What Can be Learned From The EV Project to Inform Others Who May be Interested in a Similar Study?

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Overview

In 2009, a project proposed by the Electric Transportation Engineering Corporation (ETEC, a subsidiary of ECOtality Inc.) was selected via a competitive bid process as part of the American Recovery and Reinvestment Act's (ARRA) Funding Opportunity Announcement 28 - Transportation Electrification. At the start of the fourth quarter of 2009, ETEC signed an agreement with the U.S. Department of Energy (DOE) as recipient of a cost-share grant funded by ARRA to study the use of charging infrastructure by plug-in electric vehicle (PEV) drivers. The project was subsequently called The EV Project.

The EV Project was an ambitious attempt to learn from the initial group of PEV owners and drivers how they use their vehicles and, more importantly, how a rich charging infrastructure could affect PEV use and adoption. The EV Project was designed to answer the following questions: If provided with home chargers and a significant quantity of away-from-home charging infrastructure, how would PEV drivers use their vehicles and the charge infrastructure? What could be learned from this early infrastructure deployment that could improve the effectiveness of future infrastructure deployment?

The EV Project also provided an opportunity to engage this new generation of PEV drivers in questions that surround the sustainability of charging infrastructure. Past attempts to create an electric vehicle-based transportation alternative did not include a sustainable business model for the hosts, who had only been offered the opportunity to provide free charging.

By studying the use of PEVS and the charge infrastructure, The EV Project would attempt to understand the following:

- How many publicly accessible charge sites would be needed to promote widespread adoption of PEVs?
- Where and at which venues should publicly accessible charge sites be located to be most effective?
- Which type of charging (alternating current [AC] Level 2 or direct current [DC] Level 2 fast chargers [DCFC]) would be most utilized by PEV drivers?
- How much would PEV drivers be willing to pay for the convenience of away-from-home charging?
- What impact did (and would) PEV charging at (residential and publicly accessible) sites have on the local electrical grid?
- Which type of away-from-home charging was of more interest: workplace or publicly available?
- Could charging site hosts realize enough benefit from chargers to support desired or needed deployment levels?
- How did the geographically diverse regions of the United States differ with respect to the above questions?

This paper examines The EV Project to learn what was done to meet the ambitious objectives of this infrastructure study and what was learned from the failures and successes. What can the experience of having conducted The EV Project inform others about what worked, what did not work, and what could be done better if undertaking a similar project?

Background

The EV Project was a cost-share grant that was awarded to ETEC as a result of a project proposal submitted in response to FOA 28, which was funded by ARRA. The project was selected from amongst many proposals and it began in October 2009.

The EV Project was scheduled to be conducted from October 2009 through April 2013. The total budget was $229.6M, and was shared 50/50 between federal funds from DOE and funds provided by ETEC and its partners. The value of all conducted activities to meet the project's statement of project objectives was tracked and costs were reimbursed to ETEC or accumulated as cost share after they were incurred.

The EV Project was conducted at the very outset of the newest PEVs to be sold in the United States. The markets selected for study were the first markets to receive PEVs from vehicle partners Nissan and Chevrolet. In the first year, The EV Project was conducted in the following 10 geographically diverse markets:

1. Arizona (metro Phoenix and Tucson)
2. San Diego, California
3. Los Angeles, California
4. San Francisco, California
5. Oregon (Portland metro, Corvallis, Eugene, and Salem)

6. Seattle, Washington (Seattle metro, Tacoma, and Olympia)
7. Tennessee (entire state)
8. Washington, D.C. (metro area, including Maryland and Virginia)
9. Dallas, Texas
10. Houston, Texas.

In spring 2012, The EV Project added three more markets:

1. Chicago, Illinois
2. Philadelphia, Pennsylvania
3. Atlanta, Georgia.

The first PEV delivered to a customer who had agreed to participate in The EV Project occurred in December 2010. The first non-residential charger or electric vehicle supply equipment (EVSE) was installed April 2011. Both of these events took place within 18 months of project award and were in the midst of one of the longest economic recessions in U.S. history (hence the funding from ARRA).

The EV Project

The Objective

The stated objective of The EV Project was "…to use Nissan EVs to develop, implement, and study techniques for optimizing the effectiveness of infrastructure supporting widespread electric vehicle deployment."[1] This study was to be conducted by first deploying charging infrastructure at the homes of actual PEV drivers/owners and then in public places that they visited. Once vehicles and charging infrastructure were in place, data were generated from the use of the vehicles and chargers and collected for analyses. These analyses would create understanding that could be used to modify and optimize infrastructure to support widespread adoption of PEVs.

The Approach

Collaboration – The EV Project team necessarily took a collaborative approach in its conduct of the multi-state deployment and study. Over 60 project partners were named on The EV Project's website[1] that ranged from vehicle original equipment manufacturers (OEMs), electric utilities, state and city governments, national and local retailers, property managers, parts and technical services suppliers, and more.

From the outset, The EV Project team worked closely with Nissan during the roll out of their all new, fully electric vehicle (i.e., the Nissan Leaf). The objective was to provide Leaf drivers in the initial market areas with AC Level 2 EVSE units at their home prior to vehicle delivery, and both AC Level 2 and DCFC in public places that they visited as part of their normal activities. Within a few months after the start of The EV Project, Chevrolet Volt drivers were added in an amendment to the project. Although a different enrollment process was followed for Volts, those participating drivers also received free Blink home charging units. Per an agreement entered into between ETEC and the participants in The EV Project, ETEC would collect data and information that showed how these PEV drivers used their vehicle and the charge infrastructure deployed.

Another aspect of the collaborative approach was pre-vehicle launch engagement of local stakeholders in each of the initial markets. Stakeholders included local government, business owners, electric utilities, schools, permitting authorities, and electric vehicle enthusiasts. The EV Project sought to inform stakeholders about the project and formed advisory committees of local stakeholders to help identify target locations for infrastructure. This location targeting was accomplished via the Micro-Climate planning process for electric vehicle infrastructure deployment that was developed by ETEC.

Infrastructure Deployment –Charging infrastructure itself was, by necessity, a new product. The charging standards (Society of Automotive Engineers J1772 and CHAdeMO) were brand new in the United States and the systems for charge event data collection and transmission were not available in any existing EVSE. Therefore, The EV Project needed to design and produce charging hardware that could provide data needed to conduct The EV Project.

Installation of the charging infrastructure was performed by licensed electrical contractors in each of the markets to be studied. In order to comply with guidelines for expenditure of federal funds and the specific terms of the ARRA award, selection of subcontractors was made as a result of an evaluation of bids received from local and regional contractors complying with the requirements of the Davis Bacon Act. Again, The EV Project team counseled and collaborated with the installation partners and local permitting authorities in order to more effectively manage the infrastructure installation activity. With an objective of installing over 13,000 total units in dozens of cities and towns with permitting authority, deployment of charging infrastructure was a formidable task.

Data Collection – Finally, charging hardware to be deployed was required to remotely collect, store, and transmit to a central database for analysis. This was accomplished via the Blink EVSE and DCFC and the telematics systems installed in both the Leaf and the Volt.

The Blink EVSE were capable of transmitting data to Blink network servers via the Internet (wi-fi or Ethernet) or by

cellular link, depending on installation and unit configuration (i.e., most non-residential units by cellular and most residential via the homeowners' internet connection). These EVSE data were then transferred to The EV Project partner, Idaho National Laboratory (INL), for analysis.

Vehicle data were transferred directly from Nissan's Global Data Center and from OnStar to INL, where it was matched with Blink charge data and all data curated to ensure reliable representation of PEV driver charging behavior.

In order to collect and transmit these data for analysis, The EV Project team at ETEC established data agreements with each of the following entities:

- Nissan for Leaf data
- Chevrolet for Volt owner information
- OnStar for Volt data
- Each vehicle participant (over 8,000 individual agreements)
- Each charging site host (over 1,500 agreements, which often needed modification in order to comply with business or legal requirements of the host organization).

ETEC developed processes and procedures for safeguarding of data collected from the participant's use of their vehicle and charging infrastructure. All published reports required aggregation of data rather than reporting on individual data.

In addition to the above agreements, ETEC entered into business agreements to support The EV Project with parts and service suppliers for hardware compliance testing, data communications, customer service support, and software development.

Reporting – In addition to periodic reporting required by DOE and ARRA, ETEC disseminated project information via electric vehicle industry events in each study market and at national events; maintained an EV Project website, Twitter, Facebook and other social media; and responded to inquiries from the press and public.

Schedule – The approach taken by ETEC also needed to meet the project's stated objectives and included a target schedule. The initial schedule can be broadly described as:

- 2010 – Establish project management organization and relationships with key partners for infrastructure deployment, data collection, analysis, and reporting.
- 2011 – Deploy intelligent PEV charging infrastructure.
- 2012 – Collect data on vehicle and charging infrastructure use, while reporting on initial observations.
- 2013 – Report on information analyzed from collected use data.

The EV Project had not met all of its objectives when ECOtality (i.e., the parent company for ETEC) declared bankruptcy in September 2013. As a result, the project was not totally completed. However, The EV Project did accomplish most of its objectives, including the following:

- Deployed more than 12,500 AC Level 2 charging stations at residential and non-residential locations.
- Deployed 110 dual port DCFC at publicly accessible locations.
- Collected vehicle data from over 124 million miles of vehicle use.
- Collected data from over 4 million charging events.
- Issued more than 150 reports and papers and presented at more than 20 industry events based on data collected and observations made from analyses. (The EV Project lessons learned and reports are available at http://avt.inl.gov/evproject.shtml.)

The EV Project was conducted under extraordinary circumstances and had ambitious goals. Amongst its accomplishments were lessons learned on conducting a project under these circumstances. The following section provides some of the lessons that were often a result of either failure to meet expectations or from extraordinary effort required to overcome unforeseen circumstances or unintended consequences. The hope is that elucidating these lessons will assist others with project aspirations that may be affected by some of these lessons learned, allowing them to be better prepared and, therefore, even more successful.

Lessons Learned

There were many lessons learned by The EV Project team and those who supported the project, including thousands of vehicle owners, hosts, subcontractors, suppliers, and partners.

Working with the Public and Private Enterprise

As discussed above, The EV Project's success was dependent on participation of individual vehicle owners/lessors and business owners. These individuals made their own independent decisions about commitment to a PEV for their own use or commitment of parking spaces (often "close to the entrance" spaces) at their

facility for use by PEV drivers. The approach for enrolling driver/participants and charging site hosts involved offering free equipment and installation credit in exchange for use data from the PEV and provided charging equipment. The following two important lessons were learned from implementation of this approach:

1) Providing free "stuff" and THEN expecting 2 years of commitment to the cause of data collection led to inconsistent support from participants and hosts. In the case of home owners, they had to maintain internet connection to the Blink home charger and, if they were a Leaf driver, they had to press 'accept' on their navigation screen to allow data to be collected on *every* trip. This inconsistent support for data collection led to re-engagement with existing participants and hosts, which diverted EV Project team efforts to expand enrollment and conduct other studies on use.
2) After a Blink charging unit was installed in prime parking places at retail businesses, they were not left for the exclusive use by PEVs. Often, few, if any, vehicles used the stations. Therefore, when a PEV did show up to use the Blink charger, they were often "ICE'd" (i.e., an internal combustion engine vehicle parked in a charging location) and protests to the business owners often went unheeded.

If the enrollment approach had included incentives for full-term participation by PEV drivers, there would likely have been a richer data set and less effort in maintaining participant support (who by and large were very supportive of The EV Project and its efforts to establish a sustainable charging network).

Vehicle Manufacturers are Optimistic

Part of the approach that ETEC took in creating The EV Project was to closely follow the introduction of the two PEVs (i.e., the Nissan Leaf and the Chevrolet Volt). By working closely with OEM sales activities and new car dealerships, The EV Project team hoped to ride the wave of enthusiasm shown by OEMs and the public. The EV Project had a target number of participants for each vehicle clearly identified at the outset of the project; this number was shared with both vehicle OEMs. Those quantities were 5,700 Nissan Leafs and 2,600 Chevrolet Volts.

In early 2010, Nissan introduced the "Leaf Customer Journey," a special online way to introduce the car to interested buyers, who would take the journey from expressed interest to ownership. In early 2010, Nissan reported that it had over 100,000 people expressing interest and 13,000 U.S. preorders for the Leaf in May 2010,[2] a full 6 months before the first deliveries. Meanwhile Chevrolet was making similar claims of selling 10,000 Volts in 2011, followed by projections to sell 45,000 to 60,000 the following year.[3]

Although subsequent PEV sales continue to improve each year, in hindsight, those predictions for vehicle sales made back in 2010 were optimistic. The EV Project team accepted the projections made by their project partners and assumed that the vehicle sales would come. The challenge The EV Project expected was to keep up with the demand to fulfill installation requests.

This of course was not the case; The EV Project team spent much more time and effort soliciting hosts and expanding to new markets. Although the project was extended by one year to help capture more participants and hosts, the additional time and effort required to attract hosts and expand to new markets did not include any additional funding.

Government is a Political Entity and Operates as One

Amongst the partners sought by ETEC in defining its proposal were state and local governments in each of the target markets. Garnering interest from these parties in 2009 was fairly easy and over 20 were identified at the beginning.

In 2009, the country was still in an economic recession and a project to install a significant amount of infrastructure for little or no cost was met with understandable enthusiasm. The opportunity not only offered federal funding for local benefit, but it was for a new class of sustainable personal transportation that would benefit the local economy with jobs and provide the project areas with a step toward the future of sustainable transportation. As a result, many of the state and local governments made commitments to help ETEC meet its cost share commitment, reduce or eliminate "red tape" in permitting processes, and offered other ways to help ETEC meet the project's objectives.

Although many of the local governments did provide support for permitting and other process improvements, a number made changes in their original commitments after the project actually got underway.

Much of this was due to changes in the political makeup of the decision-makers in local and state government. The EV Project was conducted over the course of nearly 4 years, which was through two election cycles (2010 and 2012). The "winds of political change" affected the makeup of government in many of the study areas. ARRA-funded projects also came under more criticism nationally, as did the funding recipients. In many EV Project areas, regional managers had to revisit local government commitments for charge infrastructure, rather than continuing to gather more host locations.

Although state and local governments can be good partners and important allies, the level of support and commitment from local government was under constant threat from other interests.

Being First is Often a Painful Learning Experience

In 2010, ETEC began to set up The EV Project team and its ability to meet the ambitious targets set out in the project proposal. The vehicles were brand new products and first-of-a-kind for each of their manufacturers. In addition, there were many other "firsts" undertaken as part of the project. In some cases, the technology was new, but in many cases, it was the scale of the application that made it first-of-a-kind. The following list provides a brief description of the new technologies, applications, or scale of utilization The EV Project had to manage:

- New charging standard – Society of Automotive Engineers J1772 was adopted in January 2010
- First CHAdeMO-certified DCFC made in the United States
- One of the first UL listings for UL2594 Standard for EVSE
- New Blink charger features to meet project objectives:
    - Video screen to communicate with user (to evaluate impact of messaging and advertising on charger use)
    - Data communication via Ethernet, wi-fi, cellular, and stored on a removable SD card
    - Over-the-air software/firmware updates of over 12,000 distributed devices
    - User authentication with RFID (Radio-frequency identification) card
    - Guest user authentication via internet
    - Revenue grade metering of electricity delivered
    - Machine-to-machine data communications
    - First application of Americans with Disabilities Act to EVSE
- Creation and operation of a network of nationally distributed charging units that accurately collected and transmitted data on use of EVSE
- Development and operation of online integration of EV Project participant enrollment with Leaf Customer Journey
- Permitting of EVSE for the first time in most authorities having jurisdiction
- Charging for charging – first network-wide application of fee-based charging
- Compliance with federal regulations, Davis Bacon Act, and ARRA reporting requirements.

All of the above were unproven technologies, new applications, or were being performed on a greater scale than had been done before. All of this occurred while The EV Project went about its tasks of soliciting vehicle participants and charging site hosts, deploying the charging hardware, and collecting and analyzing data.

The EV Project was very ambitious in creating a study of charging infrastructure deployment and use that needed all of these technologies to work simultaneously, reliably, and in support of each other.

Things Change Over 3 1/2 Years

Infrastructure Installations – As The EV Project team began to assemble what was arguably the most important aspect of the project (i.e., the certified installation contractors), the country was in the midst of a recession. The construction industry was especially hard hit.

Electrical contractors, who installed the charging infrastructure, were frequently the "face" of the project with hosts and participants. They went into people's homes and represented their interests with permitting authorities. They worked with businesses to plan and coordinate construction activities in order to minimize the impact to their businesses.

At the outset of The EV Project, the electrical contractors who had successfully bid to be part of infrastructure deployment in the study market areas were eager to participate in what, for many, was a new industry. This coupled with a protracted downturn in their businesses led many to invest in this new opportunity with additional staff and emphasis.

Years later, the economy began to pick up and business opportunities increased for the electrical contractors. This resulted in many contractors opting out of, or cutting back on their work for the EV Project for more familiar, more profitable, and less bureaucratic projects.

Plug-in Vehicle Sales – In 2010, Nissan and Chevrolet were launching what each had described as "important" vehicles for their future, were aggressively promoting the vehicles, and were receiving a lot of press coverage. They were also bullish regarding expected sales volumes.

By 2013, television advertising had disappeared, sales were a fraction of what was projected, and other PEVs were being introduced, which took a share of the small but growing demand for these vehicles.

Political Climate – In 2009, when ARRA was passed by Congress, many Americans inside and outside "the beltway" were supportive of the federal government's efforts to stimulate the economy. However, with a slower than expected economic recovery, highly publicized failures of stimulus loan recipients, and two election cycles (i.e., 2010 and 2012), support for ARRA projects lessened and, in many cases, disappeared.

Meeting the schedule was dependent on sufficient sales volumes of Leafs and Volts in the target markets and timely installation of charging hardware. Both of these did not meet the original expectations, because vehicle sales fell short of projections made by OEMs and industry experts, and the effort to enlist the support of charging site hosts and coordinate schedules for permitting and utility interface were delayed or, in some cases, cancelled.

Finally, the schedule was affected by the changing economic climate in which the project was executed. At the beginning of the project, hosts were enthusiastic, parts and services suppliers hungry for new and innovative business, and electrical contractors were desperate for business due to the severe hit that construction had taken. However, years later, as the economy showed signs of improvement, many contractors placed greater emphasis on their previous core businesses and their motivation for promoting the Blink EVSE waned.

Conclusions

The EV Project began in late 2009 during a protracted economic recession. It ended 4 years later with data collected from over 124 million miles of PEV operation, 4 million charge events, and bankruptcy of the company that had created and managed the project.

In the end, over 12,000 EVSE units were deployed for use by PEV owners across the country. Data were collected from 20,000 separate entities and delivered to INL from three different sources. INL screened, qualified, and quantified these data before analyzing it for reporting.

The scale of this endeavor was significant because at the outset of the project, the vehicles were not yet available, charging infrastructure capable of collecting all use data did not exist, and, in order to maximize the benefit of the data being collected, the project included 17 metropolitan areas in 10 states from the Pacific to the Atlantic Oceans.

The EV Project was a PEV charging infrastructure deployment and study that was conducted under once-in-a-lifetime circumstances. It occurred at the outset of the first ever volume production of electric vehicles, was in the midst of a global recession, was funded by an extraordinary U.S. federal program to stimulate the economy, and used unproven distributed data collection and communication methods.

Despite these circumstances, the project accomplished most of its objectives, including teaching participants lessons about working with the public; private enterprise; local, state, and federal government; and vehicle manufacturers and implementing new technologies in a changing political environment in clear view of the public.

About The EV Project

The EV Project was the largest PEV infrastructure demonstration project in the world, equally funded by DOE through the American Recovery and Reinvestment Act and private sector partners. The EV Project deployed over 12,000 AC Level 2 charging stations for residential and commercial use and over 100 dual-port DCFCs in 17 U.S. regions. Approximately 8,300 Nissan LEAFs™, Chevrolet Volts, and Smart ForTwo Electric Drive vehicles were enrolled in the project.

Project participants gave written consent for EV Project researchers to collect and analyze data from their vehicles and/or charging units. Data collected from the vehicles and charging infrastructure represented almost 125 million miles of driving and 4 million charging events. The data collection phase of The EV Project ran from January 1, 2011, through December 31, 2013. INL is responsible for analyzing the data and publishing summary reports, technical papers, and lessons learned on vehicle and charging unit use.

Company Profile

INL is one of DOE's 10 multi-program national laboratories. The laboratory performs work in each of DOE's strategic goal areas: energy, national security, science, and the environment. INL is the nation's leading center for nuclear energy research and development. Day-to-day management and operation of the laboratory is the responsibility of Battelle Energy Alliance.

For more information, visit avt.inl.gov/evproject.shtml and avt.inl.gov/chargepoint.shtml.

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