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SmartCharge Rewards™: Encouraging better charging behavior with price signals to shift demand to off-peak times

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Summary

SmartCharge Rewards is an electric vehicle (EV) charging initiative developed and managed by FleetCarma in partnership with different electric utilities across the globe. The program enables electric utilities to shift EV charging behavior to from on-peak to off-peak hours by promoting the behavioral change of EV owners through various methods such as rewards and gamification. This paper will outline the smart charging programs that are currently deployed across the globe and interpret the findings from a small sample of data. It will also identify and describe the key findings from the largest program initiative to date, SmartCharge New York in collaboration with Consolidated Edison in New York City.

Keywords: Smart charging, behavior, load management, electric utility, peak load

1 Introduction

SmartCharge Rewards, a platform developed and managed by FleetCarma seeks to provide electric utilities with the ability to shift electric vehicle (EV) charging within the utility service territory from on-peak hours to off-peak hours. This platform utilizes a combination of sophisticated hardware and cloud software technology that enables FleetCarma to collect and report charging profiles from EVs. This technology allows the deployment of a seamless program to the utility's residential customers.

In North America, there are five active smart charging initiatives that utilize FleetCarma's technology. The objective of these programs is either to understand EV charging profile, or to shift charging to off-peak times. These programs are:

SmartCharge Rewards

- SmartCharge New York, in collaboration with Consolidated Edison (ConEd) Company of New York,
- SmartCharge Nashville, with Tennessee Valley Authority of Tennessee, and
- Duke Energy Charge FL, with Duke Energy in Florida.

EV Charging Profile

- ChargeTheNorth, with Natural Resources Canada, and
- LES EV Study, with Lincoln Electric Systems in Nebraska.

Currently, there is also an initiative in Europe with Samorka – an association of energy and utility companies in Iceland to assist in the study of EV charging profile.

The demand to understand EV charging profile and shift charging to off-peak times is rapidly increasing, and FleetCarma expects that this trend will continue to grow exponentially with the increasing adoption of EVs across the globe.

This paper will focus on analyzing different smart charging programs that FleetCarma has deployed across North America, interpreting sample data to show impacts of different electricity rates, and analyzing the key findings from the largest smart charging program currently running, SmartCharge New York.

2 SmartCharge Rewards

This section will outline each of the six programs mentioned in section 1. In general, it should be understood that utilities provide an incentive to the participants in SmartCharge Rewards to achieve the following:

- Shift EV charging from on-peak time to off-peak time in order to:
  - avoid grid constraints resulting from EV charging during system peak,
  - mitigate secondary peak resulting from time-of-use (TOU) rate kick-in,
  - flattening of the load curve in order to minimize system load variance,
  - avoid potential transformer overload at the neighborhood level, and
  - reduce monetary loss resulting from the sale of excess electricity during super off-peak time.
- Engage more with customers in order to:
  - collect rich insights on EV driver charging behavior,
  - identify EV adoption rate growth within the service territory,
  - utilize data for future system planning, and
  - build utility brand awareness amongst EV drivers.

2.1 SmartCharge New York

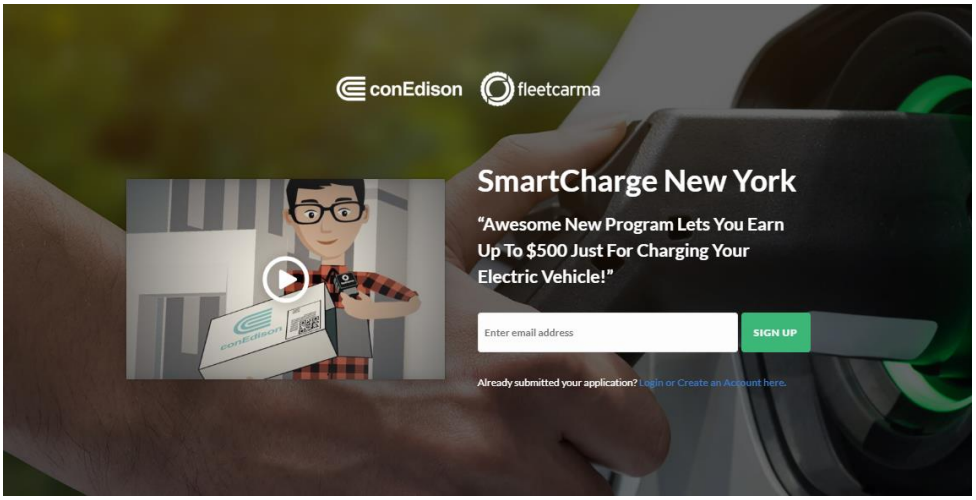

Figure 1: SmartCharge New York sign-up page

SmartCharge New York (Fig. 1) is a program run in collaboration with Consolidated Edison (ConEd) to incentivize EV owners in the service territory to charge at off-peak times. In this program, participants can earn points that can be redeemed in online gift cards. On top of the rewards earning potential, each participant receives a FleetCarma dashboard that enables them to check and redeem their rewards, as well as check their driving efficiency, energy consumption, and greenhouse gas (GHG) savings. Participants also have access to the vehicle battery state-of-health (SOH) information, which provides them insights into the battery wear and degradation statistics.

2.2 SmartCharge Nashville

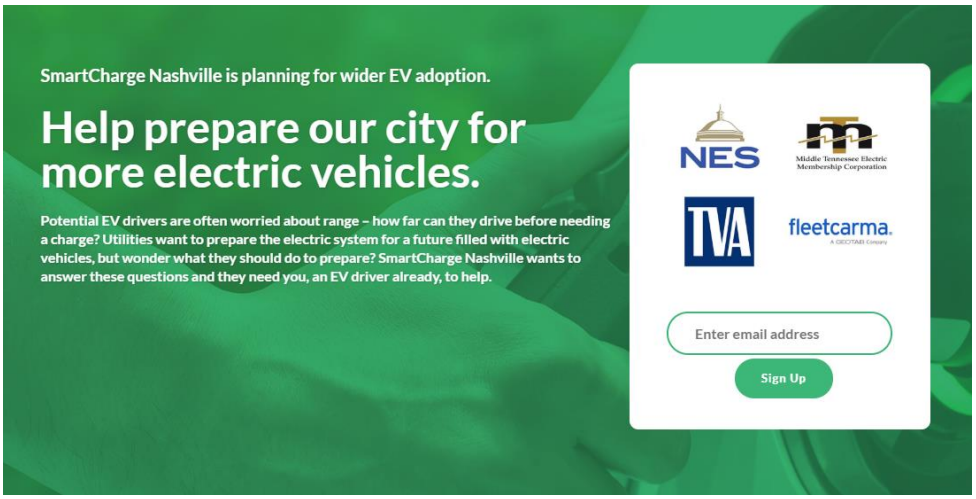

Figure 2: SmartCharge Nashville sign-up page

SmartCharge Nashville is a program in collaboration with Tennessee Valley Authority (TVA), Nashville Electric Service (NES), and Middle Tennessee Electric Membership Corporation (MTEMC). This program is designed to help the above utilities prepare for a rapid adoption of EVs, to better help with system planning and preparation. Similar to SmartCharge New York, the participants have full access to the FleetCarma dashboard, allowing them to track various data points and battery SOH. In SmartCharge Nashville, participants have no restrictions on how they charge, although there is a flat rewards component included in the program. Upon installation and activation, participants will receive $50 on the sixth month of participation, and $50 every year onwards.

2.3 Duke Energy Charge FL

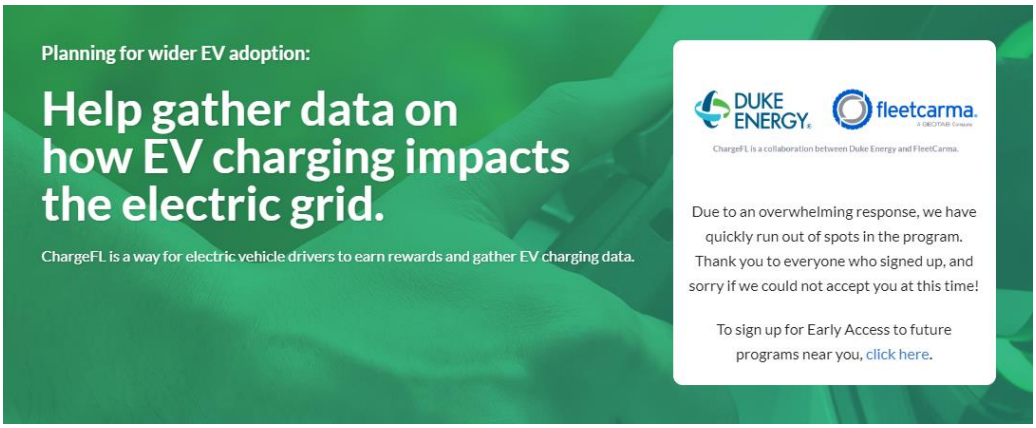

Figure 3: ChargeFL sign-up page

ChargeFL, in partnership with Duke Energy in Florida is a SmartCharge Rewards program designed to understand EV charging profile and provide incentives. This program is designed to maximize the benefit of FleetCarma platform by collecting baseline data to conduct a variety of analyses in the first year. This data will be utilized to create an incentivization scheme for second phase of the program as well. The participants of ChargeFL also receive access to FleetCarma's dashboard, which allows them to collect, download, and analyze a variety of data, as well as their vehicle battery SOH.

3 Meta-analysis of Electric Vehicle Charging Profiles

This section will analyze and interpret a small sample of data collected from FleetCarma's EV initiatives. This data is categorized into one of the following options: EV charging rewards, whole house TOU rate, and flat Kilowatt hour (kWh) pricing. These three categories represent the majority of electricity rates pertaining to residential customers and EV owners across North America.

For this section, FleetCarma analyzed real-world charging data from 650 battery electric vehicles over a period of 4 weeks. This data set contained more than 13,000 charging events that account for a total of over 120MWh of energy.

The analysis showed that EV owners in flat kWh rate areas showed grouping of charging events as drivers had no incentive to change their charging behavior. EV owners in areas with whole household TOU showed less EV charging load throughout the day, but caused an unintentional spike with charging when the off-peak rates began. Lastly, EV owners in areas with charging rewards showed the largest shift of charging to off-peak times, while demonstrating high predictability of charging load.

3.1 Flat Kilowatt Hour Rate

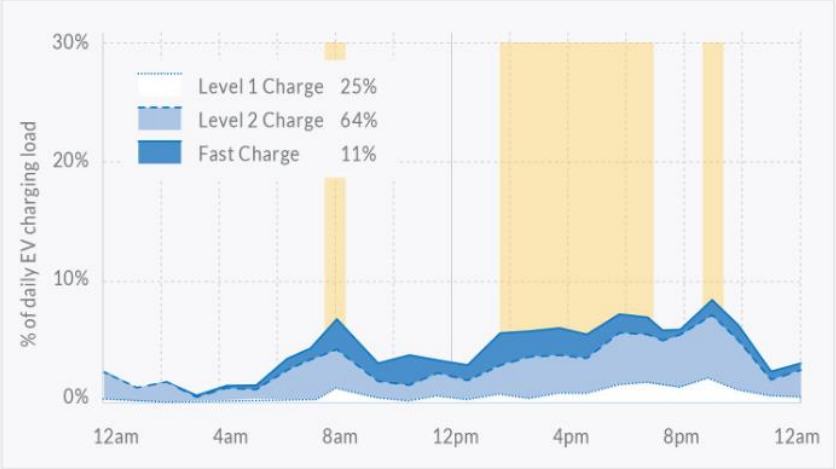

Figure 4: EV charging profile with flat price kWh structure

The above (Fig. 4) shows the charging profile of vehicles that are owned by households that have no specific EV charging incentive or a household TOU rate. The load curve looks extremely unpredictable, with charging peak shown in three different times during the day. The two prevalent peaks in Fig. 4 is 8 am when people arrive to work and plug-in their vehicles, and 9 pm where people return from their evening activities. There is also consistent charging during the day between 1 – 3 pm. This type of charging profile has significant risks, with the possibility of EV charging coinciding with other system loads such as air conditioning, and no way to curtail EV charging.

3.2 Whole Household Time-of-Use Rate

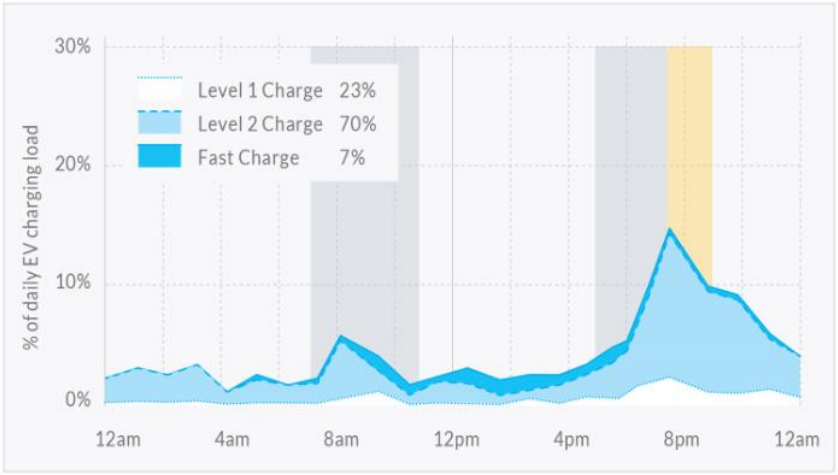

Figure 5: EV charging profile with whole household TOU rate

The figure above (Fig. 5) shows EV charging profile from vehicles that are owned by households with a whole household TOU rate. Generally speaking, these household rates have cheaper kWh prices during off-peak times, which is usually any time between 7 pm to 7am depending on the service territory. As shown in Fig. 5, it is obvious that EV owners like to begin their charging when the TOU rate begins. This can be attributed to the potential savings in energy prices by shifting charging to cheaper times. Although whole household TOU rates have been successful at shifting general electricity use to off-peak times, it creates a secondary peak with household appliances, air conditioning, and EV charging all starting at the same hour.

3.3 Electric Vehicle Charging Rewards

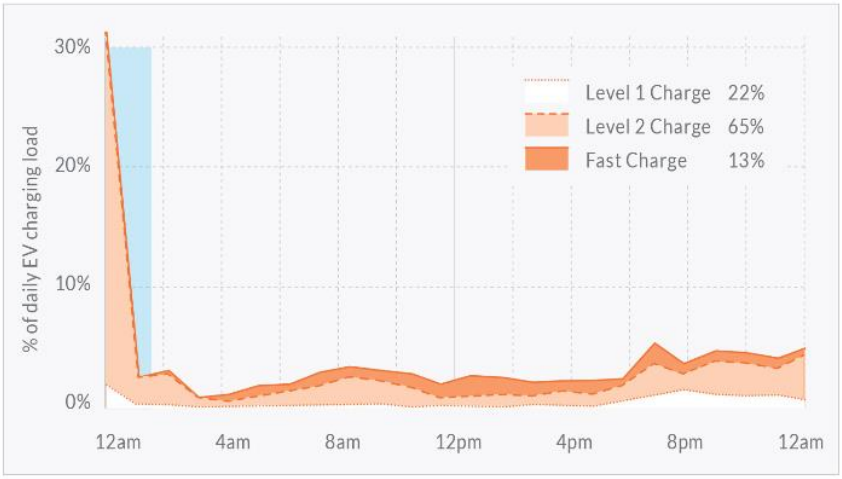

Figure 6: EV charging profile with charging rewards

Fig. 6 illustrates EV charging profile with an incentive that encourages behavioral change. In this rate structure, EV owners are encouraged to charge at times that do not coincide with any peak hours. As shown in Fig. 6, it is clear that EV owners take full advantage of any rewards that may be provided to them by simply shifting their charging hours. A clear shift of EV charging to super off-peak times also act as a valley filling tool for the utility, which maximizes the cost effectiveness of providing rewards for EV owners.

4 SmartCharge New York: Insights from First of its Kind EV Program

SmartCharge New York is the largest consumer facing EV load management initiative in North America. As shown in Section 4.1, participants can receive significant amount of rewards by simply changing their

charging behavior. It aims to shift and spread the increased electric demand from EVs to super off-peak times, ensuring the electric grid is unaffected by EV charging.

4.1 Rewards Structure

The participants can earn below rewards by joining the SmartCharge New York program:

- earn 150,000 points ($150) after installation and activation,
- $0.10 per kWh of charging done between midnight to 8 am,
- avoid charging entirely during summer peak (2 – 6pm between June – September) and earn $20 per month,
- refer a friend to participate and earn $25 once they enrol, and
- up to $650 in rewards the first year, and up to $500 starting the second year.

4.2 Technology

The technology application in this program is a combination of hardware and cloud software solution. Participants receive a FleetCarma C2 device upon acceptance to the program, which is a simple plug-and-play, self-install solution. The device automatically configures all necessary settings once powered, and the participant can start earning rewards.

All the data is transmitted through a secure cellular data connection and reported to the cloud storage. FleetCarma's software calculates all necessary parameters to ensure the participant receives accurate number of points for their change of charging behavior.

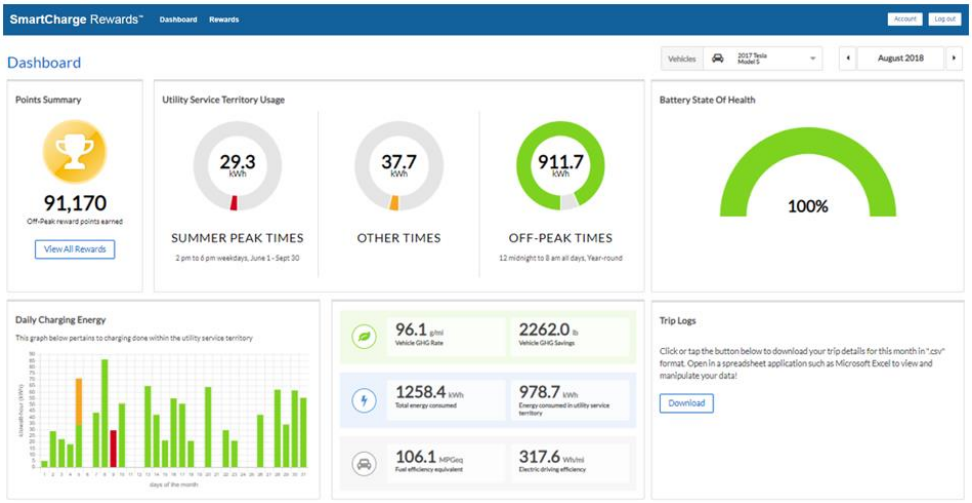

Figure 7: Participant dashboard

Participants also receive access to the dashboard (Fig. 7) allowing them to track their charging behavior, rewards, driving efficiency, and vehicle battery SOH.

4.3 Drive and Charge Data

ConEd was able to gain some interesting insights from participants on vehicle usage patterns. The average vehicle drove 1.5 hours a day and travelled 12,800 miles a year. Each vehicle on average charged 2.3 hours per day for a total of 144 kWh per month. ConEd also identified that DC fast charging stations were utilized 15% of the total charging events.

It is also interesting to note that plug-in hybrid vehicle (PHEV) owners utilized the electric motor propulsion 63% of the time, proving that PHEV owners do in fact utilize the electric motor and battery significantly more than the gasoline engine.

4.4 Shaping Electric Vehicle Charging Load

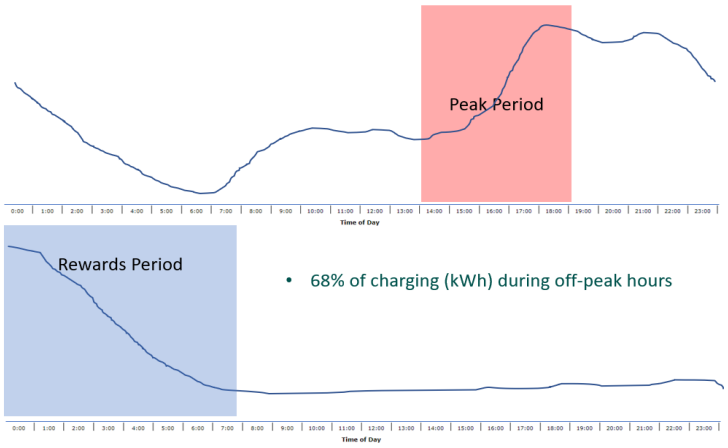

Figure 8: EV load shape in ConEd service territory

Shown in fig. 8, the upper chart shows aggregated EV load without SmartCharge Rewards in ConEd service territory. As highlighted, EV charging load increases during ConEd's peak hours making the matters worse for the utility. This can be attributed to EV owners arriving at home after work and plugging in their vehicle.

The bottom chart shows aggregated EV load with SmartCharge Rewards. It can be seen that the EV owners have shifted their charging from 2 – 6pm to midnight – 6am. By providing rewards through an engaging platform, customers have significantly shifted their charging behavior, with 68% of the charging now being done during off-peak hours.

5 Conclusion

5.1 Conclusion on Meta-analysis of Electric Vehicle Charging Profiles

It should be noted that meta-analyses of EV data in section 3 does not provide conclusive results and that it is not a representation of EV charging profiles across North America or the globe. The aggregate data used in this analysis is only a small sample of a large dataset and may not be statistically significant or representative to draw conclusions from. It should be understood that section 3 was only illustrated to demonstrate typical profiles we expect to see based on different rate structures.

In order to conduct a detailed analysis specific to a utility service territory, the data must be produced from the specific territory itself, rather than from different areas. Also, further considerations must be made in regards to increasing vehicle battery sizes, as well as medium and heavy duty EVs as it will drastically increase the potential impact of EVs on the electric grid.

5.2 Conclusion on SmartCharge Rewards Programs

SmartCharge Rewards programs have revealed that rewards can be a highly effective solution to shift EV charging to off-peak times. The drastic change in fig. 8 suggests that incentivization schemes have a much higher impact and better results versus the traditional TOU rates which tend to create a secondary peak. SmartCharge Rewards have also been proven to be a more compelling method to engage EV drivers through components such as the customer dashboard, vehicle statistics, and gamification.

For SmartCharge Rewards program to be more effective in different utility landscapes, the utility must consider the importance of collecting sufficient baseline data that is territory specific, as well as a program design that will be the most effective on shifting charging to off-peak times.

Authors

Eric Mallia is the General Manager of FleetCarma and a published author on energy management and transportation of electrification topics in the International Journal of Life Cycle Assessments, Municipal World Magazine, and National Post. His work and research, in partnership with more than 300 organizations, has focused on the implementation of energy efficiency programs in the transportation and electricity sector. Eric holds a Master's degree in Environmental Studies from the University of Waterloo and a Bachelor's degree in Business Administration from Wilfrid Laurier University.

Eric Schmidt is the Marketing Manager of EV Ecosystems at FleetCarma, a division of Geotab. He has over 10 years of experience helping Canadian technology companies tell their stories to the world. His work in marketing, design, communications, public relations, print, video, advertising, data analysis, and research has helped increase the awareness of FleetCarmas unique set of products and services. Prior to becoming interested in business, technology, and new energy Eric graduated with Honors in Graphic Design and Advertising from George Brown College.

Matt Stevens is Vice President of Electric Vehicles at Geotab. He has been working on hybrid and electric vehicles for 15 years, ranging from cars to lunar rovers to stealth snowmobile and now helps fleet managers successfully electrify their fleet and utilities integrate electric vehicles into the smart grid. He is a Board member and past Chair of Electric Mobility Canada, is a member of the CANC/IEC Council, and is Canada's representative on the IEC ahG81 working group focused on electric vehicle and infrastructure standards. Matt holds a Ph.D. from the University of Waterloo, with a focus on electric powertrain design and battery degradation.

Mike Shin is the Partner Account Specialist at FleetCarma. He works actively with electric utilities to identify ways to better utilize electric vehicle data and shift charging behaviour. His experience includes administering energy efficiency pilot programs and helping deliver energy efficiency proposals in the utility sector. Mike is also a graduate of the University of Waterloo and holds a bachelor's degree in Environmental Studies, specializing in business and sustainability.