Modeling of EV Charging Patterns Taking Chargers Congestion into Consideration

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Introduction

As the shift to electric vehicles (EVs) toward carbon neutrality progresses, demand for fast chargers is expected to increase. We have previously modeled future EV charging demand based on a traffic census Origin – Destination (OD) data. Although the model calculates the spatial average EV charging demand at the municipal level, in reality, infrastructure development must take into account temporal and spatial variations. Therefore, this study evaluates the relationship between acceptable waiting time and the required number of chargers using individual EV charging patterns that take into account daily variations.

Simulation Settings

The target area is BzoneCode 2120601 of OD data in Nakatsugawa City. This study uses the destination charging pattern of a non-commuter EVs, which was calculated in our previous study (1) as Case 0 (charging determined based on SOC upon arrival at the destination). Then, this study calculates the required number of chargers for a group of N EVs (n = 1 to N_{EV}) in the following steps.

Step-1 calculates a prospective charging pattern of N_{EV} EVs without any congestion in chargers by assuming that the charging pattern in our previous study corresponds to a probability density function of charging at the destination arrival time t (10 min temporal resolution) of n-th EV. Ten charging patterns are calculated by repeating this process by changing the initial value of random numbers. Figure 1 shows the charging patterns for N_{EV} = 1200. The required number of chargers without any congestion is determined as the maximum number of EVs simultaneously charging.

Step2 calculates the charging patterns of N_{EV} EVs when the number of chargers is smaller than that in Step-1, and evaluates the maximum waiting time for charging.

Step-3 evaluates the relationship between acceptable waiting time T_a and the required number of chargers by repeating Step-2 by changing the number of chargers.

Simulation result

Figure 2 shows the required number of chargers for 100 EVs for various T_a. When no waiting time is acceptable, 29 charges are required for N_{EV} = 1200. When T_a = 30, the number of chargers can be reduced to 15 in N_{EV} = 1200, which corresponds to 50% of that without limitation. Longer waiting time than 60 min, which is not so acceptable for EV users, is not so useful for reducing the required number of chargers at the same time. Therefore, it is necessary to install at least 50% chargers required for the prospective charging demand without any congestion. When N_{EV} = 400, the number of chargers for T_a = 30 is 6. The required number increases as N_{EV} reduces because of the reduced smoothing effect of both charging demand among EVs itself and the number of charging waiting EVs as shown in Figure 2.

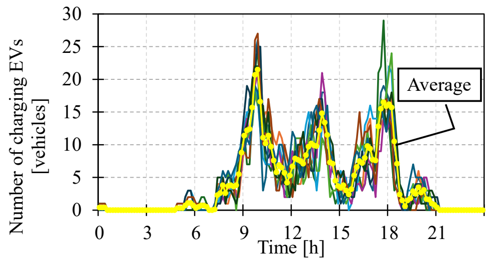

Figure 1 Change in number of charging EVs (N_{EV}=1200)

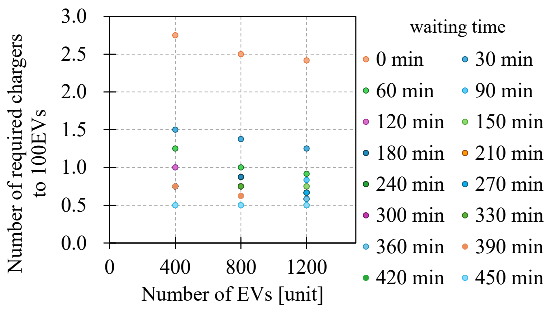

Figure 2 Number of required chargers to 100EVs

References

[1] M. Watanabe, C. Urabe, T. Kato, T. Nakamura, T. Yamamoto, Y. Hoshino and M. Konishi: “Effects of Introducing Charging Promotion Time Zone According to Day Cumulative Irradiance to Increase EV Charging with Renewable Energy”, IEEJ Trans. PE, Vol.144, No.6, pp.364-375 (2024) (in Japanese)