AN INDIVIDUAL-BASED PREDICTION MODEL FOR HOURLY ELECTRIC VEHICLE CHARGING DEMAND

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Overview

The widespread diffusion of battery-electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) poses potential energy security issues due to the insufficiency of power generation plants to cater to simultaneous charging. This study discusses an invidual-based, techno-behavioral-economic modelling approach to forecast hourly electricity demand from electric vehicle charging. This prediction model will play a crucial role in avoiding such issues. First, the model utilizes a Monte Carlo approach to generate the characteristics of a population of 1,000 individuals. Second, a discrete event simulation is independently ran for each individual to determine charging demand per hour. Results of the simulation debunk fears about electric vehicles potentially causing massive power outages in the country. In an illustrative case study in the Philippines, it is shown that electric vehicle charging would only occupy at most 5.3% of system reserves during peak hours.

Methods

The study uses actual survey data to generate probability distributions for departure times, travel distances, number of trips per day, and number of hours spent in the office of the population. As for the type of vehicle used by each individual, the study uses electric vehicle demand projections from a previous study. This information is also used to scale the simulation results to projected values from 2020 to 2030. A Monte Carlo approach is employed to create a randomized population of 1,000 unique individuals.

For each individual, a discrete event simulation (DES) is performed to determine hourly electricity demand from electric vehicle charging. The DES particularly uses information on the individual's departure time, travel distance and number of trips per day. The DES creates multiple "time pockets" for each individual, and implicitly determines the activity of the individual in each time pocket, e.g. will he/she be charging, traveling, at work or at home. The results of the DES for each individual is aggregated to get the hourly demand from EV charging, and is scaled to the national population. The hourly demand is then integrated into the system demand for analysis.

Results

Results show that EV charging demand would at most only occupy 5.3% of projected system reserves by 2030 in the Philippines. This is already using the best case scenario for electric vehicle diffusion. By 2030, assuming 170,000 PHEVs and 52,000 BEVs would drive on Philippine roads, EV charging peak would be 245 MW at around 19:00 hrs. To fulfil the mandatory power reserve requirement, an additional 25 MW generating capacity is recommended. The results also discuss various factors affecting hourly electricity demand from EV charging, such as frequent versus occasional charging behaviors of users, availability of charging facilities outside homes, subsidy of charging outside homes, etc.

Conclusions

The projected hourly demand from EV charging is determined using individual-based modelling and discrete event simulation. The model is illustrated via a case study in the Philippines. While using the best-case scenario for EV diffusion in the country, the projections debunk expected energy security issues arising from widespread electric vehicle adoption. At peak hours, EV charging would only occupy at most 5.3% of the system reserves. However, this is largely because most EVs are expected to charge at home. Outside charging can significantly increase peaks because of the larger power ratings of chargers typically installed in commercial establishments. EV charging demand should not be a critical path in the diffusion process of EVs. However, electrical safety standards and education of the public have to be intensified to avoid charging-related accidents.