OPTIMAL CHARGING STRATEGIES FOR ELECTRIC VEHICLES CONSIDERING USER'S ELECTRICITY CONSUMPTION PATTERNS

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Overview

The number of eco-friendly vehicles, such as electric vechicles and plug-in hybrid vehicles, is increasing as they are emerging as a solution to environmental problems. These electric vehicles need to be recharged at home or charging stations. Energy use is increasing nowadays as the industry grows due to economic development and also due to the increasing use of various electronic devices in everyday life. To solve this problem, there exists power management systems such as smart grid system. In this situation, the increase of eco-friendly vehicles will affect the power system. Particularly, there will be many differences depending on how and when the electric vehicle is charged. Therefore, the charging strategies for electric vehicles will have a significant impact on the peak load and total amount of power system. The electricity bill for each household will also be affected. The purpose of this paper is to research the effect of charging electric vehicles on residential power systems through big data of residential activity and find optimal charging strategies for each member on each situation. We calculate electricity usage of home appliance and electric vehicle usage from activity pattern data. Usage and rates are compared between three kinds of charging strategies and optimal charging strategies for each household is found.

Methods

In this paper, policies on electricity charges is diverse and research is done on each situation. The use of electric appliances and electric vehicles is based on residential activity big data done by Statistics Korea. First, the data are used to classify activity of each time slot for each household member and use of electrical appliances is estimated through activity. After that, we calculate the electricity consumption of home appliances accordingly.

We assumed three kinds of charging strategies for electric vehicle. These three kinds of charging strategy was proposed on (Kamankesh, Agelidis, and Kavousi-Fard 2016). The first charging strategy is to start charging as soon as user return home after using electric vehicle. The second charging strategy is to start charging at off-peak times, so it is chosen randomly among the off-peak times. In this case probability density function follows uniform distribution. In the third charging strategy, charging start time follow a normal distribution. We calculate and compare electricity rate for all strategies and find the optimal charging strategy for each household member.

Results

Depending on policies and stratgies, we compare the total electricity usage of power system and the electricity bill of each household. Though there are differences depending on the three charging strategies, the increase in electric vehicles has resulted in an increase in the peak load as well as an increase in the total usage of the residential power system. Each residential member showed a different optimal charging strategy on each pricing policy. Uncontrolled charging strategy, which is recharging as soon as return to home, showed high electricity rates under almost every household and circumstances. There were common characteristics among people with the same optimal charging strategy.

Conclusions

This paper find an optimal strategy based on given circumstances and user characteristics. It is clear that the electric vehicle affects the grid system. The people who use more electric vehicles are affected by the charging strategy more. This demonstrates that the proper electric vehicle charging strategy benefits both social and personal utility. Finding a better optimal charging strategy than our research and use as an electric storage device for electric vehicles will be conducted in further research.

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