An M&V Strategy for Evaluating Level 2 Electric Vehicle Chargers

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ABSTRACT

As the market for electric vehicles (EVs) grows, M&V contractors will need to develop methods for evaluating increasingly novel incentive programs targeting customers with personal EVs, EV fleets, and EV charging stations. This paper proposes a method for calculating the savings realized through programs that incentivize the purchase and installation of Level 2 EV chargers as opposed to Level 1 chargers.

Though uniquely applied, the method presented mirrors the methodological approach used for other common energy efficient measures – such as energy efficient air conditioners – which relies on the difference between the base and efficient rating reciprocals. For our M&V purposes, we rely on research completed by *Efficiency Vermont* that reports the efficiency gain for Level 2 chargers compared to Level 1 devices depending on ambient temperature and charge duration. Additional variables that can be tailored to specific customer bases include vehicle miles traveled annually and average kWh per 100 miles of EVs available in the local market. Overall, this presentation aims to provide guidance on developing M&V techniques for the growing EV market and includes both gross and net savings calculation methodologies.

Introduction

Electric Vehicles are becoming more and more popular. Globally, sales of electric vehicles in 2010 were 17,000. In 2019, they grew to 7,200,000 (IEA 2020). The market for electric vehicles, and by extension the need for electric vehicle chargers (EVCs), is projected to continue growing over the next several years. But when it comes to energy efficiency, not all EVCs are created equal.

Level 1 chargers use a 120V AC connection and are typically plugged into a standard wall outlet. Level 2 chargers require a 208V - 240V AC connection and supply more power to the vehicles charging system, but typically require some installation. The AC power is sent to the vehicle's internal charger and then converted to DC for storage in the vehicle's battery. As a result, Level 2 chargers provide the same amount of charge in less time.

Note that most electric vehicles come with a Level 1 charger, and it is up to the owner to purchase a Level 2 charger (ENERGY STAR). The price of level 2 EVCs can vary greatly, but on average cost over $350 for the charger and $1,200 for installation (though installation costs vary greatly by region) (INL 2015). The high cost of these devices makes financial assistance such as downstream rebates a powerful incentive for individuals looking for a better charger.

Not only do Level 2 chargers charge faster, but they have also been found to be more energy efficient than level 1 chargers. Past research suggests that Level 2 EVCs are anywhere from 2.3% to 12.8% more efficient than Level 1 EVCs (Forward 2013). The difference in efficiency varies greatly depending on charge duration, the amount of energy needed for a charge, and the ambient temperature where the charge is taking place. This research suggests that the difference in efficiency percentages is larger when charges are shorter in duration and when ambient temperature is either less than 53°F or more than 70°F (Forward 2013, Sears 2014). This means there is a potential for energy savings among all customers that purchase EVs through providing customers with programs that incentivize the purchase and installation of these Level 2 chargers.

From 2019 to 2021 ADM has been responsible for evaluating a downstream incentive program for Level 2 EVCs. This program allows any customer in the service territory to receive a rebate for the purchase of a Level 2 EVC. This program is targeted specifically at residential customers planning on installing the Level 2 EVC in their home; no commercial customers or EVCs meant for public charging areas have been included. This paper details how we developed a methodology for evaluating savings in this program and defines the methodology we created.

Methodology

Using the information about the participating population as well as research completed by *Efficiency Vermont* about the efficiency differences between Level 1 and Level 2 EVCs (Forward 2013); we developed the following methodology for calculating EVC Level 2 energy savings.

$$EVC\ kWh\ savings = VMT * \ KPM * \left(\frac{1}{EER_{base}} - \frac{1}{EER_{efficient}}\right) + ESG$$

Where VMT is the average annual vehicle miles traveled per year for the given program population; KPM is the average KPM (kWh/100 miles) of electric vehicles currently on the market; EER_{base} is the energy efficiency rating of the base technology (Level 1 EVC); $EER_{efficient}$ is the energy efficiency rating of the efficient technology (Level 2 EVC); and ESG is the efficiency gain of an ENERGY STAR certified Level 2 EVC.

The following sections discuss how the value of each variable in the above equation were found, and how those values were determined.

Average Annual Miles Traveled by Car

Information published online by the U.S. Department of Transportation's Federal Highway Administration provides estimates of a variety of highway statistical data from all 50 states (U.S. Department of Transportation 2018). The tabulations provided through this resource were reported by each state through the Highway Performance Monitoring System. For the purposes of this analysis, the value for average annual miles traveled by car was pulled directly from the reported "annual miles per vehicle" for the state in which the program was being administered. However, additional considerations based on urban versus rural drive patterns of the utility's customer base may be advantageous. To this end, we have implemented an annual survey in which participating customers are asked to self-report on the typical number of miles they drive in their EV on week and weekend days to corroborate the assumed milage. Though program participation, and therefore survey sample sizes, have been low, to date survey-reported estimates fall within 500 miles of the assumed annual distance driven.

Average kWh per Mile

The development of this value was based on several distinct data resources. Electric vehicle sales data from the entire United States spanning 2011 through early 2019 collected by the U.S. Department of Energy serves as a readily available primary resource that could be refined for utilities across the country (U.S. Department of Energy 2020). We then corroborated the national sales data by gathering regional information on the electric vehicles for sale in the utility's service area from publicly available from websites such as CarMax.com as well as phone calls to local car dealerships. Based on the Make, Model, and year of EVs we determined available for sale in the area, we compiled a weighted average of kWh/100 miles per the advertised fuel efficiency of the specific vehicles.

Efficiency Multiplier

The efficiency multiplier was calculated using a methodology for converting energy efficiency rating of other technologies.

$$\frac{1}{EER_{base}} - \frac{1}{EER_{efficienct}}$$

Where EER_{base} is the average Level 1 EVC efficiency percentage, and $EER_{efficienct}$ is the average EVC Level 2 charger efficiency percentage. Note that in this context, efficiency percentage refers to the amount of power used by an EVC during a charge that ends up stored in the EVs internal battery. We referred to research done by *Efficiency Vermont* to find these efficiency percentage values. This study utilized data collected from loggers connected directly into the internal diagnostic computer of 17 EVs, over the course of over 1,000 charging sessions. The study found that, on average, the efficiency percentage for Level 1 EVCs was 83.7% and the efficiency percentage for Level 2 EVCs was 86.4% (Forward 2013).

As this and other research has suggested, however, these values differ greatly depending on the amount of energy used for the charge as well as the ambient temperature at the location of the charge (Forward 2013, Sears 2014). Given more information about where and when most participants charge their EVs as well as how often they do so, it may be possible to choose values for these efficiency percentages that better fit the participant population.

ENERGY STAR Efficiency Gain

Additional savings can be applied to EVC chargers that are EnergyStar certified. ENERGY STAR certified electric vehicle chargers pull less electricity when the charger is in standby mode. These chargers spend a majority of time in standby mode, so having a charger with a more efficient standby mode leads to additional annual savings. The average ENERGY STAR certified Level 2 charger in the U.S. saves an average of 56 kWh a year compared to non-certified models (EPA 2013, 12). Note that this value should only be applied if the Level 2 charger being incentivized is an ENERGY STAR certified model. For models that are not ENERGY STAR certified, the value of the ENERGY STAR efficiency gain should be 0.

Determining Free Ridership

Though the approach described above encompasses our methodology for determining gross savings for incentivized Level 2 EVCs, additional steps to assess the rate of free ridership (FR) must be taken in order to reach a net energy savings value using a program-specific net-to-gross (NTG) ratio, defined here as 1 – FR. In the case of Level 2 EVCs, free riders are defined as customers who would have purchased and installed Level 2 EVCs in the absence of a program incentive. The rate of free ridership is therefore the portion of program savings that can be attributed to free rider participation.

Each program year, surveys are sent to all program participants to support accurate estimation of how participants' choices and interactions with the program could be shifting in the rapidly developing EV market. Additionally, since participation has been low in the first years of the program, free ridership scores based on survey data from only a couple of respondents are likely not quite representative of the larger market and therefore collecting additional data annually is vital. The question design of the survey aims to evaluate customers' financial ability to purchase/install a Level 2 EVC in the absence of program incentives, their plans to invest in a Level 2 EVC prior to learning of the program incentive, and the likelihood that they would have used a Level 2 EVC if there was not a utility-sponsored program. Additionally, several questions are included to appraise how knowledge of the program may have impacted the timing of participants' purchase of their Level 2 EVC. From the survey responses, three induvial metrics were calculated and used to quantify free ridership following the equation below.

$$FR = \frac{Plans\ Score + Behavior\ without\ Discount\ Score}{2} \times Timing\ Score$$

Screening for Financial Ability

All survey participants were screened with a simple yes/no question at the beginning of the FR question bank to confirm whether they would have been able to make the financial investment to purchase and install the Level 2 EVC if the rebate was not offered. Any customer that indicated that they would not have been able to afford a Level 2 EVC without the financial support of the program was automatically assigned a free ridership score of 0. All other customers were asked a variety of questions to determine a plans score, behavior without discount score, and timing score.

Plans Score

The presence of a participant's plans prior to involvement with the program was assessed by asking the yes/no question: *Before learning about the rebate, did you have plans to install the Level 2 electric vehicle charger?* Respondents who answered "Yes" were assigned a plans score of 1. All other respondents were assigned a plans score of 0.

Behavior without Discount Score

The behavior without discount score was based on respondents' stated likelihood of purchasing and installing a Level 2 EVC in the absence of the program. The survey tool invited participants to rate their likelihood of purchasing the Level 2 EVC if the rebate had not been available on a scale of 1 (not at all likely) to 5 (very likely). Responses were assigned the following point values:

- 1 (Not at all likely) = 0
- 2 (Somewhat unlikely) = .25
- 3 (Neither likely nor unlikely) = .5
- 4 (Somewhat likely) = .75
- 5 (Very likely) = 1

Timing Score

The program effect on the timing of when the participants went forward with the Level 2 EVC charger is assessed with a series of two questions:

- *Did you install the Level 2 electric vehicle charger sooner than you would have if the rebate had not been available?* (Yes/No)
- *When might you have installed the same the Level 2 electric vehicle charger if you had not participated in the rebate program?* (Response options include: Within 6 months; Between 6 months and 1 year; In more than 1 year; Never).

If the respondent states that they did not install the measure sooner because of the program, they were not shown the second question and their free ridership score is not adjusted, since the program had no impact on the timing of their purchase. If the respondent answered “Yes” to the first question (they did install the Level 2 EVC sooner because of the program), they were asked the second question and their responses are used to modify their free ridership score. If they would have installed the Level 2 EVC within 6 months of when it was installed, they are assigned a timing score of 0.5; within 6 months to one year, they receive a timing score of 0.25; and if they select more than one year, the timing score was set to 0. Note that if the timing score is zero, the respondents’ resulting free ridership score is also zero (indicating that they are not a free rider).

Conclusion

As the market for electric vehicles (EVs) grows, there is a potential to generate energy efficiency savings by promoting the purchase and installation of Level 2 EVCs. M&V contractors will need to be ready with a strategy for evaluating incentive programs targeting customers with personal EVs, EV fleets, and EV charging stations. The methodology presented in this report provides an example for how savings can be estimated for incentivized residential Level 2 EVCs. Also note that while this methodology is focused on evaluating residential Level 2 EVCs, the potential for savings also exists for EVCs at commercial buildings as well as EVCs used in public charging stations. As the market expands to include additional EV manufacturers and the number of EVs increases, however, it will be advantageous for the entire M&V community to update research on charging methods, habits, and technologies.

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