehicle monitors battery temperature during the charging process. At times, a battery's temperature can rise to a point of possibly damaging the battery. The onboard charger then pauses the charge or throttles back the rate of charge to let the battery cool. Some monitoring systems could misinterpret the pause and end the transaction. The Galaxy module, in communication with the Clipper Creek Cosmos board, determines if the pause is for cooldown or if the battery is indeed full. If paused, the tracking of charge is also paused, and resumed once electricity starts to flow again, all presented to the management platform as a single transaction. If the battery is full, then the transaction is subsequently ended.

In Summary

The FuelForce/EV product line from Multiforce Systems allows fleet managers to monitor and control the electrical charging of their entire fleet. FuelForce/EV also allows fleets to deploy low-cost, non-networked chargers, in a sense making “dumb” chargers smart and secure and minimizing communication costs for fleet and workplace parking. The system can prevent charging to take place at selected time of the day and days of the week, thus avoiding peak billing times and demand charge periods, reducing the overall cost of electricity used for EV charging. One study from Alameda County’s fleet showed that by avoiding demand charges, they could cut their costs by one third. The system also provides an alert and reservation capability, alerting drivers when their car is charged and should be moved and when a requested space becomes available for charging.

Additionally, FuelForce users can understand how much electric power, gasoline, or diesel is used by their entire fleet, by department and individual, all available anytime, anywhere. Fuel and power use can be seen by vehicle, driver, or department. Reporting is our strength, to enable management, control, and measurement of all charging and fueling. FuelServe.net, our cloud-based reporting and management platform is available 24/7 on a desktop, laptop, tablet, or smartphone. The advanced cloud-based software also offers direct integration with fleet management systems and other enterprise systems via an API.

Multiforce Systems prides itself on building quality products designed for durability and ease of use. We also constantly push innovation. As noted above, our cloud-based platform was the first in the industry, the first installation being over 15 years ago. We were the first fuel management provider to include electric vehicle power management as an integral part of a management platform. Selecting Multiforce products for your fleet fuel and EV power management ensures that your investment will last and be supported by the latest in innovations.