Electric Vehicle Load Assessment and Grid Impact Study for Distribution System Planning

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Abstract

Electric Vehicles (EV) adoption could stress distribution system beyond their capacity limits. Where and how these EV's are going to charge challenges existing distribution system planning approaches and complicates efforts to assess grid impacts. Anticipated location, timing, and demand for EV charging is critical information for distribution system planners as it guides capital projects for infrastructure upgrades to ensure continued reliability.
The poster is focused on existing data-driven methodologies to assess grid impacts from EV data collected from different sources and what to do with it. We tried to provide insight and demonstrate existing data driven technology on EV adoption, propensity and range model. Finally, we chalk out the efforts on what Eversource Energy from New England is doing with the EV load assessment for its 4 millions+ customers across three different states- MA, CT and NH.

Introduction

The transition to electric vehicles is anticipated to continue to increase and incentives for the purchase of EVs will further accelerate this transition. EV incentives have multiple benefits including lowering the cost of EVs, which allow more consumers to afford EVs and signal increased production to manufacturers. Additionally, incentives drive demand for charging infrastructure which in turn promotes EV adoption. The majority of residential EV charging typically happens at home where vehicles are parked overnight. To support mass adoption of EVs, including by people who cannot charge at home or at work, significant investments in public charging infrastructure and workplace charging infrastructure will be required. Publicly available and workplace EV charging will enable more drivers to switch to EVs by providing convenient access to charging stations and promote equitable access to EV ownership by making it possible for people without access to home charging to have an EV. Availability of DC fast chargers on travel corridors is also a significant consideration in promoting the transition to EVs. Although on average a vehicle is driven less than 30 miles per day, many consumers cite range anxiety as a barrier to EV adoption. The electrification of commercial fleet vehicles will be a significant driver of anticipated load growth. Large-scale fleet electrification will result in hyper-local grid impacts that may require fleet charging optimization to reduce peak demand and infrastructure costs.

As customers overcome negative perceptions regarding the limitations of Electric Vehicles (EV's), including range anxiety (travel distance), long charging time, limited charging infrastructure and relatively higher purchase prices, the cumulative number of EV's in operation will continue to increase. In addition to cost and convenience, electricity consumers now also consider impacts to climate change and decarbonization when deciding whether to buy electric vehicles. EV commercial and residential charging will generate significant load growth and will impact reliability considerations. In order to support this increased load from EVs the electric industry will need to proactively plan and make substantial investments to EV-supporting infrastructure, including generating capacity, transmission and distribution capability, smart grid technologies and readily accessible charging stations. EV charging will need to be implemented in ways that promote a reliable and resilient electric grid.

Existing Methods

There are currently different data-driven approaches to model the EV adoption and grid impact, but most approaches are either top-down or bottom up. Top-down approaches are popular because it adheres to the state regulations and policy forecast that utilities are bound to follow. There are two models widely available that describes their methodology. Brattle group developed an EV adoption and load impact model for ERCOT [1]. The granularity level in this study is zip code. Blast point developed another model on EV adoption outlook [2]. Bottom-up approaches are still in research phase but gaining attractions from researchers in academia. For example, Pacific Northwest National Laboratory (PNNL) developed a bottom-up approach [3] using Bass and binary logit model. Idaho National Laboratory (INL) has developed an EV modeling platform called Caldera [4].
Different consultancy companies have also developed their proprietary tools for EV forecasting and grid impact studies. For example, Quanta Technologies has their own platform LEAF ETM [5]. Other companies are also developing tools.

Eversource EV Load Model

Eversource has taken a top-down approach for EV adoption model. For example, Massachusetts has a decarbonization road-map for going 100% electric in transportation by 2050. This simplifies long-range EV forecasting. To model the EV load impact on our bulk sub stations, mobility data has been purchased and analyzed. This mobility data is different from vehicle on-board telematics data. The dataset contains number of light, medium and heavy-duty vehicles arrival by zip code every 15-minutes. It also contains distance driven to reach a zip code. Using an 'arrive-and-charge' assumption, we modeled the load profile for our bulk substations. This method is also expanded to model zip code level load profile modeling. Fig. 1 and Fig. 2 show the arrival profile and charging profile for the city of Cambridge with a 95% confidence interval for types of day variation i.e., weekday/weekend in 2050. Furthermore, seasonal peak load and time were also analyzed.

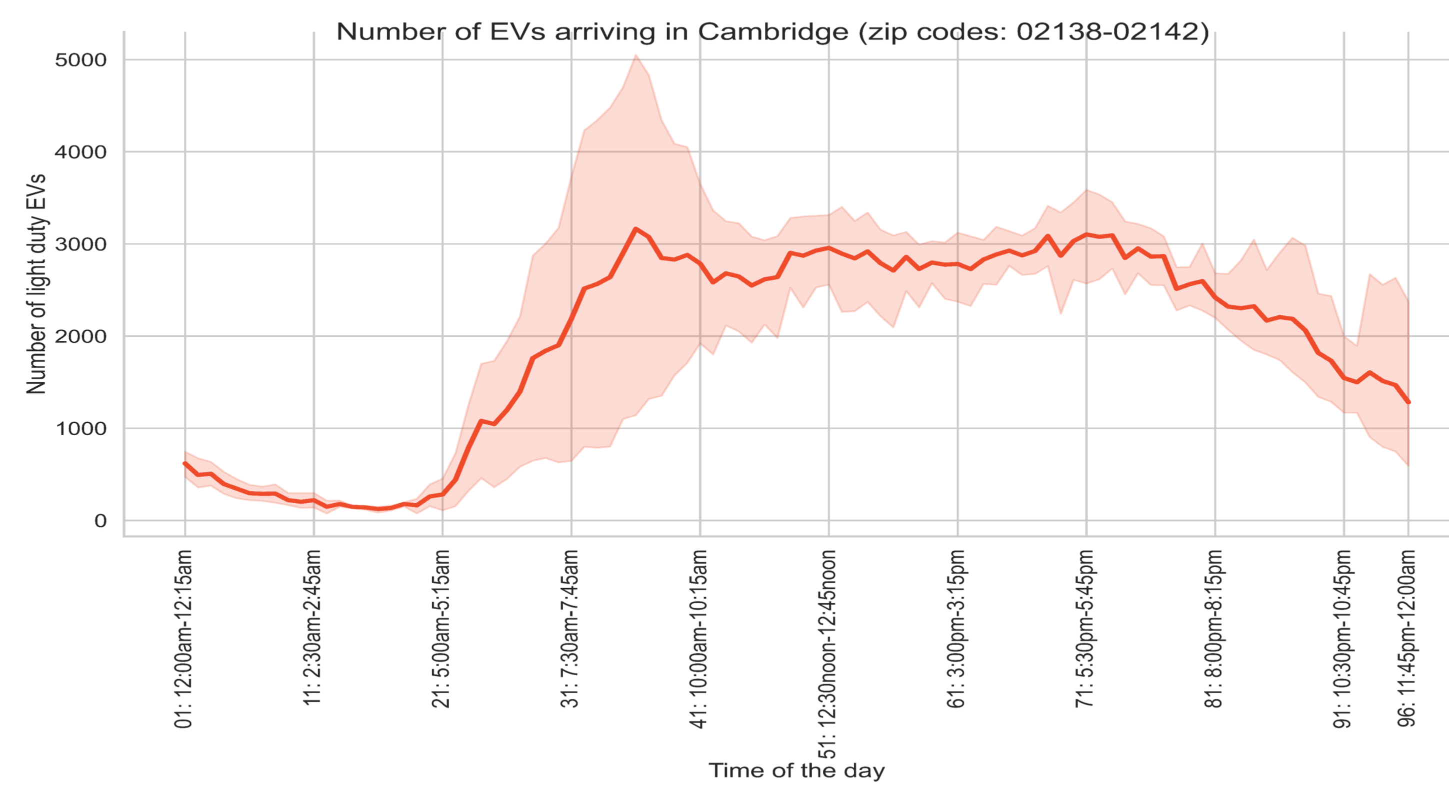

Figure. 1. Arrival Profile in Cambridge.

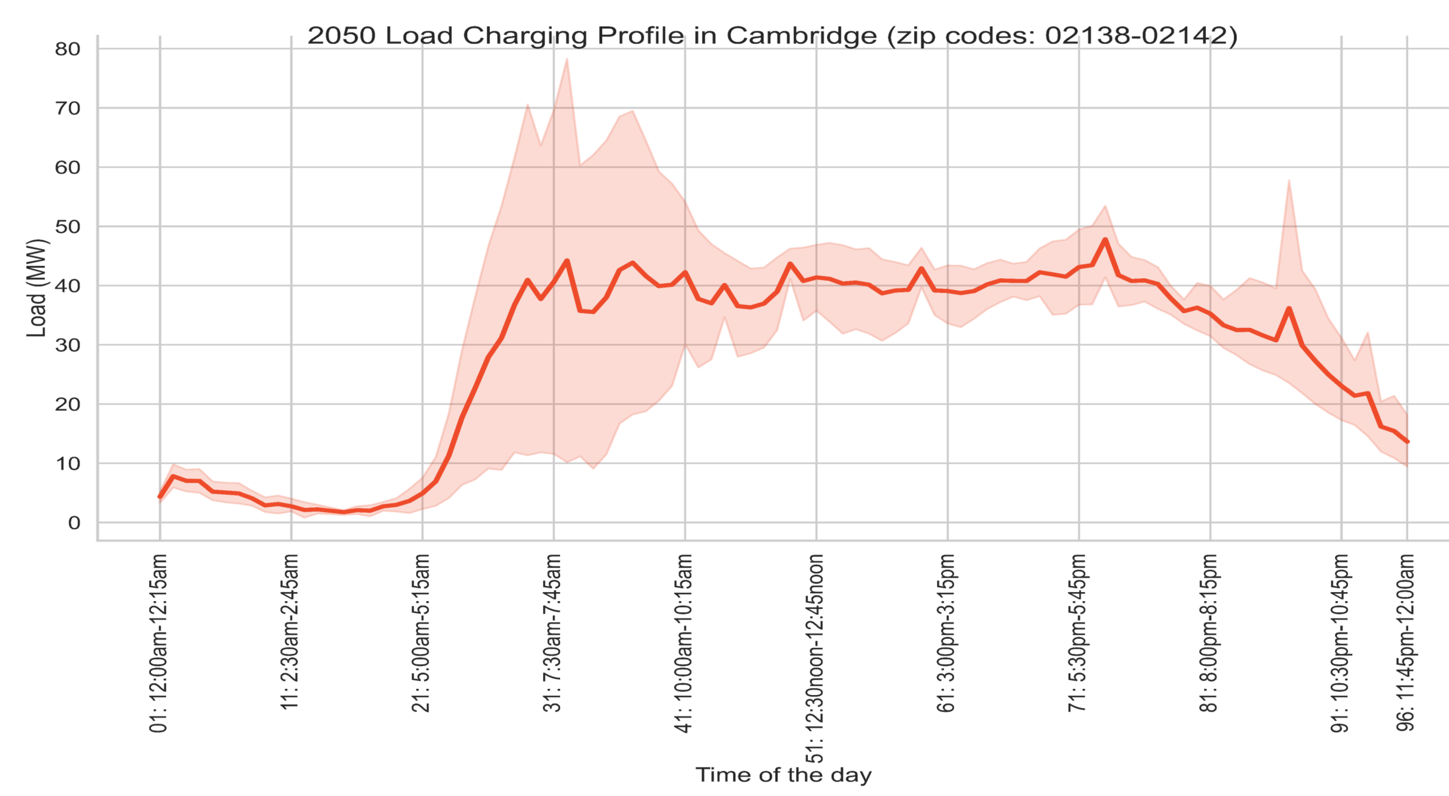

Figure. 2. Charging Profile in Cambridge.

	Load (MW)							
Season	Weekday (M-Th)	Peak Time	Friday	Peak Time	Weekend Day (Sa-Su)	Peak Time	Holidays	Peak Time
Mar-May	90.8	7:45am-8:00am	89.0	7:45am-8:00am	63.3	2:30pm-2:45pm	59.5	4:45pm-5:00pm
Jun-Aug	88.4	7:45am-8:00am	76.4	7:45am-8:00am	43.7	2:00pm-2:15pm	72.8	9:30pm-9:45pm
Sep-Oct	89.1	8:15am-8:30am	89.3	8:15am-8:30am	68.2	5:00pm-5:15pm	61.8	5:00pm-5:15pm
Nov-Dec Jan-Feb	75.3	7:30am-7:45am	74.7	7:30am-7:45am	61.0	5:00pm-5:15pm	51.0	5:00pm-5:15pm

Table. 1. Peak load due to EV charging in Cambridge

Conclusions

The increasing adoption of EVs is expected to have a significant impact on distribution system planning. EV mobility data analysis can be used to better understand EV charging patterns and needs, which can help to mitigate the impacts of EV charging on the distribution system. It also helps long-term understanding of load. EV mobility data analysis can be used to identify peak charging times and locations. This information can be used to develop strategies for managing EV charging, such as time-of-use pricing and demand-side management programs. Utilities can make better decisions about where to install charging stations and how to design them. Eversource is taking the lead in EV forecasting.

Contact

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