CRN
Cooperative Research Network

TechSurveillance

Fleet Electrification 101

BY CHRISTINE GRANT, REBECCA HSU, PATRICK KEEGAN OF COLLABORATIVE EFFICIENCY
NOVEMBER 2014

The End-Use Energy Efficiency work group, part of NRECA's Business and Technology Strategies team, is focused on identifying the opportunities and challenges associated with electricity end-use and demand-side management strategies. *TechSurveillance* research relevant to this work group looks at the various aspects of energy efficiency technology, including market status, related policies and regulations, and business models. This article, the first of a two-part series, examines the evolving market of electric vehicles and application of this technology in utility fleets. For more information on electric vehicles, please visit our research topic area website on cooperative.com.

INTRODUCTION

Plug-in electric vehicle (PEV) sales are steadily rising. From 2010 to 2014, over 260,000 PEVs were added to American roadways. PEV adoption is not just happening at the consumer level. Businesses, government entities, and other institutions—including electric co-ops—are converting some or all of their fleets to PEVs. As battery costs continue to fall and financing options make PEVs more affordable, commercial fleet electrification is poised to become more widespread. Electric co-ops have a unique interest in considering the adoption of PEVs in their own fleets; end users will look to their electric co-op for leadership and guidance about PEVs. PEV growth presents a rare opportunity for electricity providers to strategically add load that could not only be a source of additional revenue—but which could also be used for load shaping.

This is the first of two articles covering the basics about using PEVs as fleet vehicles. The information presented in these guides is intended for use primarily by fleet managers at co-ops—and is also relevant to commercial co-op members that have questions about PEVs. This article provides a quick snapshot of PEV technology, an up-to-date report on the PEV market, an overview of key PEV benefits and drawbacks, and background on PEV

NRECA
A Touchstone Energy® Cooperative

The key distinction between PEVs and non-PEVs is whether or not the battery can be recharged by plugging the vehicle in.

PEVs now match or even beat conventional vehicles in some performance categories.

use in commercial fleets—including information on charging infrastructure and total cost of ownership. Part Two of this series, "**A Guide to Adopting Plug-in Electric Vehicles to Your Fleet**," continues the discussion on PEVs, with a specific focus on co-ops exploring PEVs for their own use. Subsequent NRECA research will be focusing on technical details related to PEVs, what factors are influencing the PEV market, and the implications PEVs could have on electric cooperatives.

EVOLUTION OF PEV TECHNOLOGY

Although internal combustion engines (ICE) have dominated the auto market for the past century, electrically-powered cars were popular on American roadways in the early 20th century. A famous anecdote to illustrate the past predominance of electric vehicles is the fact that Henry Ford's wife, Clara, wouldn't drive a Model T, preferring her 1914 Detroit Electric for its ease of use and reliability (Shahan, 2014). In recent years, advancements in battery and power management technology, expansion of charging infrastructure, and environmental concerns have sparked an electric vehicle renaissance. In the early 2000s, there were almost no PEVs on American roadways—now there are more than 260,000 (EDTA, 2014).

PEVS TODAY

PEVs, also referred to as electric vehicles, include any vehicle that derives all or part of its power from grid-supplied electricity, which is stored in an on-board battery. Gasoline-dependent hybrid electric vehicles (HEVs) partially run on an electric vehicle battery powered by regenerative braking—but they cannot plug into the grid, and therefore, are not considered PEVs. The key distinction between PEVs and non-PEVs is whether or not the battery can be recharged by plugging the vehicle in.

Regenerative braking: As the vehicle brakes, the propulsion motor becomes a generator, recovering energy used while slowing the vehicle.

Within the PEV grouping, there are two basic configurations:

- **All-electric vehicles** are powered 100% by grid-supplied electricity stored in the on-board battery energy storage system. Most advanced all-electric vehicles are able to recapture energy through regenerative braking.
- **Plug-in hybrid electric vehicles (PHEVs)** are propelled by a combination of a small ICE and large, grid-rechargeable batteries that enable all-electric driving ranges of 10-40 miles or more.

PEV technology has evolved considerably: vehicles currently on the market have greater range capacity, improved fuel economy, and better batteries. Newer lithium ion and nickel-metal-hydride batteries have replaced lead-acid batteries as the chemistry of choice, due to their lighter weight, superior power and energy density, increased efficiency, and longer cycle life. Battery capacity can range from 3 kWh to 85 kWh for passenger vehicles. Larger commercial vehicles, including heavy trucks and buses, offer even larger battery capacity—as much as 320 kWh (BYD, 2014). Average battery life varies depending on the vehicle—ranging from 5 to 20 years (eTec, 2010/ACS, 2013). PEVs now match or even beat conventional vehicles in some performance categories; PHEVs eliminate the problem of range anxiety (concern that vehicles will run out of charge before reaching their destination) due to their ICE, which provides backup fuel capability once the battery is depleted. Future PEV technology improvements include promising applications for the grid. For example, research is underway on “smart charging” systems that can modulate vehicle charging in response to utility signals.

EXPANDING THE MARKET FOR PEVS: FLEET VEHICLES

Unlike individual consumers, commercial fleet managers may weigh the lower operating costs of PEVs over their high upfront costs.

Until recently, most available PEVs were passenger vehicles. Now, more manufacturers are developing PEVs for the commercial market, ranging from light-duty cargo vans to shuttle buses to heavy-duty trucks. As the commercial PEV market matures and more is learned from field-testing the vehicles, more PEVs are likely to be used in commercial fleets. The operational norms of many fleets—such as centralized refueling, high vehicle utilization rates, and predictable routing—enable them to minimize some of the drawbacks other consumers face with PEVs. Unlike individual consumers, commercial fleet managers may weigh the lower operating costs of PEVs over their high upfront costs. Commercial fleet managers are increasingly testing out small numbers of PEVs to gain an understanding of the vehicles’ benefits and drawbacks (see Figure 1).

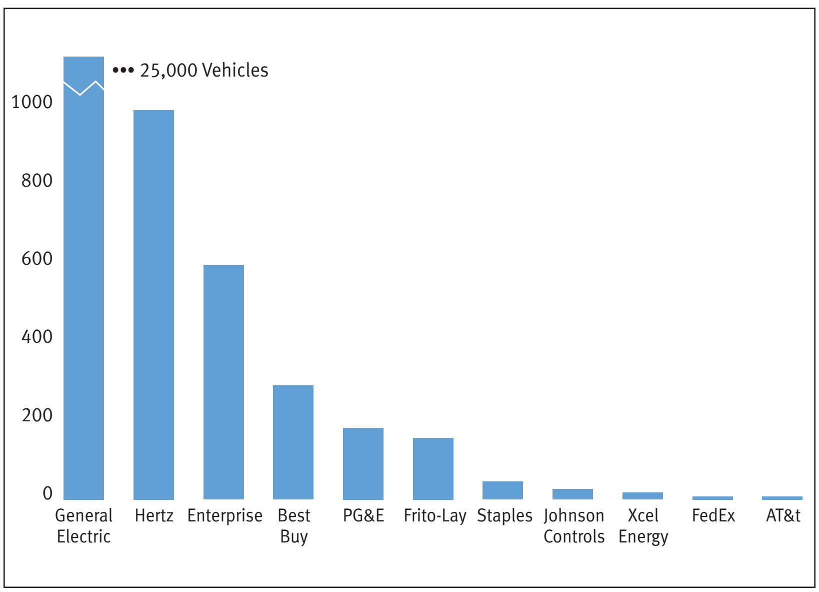

FIGURE 1: Projected Commercial Fleet PEV Purchases (2011 – 2015)
Source: EC 2010

WHAT CAN PEVS DO FOR YOUR FLEET?

The business case for incorporating PEVs into your fleet is increasingly compelling. Though many PEVs cost more upfront than ICE equivalents and have certain drawbacks—such as limited range—today’s PEVs are more capable and reliable, and are better able to meet commercial fleet’s operational needs. Below are a few of the key ways PEVs can benefit co-op fleets:

- **Lower total cost of ownership:** Total cost of ownership (TCO) for PEVs (purchasing, refueling, and maintaining) can be lower than conventional ICE vehicles, offsetting their higher incremental cost. In a recent survey of 180 government, utility, and private fleet managers, 58 percent of respondents reported lower operating costs as their primary motivation for purchasing PEVs over other alternative fuel vehicles (DK, 2012). A recent electric vehicle fleet modelling project found that fleet operators could expect to save more than $10,000 per electric vehicle in lifetime costs, even in the absence of incentive dollars (FC, 2014).
- **Improve fuel economy:** Exact fuel savings depend on PEV type, size, and application, but in general, PEVs reduce fleet fuel costs dramatically. Electric motors convert more than 90 percent of electric energy into mechanical motion, whereas a typical medium-duty truck only converts between 15 to 25 percent of diesel fuel into motion (ES, 2010). Assuming normal efficient operation, an electric mile costs only three to five cents to drive, whereas a gasoline mile costs 12 cents (EC, 2013). If a co-op or utility offers time-of-use rates, charging PEVs during off-peak times may further reduce fuel costs. As electricity prices are less volatile, PEVs can cushion a fleet against fuel price shocks.

- **Avoid on-site engine idling:** Bucket trucks outfitted with plug-in hybrid systems can use batteries to operate equipment ordinarily powered by an idling engine, such as lift buckets. A study on PG&E's hybrid trucks showed that the reduction in fuel consumption can be large enough to generate a 2.5 year payback; however, exact payback timelines will vary due to factors such as fuel costs (EC, 2012). Plug-in hybrid bucket trucks reduce both noise and tailpipe pollution. Additionally, running a truck's main engine at low load to power lifts is inefficient and shortens engine lifespan. Using bucket trucks with battery-powered lifts can reduce maintenance costs.
- **Decrease lifecycle emissions:** Numerous studies have demonstrated that total PHEV CO2 emissions (factoring in both emissions from gasoline and electricity production and tailpipe emissions), are substantially lower than those of conventional vehicles. Even when a battery is charged with coal-generated electricity, PHEV CO_2 emissions are 30 percent lower than ICE vehicles (ES, 2010).

CHARGING INFRASTRUCTURE

Charging infrastructure is an important prerequisite for fleet electrification. PEVs are charged through electric vehicle supply equipment (EVSE), classified into three categories based on battery charging rates:

- **Level I:** uses a standard 120-volt (V) outlet. Adds about three to five miles of driving range per hour of charging.
- **Level II:** uses 240-V (typical in residential applications) or 208-V AC plug (typical in commercial applications). Commonly used by fleet facilities. Adds about 10 to 25 miles of driving range per hour of charging.
- **DC fast charging:** rapid, direct current (DC) charging adds 60 to 80 miles of range to a light-duty PEVs in less than 30 minutes.

The network of public charging stations is expanding, thanks in large part to $190M in American Reinvestment and Recovery Act funds for installing PEV charging infrastructure (EC, 2013). As of July 2014, there were 8,548 public charging stations nationwide, not including legacy chargers (older charging infrastructure) (DOE, 2014). However, the network is highly region-dependent, concentrated in major metropolitan areas and along the Eastern seaboard. Depending on the availability of local charging infrastructure and a fleet's needs, charging stations may need to be installed in both central and field locations. Fleet characteristics such as route predictability, miles driven, and hours of operation will affect the type, number, mix, and location of chargers needed.

Although using high-output Level II and DC fast charging infrastructure reduces charge time, Level I infrastructure costs less and will often meet fleet operation needs, if vehicles are recharged overnight. A study done by PlugInsights in late 2013 of 1,370 PEV drivers found that 81 percent of charging is done at home. The driving patterns of fleet vehicles are also likely to facilitate "at home" charging (at a depot or fleet facility) rather than at a public or fast charging station.

IS FLEET ELECTRIFICATION COST-EFFECTIVE?

Upfront costs for today's PEVs are still considerably higher than for conventional vehicles, primarily due to high battery costs. However, multiple reports have found that on a total cost of ownership (TCO) basis, some PEVs can be cost-competitive with HEV and ICE vehicles (see **Figure 2**. BCG, 2013 & EC, 2013).

PEVs generally require less maintenance, as there are fewer fluids to change and fewer moving parts. Payback timelines are affected

Numerous studies have demonstrated that total PHEV CO_2 emissions (factoring in both emissions from gasoline and electricity production and tailpipe emissions), are substantially lower than those of conventional vehicles.

The network of public charging stations is expanding, thanks in large part to $190M in American Reinvestment and Recovery Act funds for installing PEV charging infrastructure (EC, 2013).

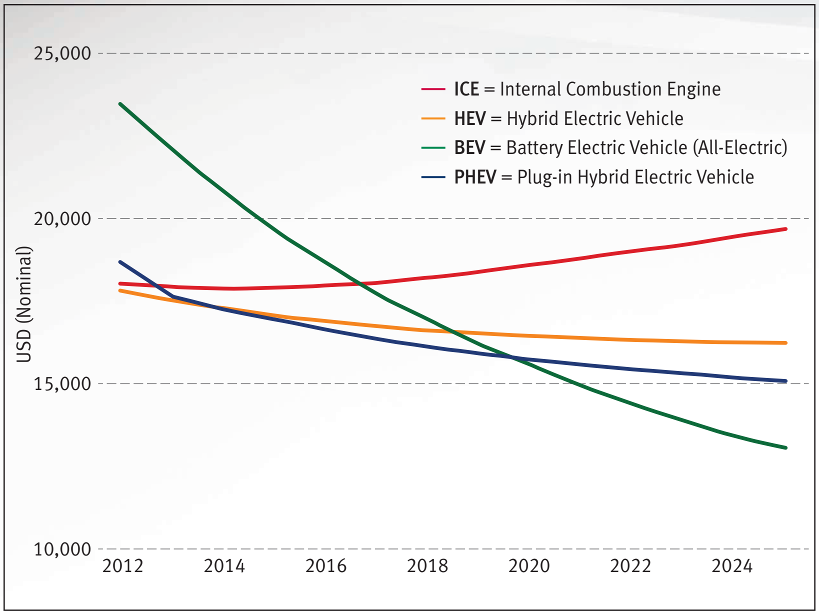

FIGURE 2: Total Cost of Ownership *Source: EC 2013*[1]

Battery cost is the main driver of the incremental cost difference between PEVs and ICEs.

by vehicle duty cycles, ownership duration, and other factors.

PEV purchase prices will likely decline as production volumes rise and battery costs fall, due to technological advances and increasing economies of scale. Battery cost is the main driver of the incremental cost difference between PEVs and ICEs. Future lithium-ion battery prices are uncertain and projections vary; however, battery costs have fallen significantly—in 2010, battery costs were as high as $1,000/kWh—prices dropped to about $600/kWh as of 2013 and are expected to continue to fall (EC, 2013; McKinsey, 2012; UCLA, 2012).

CONCLUSION

The PEV market is growing quickly as battery costs drop and charging infrastructure expands. More and more vehicle manufacturers are developing PEVs for the commercial market. As these trends continue, more co-ops may consider adding PEVs to their fleets as a way to lower transportation costs, learn about PEVs, and as an educational tool for their co-op members. The sequel to this report, "**A Guide to Adopting Plug-in Electric Vehicles to Your Fleet**," goes into more depth about how to select PEVs for your co-op's fleet, with information on how to assess your fleet, select a PEV, and install charging stations. Several real-world examples of how other co-ops are approaching PEVs are also provided. ■

1 Figure 2 compares lifetime ownership costs across a variety of vehicles based on a TCO model developed by the Electrification Coalition/PricewaterhouseCoopers. The model assumes that a vehicle was purchased new in that year and was driven 14,000 miles per year for five years, and factors in U.S. government projections of gasoline and electricity prices.

REFERENCES

[American Chemical Society, 2013] American Chemical Society. 2013. "**Understanding the life of lithium ion batteries in electric vehicles**"

[BCG, 2010] Boston Consulting Group. 2010. "**Batteries for Electric Cars: Challenges, Opportunities, and the Outlook to 2020**."

[BYD, 2014] **www.byd.com/na/auto/ElectricBus.html**

[DK, 2012] Dow Kokan and Fleet Answers. **Vehicle Trends & Maintenance Costs Survey**. 2012.

[DOE, 2014] Department of Energy Alternative Fuels Data Center. Accessed August 12, 2014. **www.afdc.energy.gov/locator/stations**

[EC, 2010] Electrification Coalition. 2010. "Fleet Electrification Roadmap."

[EC, 2012] Electrification Coalition. 2012: "It's Electrifying: Positive Returns in PEV Deployment. PG&E on how Electrification is Saving its Fleet Money Today."

[EC, 2013] Electrification Coalition and PwC. 2013. "**State of the Plug-in Electric Vehicle Market**."

[EDTA, 2014]. Electric Drive Transportation Association. Electric Drive Sales Dashboard. Accessed November 7, 2014. **www.electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952**

[ES, 2010]. E Source. 2010. "Plug-In Electric Vehicles for Fleets."

[eTec, 2010] The EV Project (eTec). 2010. "**Electric Vehicle Charging Infrastructure Deployment or Guidelines for the Oregon I-5 Metro Areas of Portland, Salem, Corvallis and Eugene.**"

[FC 2013] FleetCarma and Frasel Basin Council. 2013 (updated 2014). **Electric Vehicle Fleet Modeling Project** [McKinsey, 2012]. McKinsey. 2012. "Battery technology charges ahead."

[Shahan, 2014] Shahan, Zachary. April 11th, 2014. "**Henry Ford's Wife Wouldn't Drive Ford Model T, Kept Her Electric Car**."

[UCLA, 2012]. UCLA Luskin Center for Innovation. **Early Plug-in Electric Vehicle Sales: Trends, Forecasts, and Determinants**. 2012.

About the Author

Christine Grant, Senior Associate, provides energy efficiency research, anlysis and technical writing for Collaborative Efficiency. Her previous work experience includes five years with Cascadia Consulting Group where she worked with municipalities, utilities, and businesses on resource conservation strategies and programs. Residential energy efficiency was a primary focus of her work while at Cascadia. Her writing has appeared in numerous publications and a major newspaper. Christine holds a B.A. degree in Environmental Studies from Wellesley College.

Rebecca Hsu, a Research Associate at Collaborative Efficiency, graduated from Stanford University. She developed her research skills working for several Bay-area philanthropic or academic institutions, most recently at the Lucile Packard Foundation for Children's Health.

Patrick Keegan is the founder of Collaborative Efficiency, an energy services firm specializing in support for all phases of energy efficiency program development at electric cooperatives and municipal utilities. Pat began his career in the 1980s at the Washington State Energy Office, managing pioneering energy conservation programs and working with all types and sizes of utilities. He left the region in the 1990s, worked for the National Renewable Energy Laboratory on energy efficiency and renewable energy initiatives, and then became Executive Director of the Colorado Energy Science Center, focusing on energy efficiency and solar programs. Hired by Ecos in 2008, he was the VP of residential programs. When Ecos became Ecova Pat led the effort to develop markets with rural electric cooperatives and municipal utilities.

Questions or Comments

- Keith Dennis, NRECA Senior Principal, End-Use Solutions and Standards: **Keith.Dennis@nreca.coop**
- Brian Sloboda, CRN Senior Program Manager, End-Use Solutions and Standards: **Brian.Sloboda@nreca.coop**, or
- CRN online **feedback form**.