Taikichiro Mori Memorial Research Grants 2020

Research projects :

Hydrogen station allocation and development plan using bus office as candidate location

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1. Background

To achieve carbon neutrality and address domestic energy challenges, Japan has been seeking a sustainable shift in the energy mix. Hydrogen energy, due to its benefits of clean, renewable, highly efficient, numerous sources to produce, has received more and more attention in recent years. Japan has proposed the idea of building hydrogen society and a detailed road map in 2014. Since then, the development of hydrogen energy has become a fundamental national policy and a series of strategies have been made, which are specifically designed for hydrogen energy development.

Among the many applications fields of hydrogen energy, the introduction of fuel cell vehicles (FCV). Japan has chosen private FCV as a breakthrough to expand the application of hydrogen energy in the field of transportation instead of public transportation systems. However, the high cost of building stations and the uncertain market penetration of FCV have put the spread of both in a chicken-and-egg dilemma. The scattered and small demand of FCV market makes it difficult to support the business of hydrogen refueling stations, and insufficient hydrogen refueling stations also hinders the development of the FCV market. Although the Japanese government has proposed to develop FCV market in parallel with new HRS building. Data show that the current market penetration rate of fuel cell vehicles is far below the set targets. There is a large potential demand for hydrogen in public transportation systems compared to the private FCV market, and the demand from public transportation is more stable and concentrated.

2. Research objectives

This research aims to evaluate the impacts of introduction of FC bus on hydrogen station development and to clarify the feasibility of building hydrogen station in bus

office. Firstly, the amount and regional distribution of potential hydrogen demand of both FCV and FC bus at each bus office will be calculated by analyzing collected data. Secondly, needed number of FC bus to support different scale hydrogen station in different scenario will be calculated. Thirdly, considering the possibility to provide refueling service for private FCV users, this research will derive optimal locations for hydrogen deployment by applying maximal covering model.

3. Study area and research method

This study will choose Kanagawa prefecture as study area. Kanagawa prefecture is located in the southern part of Tokyo metropolitan area with a population of 9,246,429. The land area of Kanagawa is 2416.11 km^2 accounting for about 0.6% of the country`s land area. However, the population of Kanagawa account for about 6.9% of the total national population. Also, Kanagawa prefecture has the fourth highest number of vehicle ownership in the country which is 4,032,723. According to Kanagawa bus information web and National Land Information Division, there are 20 route bus companies and 2018 bus route systems in Kanagawa prefecture.

Firstly, this research will estimate the number and regional distribution of potential FCV users considering future demographics change and geographic characteristics, including population, household types, vehicle ownership rate, location type. Secondly, this research will use bus route data (2017) from National Land Information Division to calculate potential hydrogen demand of each bus route system for one year in Kanagawa prefecture. Finally, based on the relationship between bus route systems and bus offices, this research will estimate the total potential hydrogen demand of each bus office by summing up calculated hydrogen demand of each bus route before.

4. Conclusion

This research firstly has examined the regional distribution of potential FCV users in future. The results shows that potential FCV users are unevenly distributed in Kanagawa prefecture and mainly concentrated in three government ordinance-designated cities which are Yokohama city, Kawasaki City, and Sagamihara city and south area. The uneven distribution of FCV users will hinder the deployment plan for HRS and has negative impacts on service equity since it is difficult to maintain HRS business in specific region with low hydrogen demand. Besides, according to the strategic road map of Kanagawa, even under the optimal scenario of which the target of FCV development is achieved 100%, there are still half of bus offices cannot support a 100% operation rate for middle-scale and large-scale HRS business. In 50,000 FCV scenario, the hydrogen demand of most bus offices is only enough to support small-scale HRS keeping more than 100 operation rate. In 20,000 FCV scenario, most of offices cannot even support small-scale HRS. In conclusion, there is still gap existing between FCV development target and HRS deployment based on the road map of Knagawa.

Compared with hydrogen demand of FCV which is small and uneven distributed in the region, Hydrogen demand of FC bus almost all bus offices is quite larger than demand of FCV and have enough to support a middle scale and large- scale hydrogen station keeping 100% operation rate. Also, the regional distribution of FC bus hydrogen demand is even which means that HRS could be dploymented in area with low population density and still keep high operation rate. Hence, the introduction of FC bus can play a significant role in reducing financial risk of hydrogen station business and helping to increase service equity in specific area with small hydrogen demand. Besides, there are only 7 bus offices have quite small hydrogen demand. Therefore, these bus offices could have extra capacity to provide refueling service for private FCV users. By providing public service for private users, hydrogen demand of these 7 bus offices will be enough to build small-scale or middle scale HRS.

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