EVS26
Los Angeles, California, May 6-9, 2012

Observations from the Frontline

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Abstract

Lack of infrastructure is clearly one of the most significant obstacles to greater plug-in electric vehicle (PEV) adoption. Few better understand this issue than a company working on the front lines to solve it, California-based EV Connect. The company's work with Fisker Automotive and the significant roles it plays in the Department of Energy's EV Project, the ChargePoint America Program and the California Energy Commission's Reconnect Grant have given EV Connect a unique hands-on perspective of the latest issues related to the deployment of both commercial and residential EV charging infrastructure throughout North America. The company, which has also earned the distinct ability to validate the claims and expectations made for federal and state funded programs, will share its knowledge to help others in the industry better understand consumer behavior.

Some of the topics discussed include:

- Observations on Electric Vehicle Supply Equipment Installation
- PEVs Gaining Ground - Costs and Availability of Infrastructure
- EV Economics
- How People Really Drive
- Networked Charge Stations Make Sense

Each of these topics contributes to a holistic view of current electric vehicle supply equipment (EVSE) installation activities as well as possible directions in the evolution of EVSE infrastructure.

Keywords: EV Connect, EV infrastructure, EV charging, EVSE, charge station

1 Introduction

In the 15 years of electric vehicle charging experience that EV Connect can draw on, a number of lessons have been learned performing EVSE installations whether residential, commercial or workplace. Many technical developments, both in the vehicles and the recharging equipment, have moved the industry forward. By way of example, in 1996, we had the confusing situation of inductive versus conductive charging. Today we have a single connector solution for Level 1 and 2 charging equipment. Back then, we had commercial EVSE that had no ability to be networked or provide for convenient billing. We also had permitting agencies that were reluctant to issue permits for these uncertain new requirements. Today, we have a wide range of agency preparedness: traditional and time consuming and inefficient counter visit to full online expedited permitting for those agencies that have wisely embraced technology. With respect to the actual EVSE installation, in the '90's, we had electricians with pagers, today we have connectivity with smartphones, notebooks and iPads for immediate responses. Additionally, upgraded installation procedures, web-based installer training and online coordination of installation activities have also made the "EVSE experience" more likely to be expeditious and a pleasing success. The span of years have that EV Connect has served the PEV industry has positioned EV Connect well to both observe and consider the impacts of trends in infrastructure.

2 Observations on Electric Vehicle Supply Equipment Installation

The simple prospect of an EVSE installation – the mere installation of an electrical appliance supported by an electrical circuit - becomes immediately complex because of significantly different owner expectations, venues and options. Further, each of these venues are evolving in different directions and at different rates.

2.1 Residential

EV Connect's experience indicates PEV owners must be provided with expert support to traverse the entire EVSE installation process. PEV owners want to maximize "electric drive" miles, therefore the opportunity to recharge quickly, sometimes several times a day, is important. Hence, a Level 2 charge station at the home becomes an attractive, if not a necessary, option. However, new PEV owners are faced with a multitude of decisions when it comes to selecting the appropriate recharging equipment. In this evolving environment, where most new owners have little to no experience, a number of topics need to be addressed to make the best decision. For example, in a typical residential installation, the topics to be addressed include:

- Choose between an ever increasing choice of Electric Vehicle Supply Equipment (EVSE) with a broad range of standard features and power output

- Selecting an EVSE installer from a variety of providers that range from no EVSE installation experience to trained, certified and deep experience with many EVSE types
- Where the electric utility offers a variety of rate plans for the new PEV owner, choosing a rate plan that provides the best economics is paramount while recognizing that the choice may also impact EVSE installation costs
- Obtaining the appropriate installation permits in an expeditious manner from the local building authority that may, or may not, be familiar with EVSE installation
- Additional complications if the PEV owner lives in a multi-family dwelling or condominium cooperative where common parking areas and proximity of electric power pose extra issues to resolve.
- Verifying that EVSE manufacturers have included the latest software updates from PEV manufacturers in order to minimize "non-charging events"

Currently, support for the PEV owner can come from several sources. However, PEV manufacturers range in their level of support from "white glove coordination" to sales of the EVSE only to mere recommendations as to next steps. In EV Connect's experience, the installation process must still be handled in a carefully orchestrated coordination between the PEV owner, the utility, the EVSE requirements, the permitting authority and any other parties that have influence. The comprehensive service that EV Connect has developed for its Fisker Automotive and other customers supplies provides a high level of assurance that the "EVSE Installation experience" is a complete success.

2.2 Commercial and Workplace

While the foregoing dwells on the PEV owner and the residential EVSE, similar topics can be drawn for commercial and workplace EVSE installations. In these instances, as learned from EV Connect's California Energy Commission Reconnect Project and other installation customers, hurdles to EVSE installation in the commercial and workplace setting:

- Uncertainty of utilization rate "Where are the cars?"
- What should constitute the "installation"
- High costs of the installation
- Cost recovery methods
- Uncertain means by which to monetize the "green" aspect

Commercial owners and workplaces need support and assistance to work through the foregoing. Inexperience in EVSE application can be overcome by an accomplished EVSE provider such as EV Connect. Approaches to each of the issues are as follows:

- Provide details on the PEV rollout programs of manufacturers including likely uptake by geographic area based on past hybrid registrations and income distribution
- Expert evaluation of site specifics, customer budget, cost recovery desires provide input to a customized installation approach
- Cost reduction approaches by selection of EVSE types, power rating, number and location relative to power sources
- Review potential of a managed service to bill for charging with cost recovery for the owner
- Provide means by which EVSE are advertised through signage and press releases

A key development in the advance of commercial and workplace infrastructure is the ability to network EVSE. The networking connectivity provides the means by which commercial and workplace owners can collect revenue and evaluate utilization and performance. A networked system also allows the owner to exert a level of control of the availability and function in order to align the use of the units with the expectations of the owners. With respect to charge station power rating, the duration of the work day implies that Level 2 charging may not be required. Instead, Level 1 charging may be a better solution in most cases. Further, networked Level 1 stations are less costly to produce and install and a higher number of workplaces can accommodate the additional power draw from the lower 1.4 kW ratings of the Level 1 unit. EV Connect's development of a managed, networked Level 1 and Level 2 EVSE system includes these considerations. A summary comment on policy: Current grant programs provide a heavy focus on retail and other commercial venue public charging. Studies for these programs plan to evaluate the use of public charging to establish utilization rates and the merits of these installations. It should be noted that grant programs should also address workplace charging where the likelihood of higher EVSE use is probable given the PEV's presence at the workplace for the long work day.

3 PEVs Gaining Ground - Costs and Availability of Infrastructure

As more electric vehicles come to market, charging infrastructure will continue to help new drivers overcome range anxiety and maximize the usage of their EVs. As this happens, more consumers will become interested in EVs, especially as the cost of driving these vehicles proves to be significantly less than internal combustion engine vehicles.

3.1 Range Anxiety and PEV Range

Range anxiety has been and continues to be, an important part of the infrastructure discussion. Battery electric vehicles (BEVs) are most dependent on convenient recharging infrastructure. Recent announcements of higher range BEVs suggest that rapid progress in eliminating the range anxiety issue is being made. But does this

perception bear up under scrutiny? Figure 1 [1] compares battery electric vehicles (BEVs) from the late 1990's to current and launch ready BEVs based on stated and estimated ranges on a single full charge.

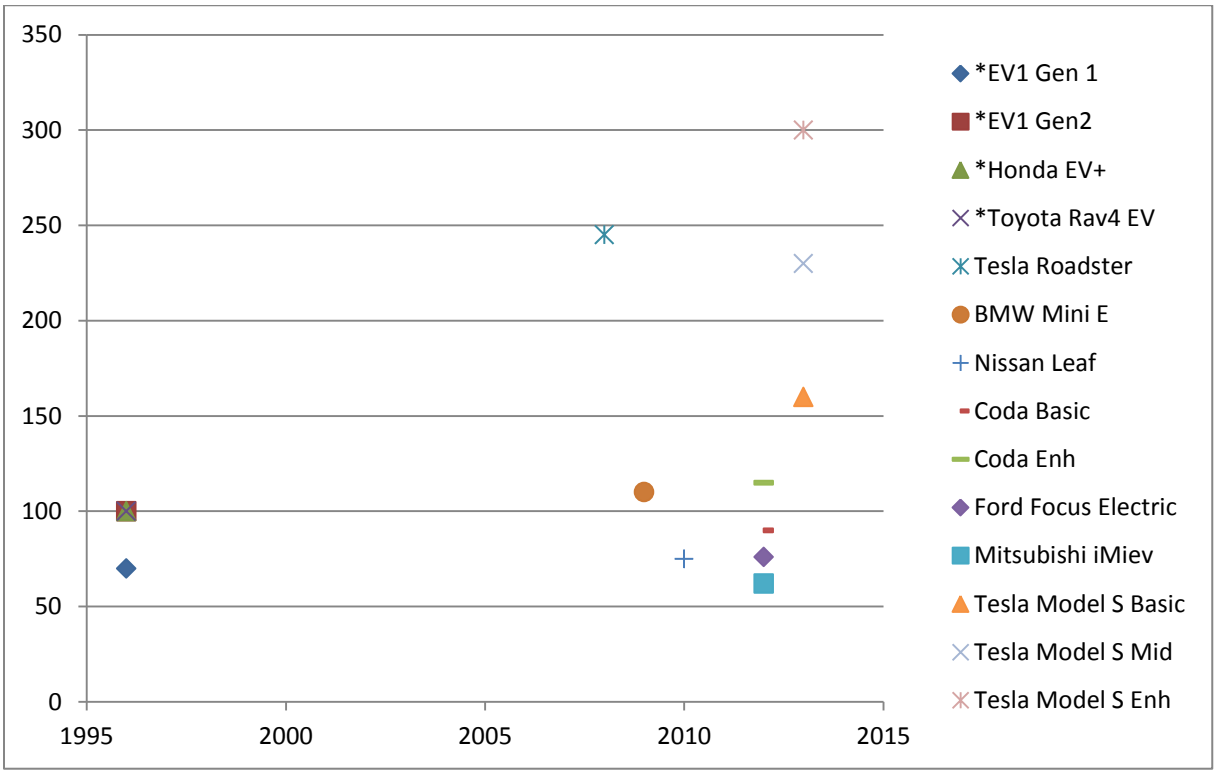

Figure 1

As the chart portrays, larger battery capacities, and hence longer ranges, are beginning to be designed into the vehicles. But as the chart also indicates that a number of current vehicles, typically in the lower price range and, hence, likely highest sales volumes, have made only marginal progress in increased range. Since the range for these BEVs is still substantially less than internal combustion engine vehicle consumers are accustomed to recharging infrastructure will continue to be as important as ever.

Overcoming range anxiety includes several solutions. An observation of driver charging behavior suggests that approximately 80% of charging will be conducted at the home [2]. Further, it is expected that workplace charging will likely take second place behind residential charging in frequency of use. This is an observation based on the frequency of actual installations as well as inquiries. Finally, public infrastructure programs such as the California Energy Commission's Reconnect Program provide the opportunity to recharge at various publicly available locations. A PEV driver has a higher degree of confidence, when venturing out beyond their normal route, that a "topping up" location is available. The Reconnect Program will result in the replacement of older incompatible charge stations with current standard J1772 stations. EV Connect, as the installation

services provider, will conduct the replacement of approximately 600 stations by mid – 2012. Use of the stations will be at no cost to PEV drivers and installation costs are covered by grant funding.

3.2 Infrastructure Cost and Availability

Given the importance of infrastructure, what is the current state of EVSE availability? When compared to the late 1990's, there are approximately10 times the number of EVSE suppliers today. Specifically, approximately 44 manufacturers have indicated they have Level 2 EVSE products. Of these, 21 manufacturers have made detailed specifications available for 36 specific residential and commercial units. Features and prices vary. The range includes the most basic Level 2 (but J1772 and NEC compliant) 3.8 kW EVSE at about $750 to the full featured, network connected 7.7 kW smart EVSE selling in excess of $3000 [3]. It is likely that a trend to commoditization is already underway which speaks to reduced cost for PEV drivers. Additionally, some of initial releases of EVSE product in 2009 were embellished with a large array of features. Lately, new products rolled out by large established electrical and electronics manufacturers have increasingly been pointed to the lower price range of the market. From the buyer's perspective, the current trend indicates greatest demand for the lower priced units regardless of the price of the vehicle. However, as drivers become familiar with merits of additional features (such as connectivity to your smartphone) it is possible that specific features will be considered a "new minimum". Indeed, EVSE may eventually mimic the evolution of "smarts" and price progression found in cell phones over the last few years.

3.3 Incentives

Support of PEV market expansion also comes from the large variety of incentives available on the federal, state, utility and supplier levels. EV Connect maintains a database of incentives nationwide. Incentive information is dynamic as new incentive programs are implemented, some are changed and others are suspended. At last count, over 40 incentive programs related to reduced cost or free EVSE and reduced utility electricity rates are in effect. EV Connect, as an infrastructure provider, provides consultative services as an integral part of responding to the customer's infrastructure needs before and during the installation. A majority of EV Connect's EVSE installations, both residential and commercial have benefited from incentive programs.

4 EV Economics

Simple mathematical and engineering calculations show BEVs or plug-in hybrid vehicle cost less to operate. PHEVs operating from battery power taken from the grid are considerably more cost effective than vehicles operating on internal combustion engines (ICE). Figure 2 excerpted from a US DOE report [4] shows that on an energy-cost-per-mile basis with gas prices at $3.85 per gallon and home energy costs at $0.12 per kwh, BEVs are 50% to 80% more efficient than the ICE alternatives.

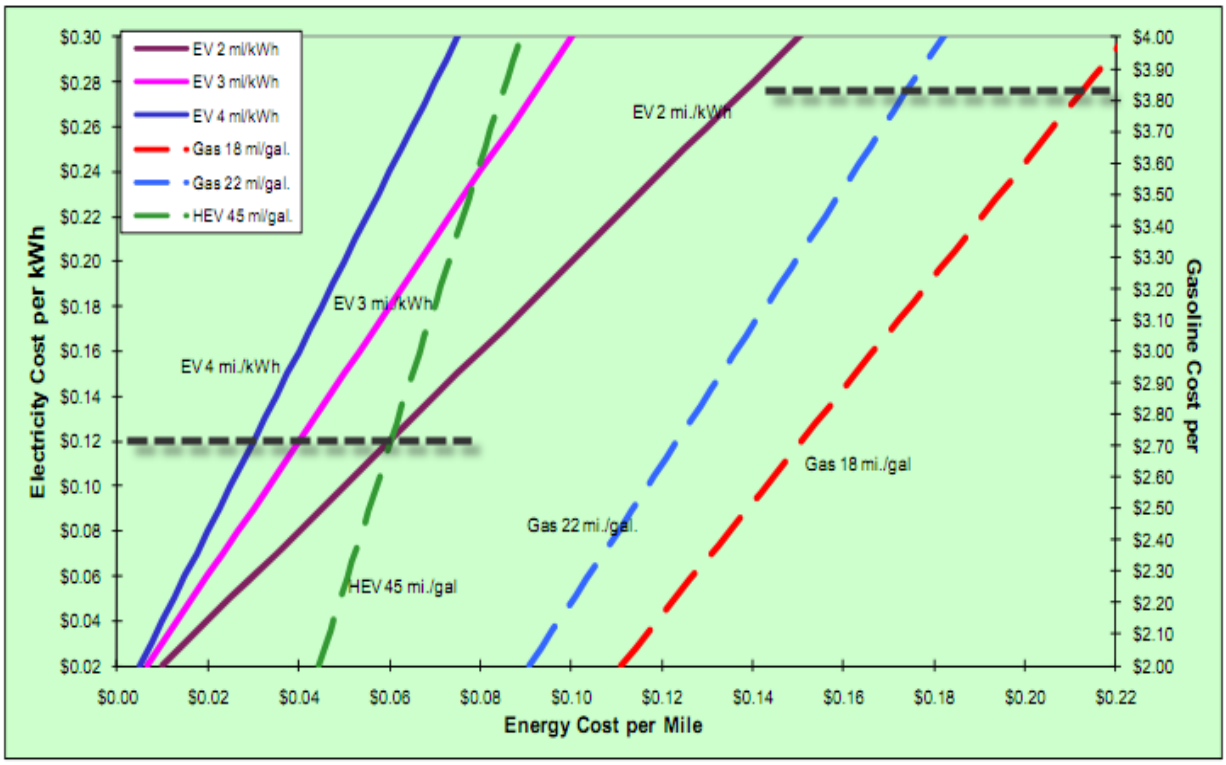

Figure 2

These efficiencies, which will only improve as batteries and vehicles become lighter, points to significant fuel cost advantages for BEVs – especially as gas prices continue to increase due to global demand and resource scarcity.

The relationship between gasoline prices and sales of fuel efficient cars, especially hybrids is clear. Using hybrids as a proxy for PEVs allows a quantitative insight as to the prospective PEV future sales. Figure 3 indicates a longer term view of the relationship between gasoline price hikes and hybrid sales [5]. Although the chart was first prepared in 2009 using over 3 years of pre-Great recession data, a quick review of current data by EV Connect suggests that the basic relationship continues to hold.

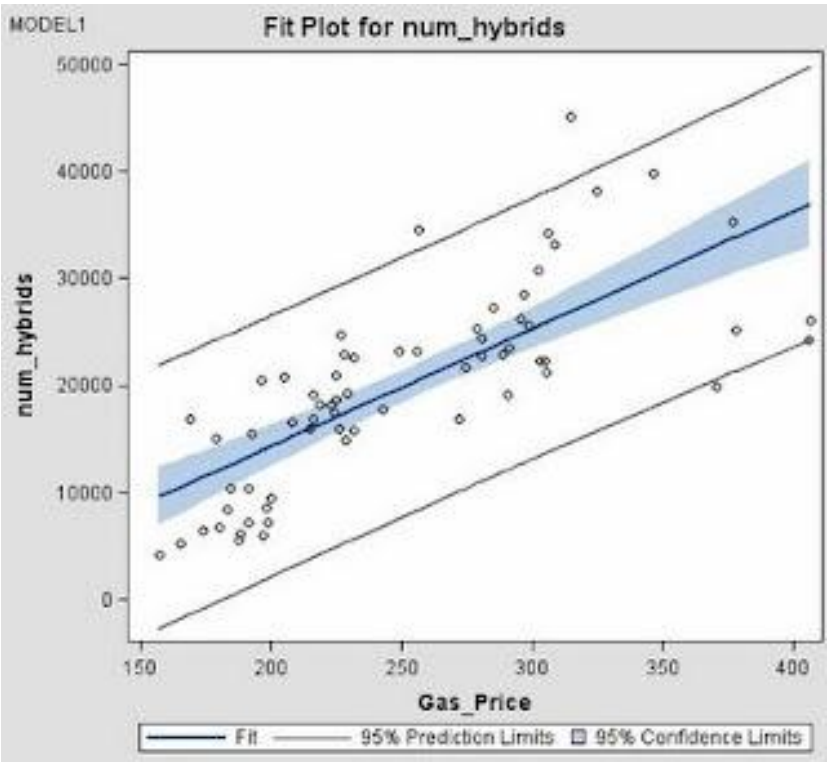

Figure 3

The relationship is further confirmed by a February 2012 analysis of price increases of used fuel efficient ICE compact cars versus used hybrids for sale at auctions. Whereas the fuel efficient ICE vehicle auction prices rose 1.3% during the course of the month, hybrid prices jumped 3.6% [6]. This clearly indicates several things: buyers are interested in fuel economy and are willing to pay a premium for greater fuel efficiency and, importantly, buyers are becoming increasingly aware of electric drive technology as a key to the highest fuel efficiencies.

Over the last 24 months, the national average gasoline price (All Grades) has increased by 30% [7]. Most industry analysts believe that that PEV energy efficiency and cost difference will continue to drive the demand for electric vehicles – but only if there is enough charging infrastructure in place to overcome potential buyers "range anxiety" for BEVs and extend the useful all-electric driving range of PHEVs.

4 How People Really Drive

Periodically, the US Department of Transportation performs a nationwide study called the Omnibus Household Study or National Household Travel Study. This study produces volumes of information on how and why Americans travel and by what mode of transportation and breaks down all of this information in demographic categories including household income, age, region of the country, urban vs. rural, etc.

The most interesting part of the report for our purposes deals with the commuting statistics. As Figure 4 indicates, among the key findings in a 2005 review of the 2001 study:

- 92% of commuters drive less than 35 miles (one way) each day
- 42% of commuters travel

Further, during their daily commute, 45% of drivers make at least one additional stop more than half the time. Additionally, 37% report that they make an additional stop regularly but less than half the time [8].

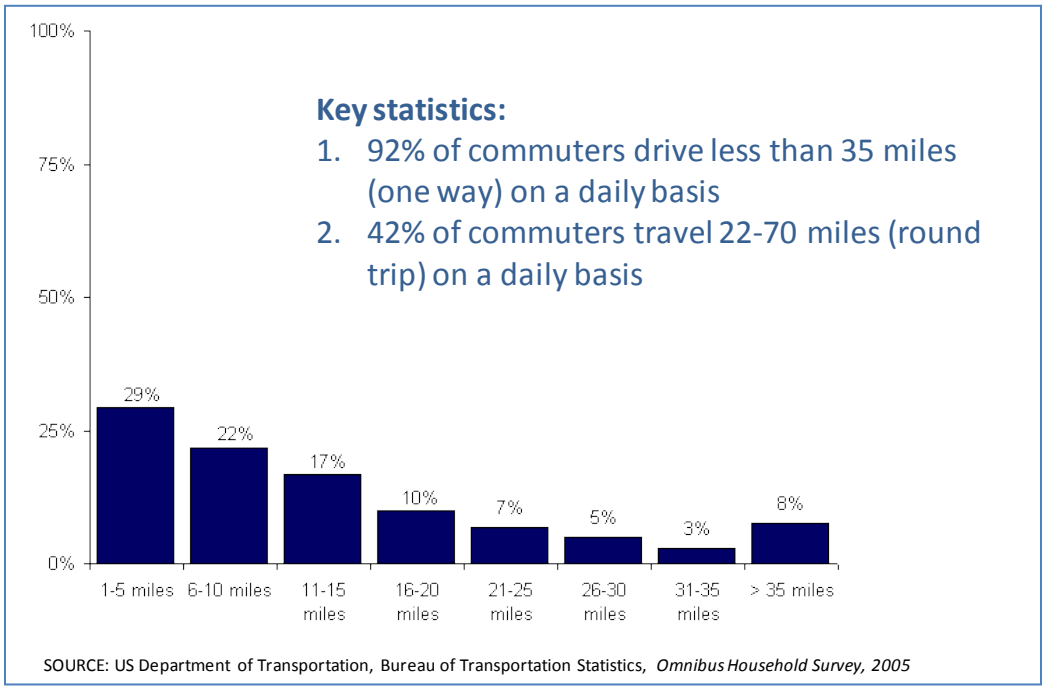

Figure 4

The implications of these observations on how people really drive suggest that most PEVs will provide sufficient range for most of the people most of the time. However, to expand range for PEV drivers, especially those that are at the high end of the commuting range (50 to 70+ miles round trip), workplace charging and opportunistic commercial charging can provide important additional range. This additional range will make the difference between the driver restricted to a defined route or allowing the driver to deviate from the usual route at their option. The foregoing is supported by a recent study from Deloitte & Touche which quantifies consumer expectations. The vast majority believe that pure EVs do meet their expectations of 300 mile range, 2 hours to recharge and wide spread availability of public charge stations [9]. Clearly, additional charging support away from the home appears to be a necessary requirement in the mind of the EV driver.

5 Networked Stations Make Sense

Most research indicates that building a network of well dispersed charge stations will help drive PEV demand by allowing drivers to charge when away from their homes. Through EV Connect's current residential and commercial deployments, EV Connect will be able to offer new empirical data on the following and share new conclusions with the audience about driver preferences, needs and behavior:

- Number of vehicles charged per day per station
- Number of days per year stations are open and in operation
- Amount of time per charge
- Percentage charging at home/workplace/destination
- Maximum capacity of each station
- Estimated gallons of gasoline and/or diesel fuel displaced (with associated mileage information)
- Estimated greenhouse gas emissions associated with vehicle miles traveled

Smart networked stations will also provide the kind of data that allow drivers to understand their driving and charging behavior. As energy becomes more expensive and regulations drive awareness to reduce energy consumption, drivers will increasingly seek more options to better manage their energy usage.

6 Conclusion

- Installation EVSE and circuits remain a highly variable activity with installations ranging from the straightforward to the complex - installations benefit from expert advice and experience.
- The EVSE market has become a crowded space with a variety of products available from a number of manufacturers.
- Incentives have played a key and important role in EVSE deployment.
- EVSE installations at the residence, workplace and in commercial settings can expand the PEV range to allow increased trip flexibility and reduce "range anxiety".
- Networked EVSE station will expand the driver's knowledge of driving patterns and charging behavior that will better allow managing energy consumption and driving costs.

Acknowledgements

The staff at EV Connect participated in the preparation of this paper.

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