iREV

Initiative for Resiliency in Energy through Vehicles

Electric Vehicles and Emergency Response

LAPD purchased 100 BMW i3 electric cars.

June 2016

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Plug-in electric vehicles (EVs) can be a valuable resource during disaster relief efforts in part because many electric vehicles can export energy from their batteries to power emergency response systems, such as communication equipment, traffic lights, or fuel pumps. Having the energy stored in a vehicle means it is mobile and can be driven to locations where power is needed. The ability to bring power where it is needed, even on a local scale, can be an invaluable resource during emergencies.

Los Angeles Air Force Base has replaced some of its general-purpose fleet with electric vehicles as part of a vehicle-to-grid demonstration.

Another benefit of electric vehicles during disaster relief efforts is having access to transportation that is powered by something other than gasoline or diesel. While electric lines can be compromised during an emergency, they are often back online fairly quickly. Disruptions to conventional fuel supplies, on the other hand, can take longer to reactivate. Having access to transportation that doesn't rely on conventional fuels is an asset to disaster relief crews because it increases their flexibility and ability to respond in different situations.

While electric vehicles hold tremendous potential as a resource in disaster relief effort, they are still considered an emerging technology that represent a fraction of the overall vehicle market. Consequently, the emergency response sector's experience with electric vehicles is limited. As different agencies and organizations gain experience using EVs in emergency response efforts, their experience should be widely disseminated to help advance the technology.

The following pages include examples of cities and states that have used electric vehicles during emergencies, and provide additional information that fleet and emergency managers should consider when incorporating electric vehicles into their fleet.

Electric Vehicles in Disasters

PROS:

- ✓ Energy can be exported to power emergency response systems
- ✓ Can be driven to locations where power is needed
- ✓ May be easier to find electricity than gasoline

CONS:

- × New technology with limited experience in emergencies
- × Must have access to power or a generator

CASE STUDY

PG&E's Electric Vehicles: the Value of Exportable Power

The exportable power module on PG&E's Class 5 PHEV utility work truck is capable of providing up to 120 kW of exportable power, enough to power 80 percent of the transformers in PG&E's service area.

The ability of electric vehicles to export power and interact with the grid and/or buildings is an emerging technology that has tremendous benefits in disaster relief efforts. One of the innovators with regards to exportable power is Pacific Gas and Electric (PG&E). PG&E is one of the largest natural gas and electric utilities in the U.S. It primarily operates in northern and central California and serves a population of 16 million. The size and scale of PG&E means it contends with emergency situations frequently, including unplanned power outages as well as earthquakes and forest fires.

Recognizing the need and value associated with a mobile power source, PG&E worked with vehicle manufacturers to develop a series of purpose-built plug-in hybrid trucks that are equipped and designed with the capability to export power. The plug-in hybrid systems mean the battery can be charged by plugging into a power source, or running the diesel engine. Earlier versions of the vehicles could export 50 kW of power, while the newer, larger trucks are able to export 125 kW of power for several hours. PG&E estimates that with the newer models, the diesel engine can charge the battery in about 30 minutes. PG&E places a high value on the ability of the power source to be mobile. Exportable power assists their daily operations and planned outages, but has also proven to be valuable in emergency situations.

In September and October 2015, large wildfires burned at the foothills of the Sierra Nevada Mountains in Calaveras County. The fires caused damage to the electric network, threatened several communities and forced an evacuation. Some residents evacuated to a shelter where power was down, and PG&E was able to use one of their plug-in hybrid vehicles to power the shelter until power was restored. The PG&E vehicle supplied power for two days until a replacement shelter became available.

Similarly, in August 2014, the City of Napa experienced a 6.0 magnitude earthquake. The earthquake resulted in a power outage and the City's Fire Department lost electricity. Even though the Fire Department had fuel supplies, without electricity, they were unable to pump fuel into their trucks. After the event, PG&E donated a plug-in hybrid truck with exportable power to the Napa Fire Department. The truck will be able to export up to 80 kW of power, and can be used in a variety of applications, including being used as a backstop generator that could be used to pump fuel supplies.

Pacific Gas and Electric work truck developed in partnership with Efficient Drivetrains, Inc (EDI) has the ability to export power for on-demand power when the grid isn't functioning. The above picture shows a PG&E truck powering a site at a Red Cross event in California.

While PG&E provides an excellent example for community-level response, the ability to export power can also be a tremendous asset to individuals and households. Having access to power, even for short periods of time, can mean the difference between evacuating homes and staying for the duration of the outage. After the Great East Japan earthquake of March, 2011 (see also next section), the value of being able to export small amounts of power was evident. EVs played several roles in that disaster relief effort, including exporting power to operate communication equipment. As one way to commemorate the disaster and prepare for future ones, Nissan donated electric vehicles and "Leaf to Home" power stations to each of Japan's 47 prefectures. The Leaf to Home power stations provide a two-way charging unit that allow users to export power for resources such as lights, communication equipment and even basic kitchen appliances. The estimated cost of the LEAF and power station is about $33,000 (based on 2016 model).

CASE STUDY

Great East Japan Earthquake: The Importance of a Diverse Fleet

An electric Mitsubishi i-MiEV on site, following the Great East Japan earthquake and tsunami.[1]

EVs are valuable in emergency situations because they diversify the fleet and offer flexibility in cases when conventional fuel supplies are constrained. Even though electricity is often the first energy source to be lost during emergencies, there are established systems for bringing electrical power back online quickly. When conventional transportation fuel lines are down, however, it can be difficult and take longer for the supplies to be restored. In these situations, EVs offer an alternative form of transportation.

The value of a diverse fuel fleet proved itself in the wake of the Great East Japan Earthquake in March 11, 2011. This massive and complicated event was caused by a 9.0 magnitude off-shore earthquake and resulting tsunami. The event displaced 340,000 individuals and ultimately resulted in death totals nearing 16,000 individuals and another 6,200 injured. As of 2015, another 2,600 were still reported as missing.[2] The event caused damage to nearly all sectors and disabled energy generation, including nuclear power plants. In the immediate aftermath of the event, some 4.4 million households lost electricity. Oil refineries were also destroyed by fires.

Once the immediate humanitarian response effort was addressed, several challenges persisted – including lack of access to transportation fuel. The loss of refining capacity and damaged storage tanks created an acute demand for finished (refined) oil products, particularly gasoline. Shortages were so severe that Japan's Self-Defense Forces had to provide gasoline, and Japan accepted donations of diesel fuel from China.

Electric vehicles were a tremendous asset during this time because they could refuel at any electrical outlet. To assist with the relief effort, several EV manufacturers, including Mitsubishi and Nissan, donated or loaned EVs to damaged communities. Other public agencies that had EVs in their fleet also loaned them to the affected areas. EVs were used to transport supplies to refugee centers and take doctors into affected areas. Other vehicles were used to inspect schools for structural damage and deliver supplies.[3]

BACK TO BASICS

What You Need to Know About Electric Vehicles

Electricity is one of the most common and widely used forms of energy. It has two fundamental characteristics that differentiate it from other fuel sources. First, electricity is a secondary energy source, meaning it is generated from the conversion of primary sources of energy, such as fossil fuels (coal, natural gas, oil, etc.), nuclear power and renewable sources (wind, solar, hydro and geothermal). Second, electricity must be used when it is generated, converted to another type of energy, or stored in a device, such as a battery.

In the U.S. electricity is used to provide light, to heat and cool homes, operate machinery, and power vehicles. Electric vehicles are not a new concept – the first vehicles invented were powered by electricity, and there are some 1.6 million EVs in use by fleets and individuals today.[4] In total, the U.S. has more than 400,000 light duty EVs registered[5], with over 14,000 charging stations and 34,600 charging ports, and almost half of the EVs on the road are plug-in hybrids.[6]

There are a variety of different electric based vehicle technologies, but for the purposes of this case study, EVs refer to a class of vehicles that use energy stored in a battery for propulsion, and are plugged into a source of electric power to charge and recharge. EVs

Charging Systems

Plug-in hybrid and all-electric vehicles need to be connected to a power source to charge their batteries. There are three main types of electric vehicle chargers:

Level One uses the same 120 volt current found in standard household outlets. Enabling charging can be simple as installing dedicated 120 volt outlets. The disadvantage with this type of charger is it is slow and typically provides 3-5 miles of range per hour.

Level Two uses 240 volt power to speed up vehicle charging. This type of system requires dedicated charging equipment and electrical wiring capable of handling higher voltage power. Charge times are 10-20 miles of range per hour.

DC Fast Charger allows vehicle to charge their battery (up to 80 percent of battery capacity) in 20-30 minutes. Requires more expensive charging equipment as well as high voltage 3 phase power connections.

For more information on charging systems, visit the U.S. Department of Energy's Alternative Fuels Data Center.[7]

Portland State University's original "Electric Avenue" featured seven charging stations from different manufacturers. The Avenue was later relocated to the World Trade Center Portland (pictured).

include cars (automobiles) as well as medium and heavy duty vehicles, such as delivery trucks, ambulances, school buses and transit vehicles. EVs can travel as long as their batteries have stored energy; when the energy is depleted they must be recharged, or switch to another fuel source. One of the limitations with EVs is that the batteries have limited capacity to store energy, which limits how far a vehicle can travel. Another challenge with EVs is that the time required to charge a battery can take 20 minutes (using fast charge equipment) or between four and six hours depending on the charging technology (see following section).

The travel range of electric vehicles varies by vehicle type, but typical passenger EVs (such as the Nissan Leaf) can drive between 70 to 90 miles on a single charge. Range is also impacted by driving conditions. Cold weather, for example, can mean the battery is also used to heat the car, which leaves less energy for travel. Battery technology is advancing quickly and a number of extended-range EVs models are scheduled for sale in 2017; these new vehicles will be able to travel over 200 miles on a single charge. Plug-in hybrid electric vehicles (such as the Chevy Volt) typically have both a shorter electric range, as well as a gasoline-powered engine, with a combined electric-gas range of over 300 miles.

As noted above, EVs can also be a source of power for auxiliary needs, not just used for propelling a vehicle. EVs can potentially function as an energy resource during emergencies by using the energy stored in the vehicle battery to export power. This ability to export power could be a valuable resource in a variety of applications ranging from powering communication devices (radios, cell phones, etc.), to maintaining traffic control systems such as traffic lights. With the right capacity, exported power could also be used as a back-up generator to power emergency shelters.

EVs are an emerging technology, thus despite offering considerable advantages, experience with EVs during emergency situations is limited. In addition, using EVs to export power has largely (but not entirely) been used in controlled situations, such as to maintain power during planned outages. Consequently, EVs offer tremendous promise, but their use in emergency planning has not been sufficiently tested and replicated; as a result, they are best classified as an emerging resource.

Costs

Electric vehicles have distinct advantages and disadvantages with regards to cost. The purchase price of an EV is almost always higher than a similar conventional vehicle. Operating costs, however, are almost always lower than conventional vehicles because electricity prices are low. Historically, electricity prices have been more stable than other energy sources, which makes it easier for fleet managers to accurately predict fuel costs over longer periods of time.

The below total cost of ownership (see Table 1) model shows that the cost to own an EV is roughly equivalent with the cost of a conventionally fueled vehicle. This analysis compares and contrasts light duty vehicles. Heavy duty EVs, however, will likely show increased savings due to the lower fuel economy of conventional heavy duty vehicles. Other conditions, such as the amount of time the vehicle spends idling or the operating conditions (climate, topography) will influence the relative financial costs of EVs as compared with conventional vehicles. For more information and to calculate Total Cost of Ownership, fleet managers can use the U.S. Department of Energy's Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool. AFLEET examines both the environmental and economic costs and benefits of alternative fuel and advanced vehicles.

Cost Comparison – Electric Passenger Vehicle and Conventional Vehicle[8]

KEY ASSUMPTIONS

KEY ASSUMPTIONS	Ford Focus – Gasoline	Ford Focus - Electric
Annual Mileage	16,000 miles	16,000 miles
Vehicle Range per Tank/Full Charge	350 miles (12.4 gallon tank)	76 miles
Fuel Economy	26/36 MPG	3 miles per kWh
Maintenance and Repair	.18 $/mile	.09 $/mile
Fuel Price	$2.35/gallon	$0.12 kWh
COST OF OWNERSHIP		
Purchase Price	$18,515	$29,170
Annual Fuel Cost	$1,212	$653
Annual Maintenance Cost	$2,880	$1,440
ANNUAL OPERATING SAVINGS	**$0**	**$2,093**

RESULTS: *Not including any state or federal incentives, the annual operating savings for an electric vehicle v. gasoline vehicle is $2,093, with a payback period of 5.1 years.*

Other Benefits of Electric Vehicles

Fleets, including fleets involved with emergency preparedness, are adopting EV technology because of other environmental and energy security benefits. Electric motors run on energy stored in the vehicle battery, thus electric vehicles, or vehicles operating electrical systems, have no tailpipe emissions. The energy produced to power electric vehicles can generate greenhouse gas emissions, since regional grids are powered by a variety of fuels, including renewables, coal and natural gas power plants. The lifecycle emissions of an electric vehicle, therefore, vary by region, but are almost always lower than traditional gasoline vehicles.[9] In addition, EVs operate quietly, which is a benefit to work crews and the surrounding area.[10]

EVs also offer energy security benefits. Electric vehicles plug into external source electricity for some or all of their power, reducing the need for imported petroleum products. Because almost all electricity in the U.S. is produced from domestically generated coal, nuclear energy, natural gas and renewable resources, EVs reduce the demand for imported petroleum products. In addition, hybrid electric vehicles typically use less fuel than similar conventional vehicles, because they employ electric-drive technologies to boost engine efficiency and fuel economy.[11]

Other Considerations

Product Development: While EVs are deployed in a variety of markets, specialized models may not be widely available. PG&E, for example, had to work directly with manufacturers to develop the vehicle they needed. Other vehicle types commonly used by emergency responders, such as ambulances and fire trucks, may only be available through select manufacturers. If your community is interested in purchasing electric vehicles for general or specialized uses, contact your Clean Cities Coordinator to learn about vehicle availability in your area.

Vehicle Range: Challenges associated with vehicle ranges affect all-electric vehicles only; plug-in hybrid vehicles have back-up gasoline or diesel engines that do not restrict vehicle range. The travel range for all electric vehicles is limited by the power stored in the vehicle's battery. Current year (2016) passenger all electric vehicles (excluding the premium priced Tesla models) have travel ranges between 60 and 100 miles, although the range will vary based on the temperature, topography, vehicle size and driving styles. Vehicle manufacturers have announced longer range electric vehicles for the mainstream market that are expected to offer a travel range closer to 200 miles on a fully charged battery.

Technology (Battery) Development: The limited range of vehicle batteries are among the most significant barriers facing greater EV deployment. They are also the most expensive piece of equipment and one of the reasons why EVs are more expensive than traditional gasoline power vehicles. The U.S. Department of Energy and private sector are exploring battery chemistries and technologies in support of EV development. Both engineers and manufacturers expect new battery technologies to be able to both reduce the cost and increase the capabilities of the battery. These advances are continually being applied to applications over time.

Conclusion

Electric vehicles can be a significant asset during and after an emergency event. The ability to export power has been a tremendous asset to communities in PG&E's service territory, and will be increasingly used by emergency responders as the technology is more widely adopted. Electric vehicles can also provide critical services during fuel shortages, given the ubiquity of electricity and charging points. While electric vehicles offer advantages for the emergency response community, emergency managers should be aware of how they work, what they cost, and shortcomings that exist before deciding how they may be incorporated into an emergency response fleet.

Ready to Get Under the Hood?

Resources to Help Fleets Get Started and Connected with Existing Electric Vehicle Users

The Initiative for Resiliency in Energy through Vehicles (iREV)

NASEO's iREV initiative supports state and local emergency management decision makers by providing tools and information on alternative fuel vehicles and their use in emergency management and response. iREV is led by the National Association of State Energy Officials and supported by the U.S. Department of Energy Clean Cities Program. Visit **www.naseo.org/irev** for more information.

U.S. Department of Energy Clean Cities Program

The Clean Cities program advances the nation's economic, environmental, and energy security by supporting local actions to cut petroleum use in transportation. Nearly 100 local coalitions serve as the foundation of the Clean Cities program by working to cut petroleum use in communities across the country. Visit **cleancities.energy.gov** for more information and to find contact information for your local coordinator.

Electric Drive Transportation Association

EDTA is the trade association promoting battery, hybrid, and plug-in hybrid and fuel cell electric drive technology and infrastructure. EDTA conducts public policy advocacy, provides education and awareness, industry networking, and conferences. Visit **www.electricdrive.org** for more information.

Edison Electric Institute

EEI is the trade association for investor-owned electric companies. EEI provides resources on transportation electrification and the role of utilities, and helps connect utilities with other stakeholders. Visit **www.eei.org** for more information.

Endnotes

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