Potential of Plug-in Hybrid Electric Vehicle for Demand of Electric Power and Reduction of CO_2 Emission in Japan

Background

Climate change and environmental issues worldwidely are recognized as critical issues, and many kinds of low emission vehicles are being developed. Plug-in Hybrid Electric Vehicle (PHEV), which has a larger battery than a usual hybrid vehicle and can be charged from a electric grid, is proposed as one of the low emission vehicles (Figure 1). This PHEV is expected to offer the key to reduce oil consumption and emissions by charging from the grid nightly. The introduction of PHEV results in the electrification of the vehicle transport, which has a great impact on the electric power industry in Japan. In this report, the potential of PHEV on the demand of electricity and the reduction of CO_2 emission in Japan is evaluated.

Objectives

First, the status of R&D on PHEV in the world is summarized. Second, a method to analyze the demand of electricity and the reduction of CO_2 emission by the introduction of PHEV in Japan is established, and the potential of PHEV in Japan is revealed.

Principle Results

A method to analyze the demand of electricity and its prospect and the reduction of CO_2 emission and oil consumption by PHEV is established. Using the performance of PHEV optimized by EPRI and an estimation on the pattern of driving and charging in Japan, the following results are obtained.

1. The electric demand for PHEV60 and PHEV20 is evaluated at 79.3 billion kWh and 41.2 billion kWh, respectively, in case that all vehicles in Japan (80 million cars) are replaced by PHEV (Table 1).
2. The load leveling effect on the Japanese grid, which is hypothetically considered as one electric grid, is evaluated at about 30 million kW, in the case when all vehicles in Japan are replaced by PHEV60 and charged in the middle of the night. However, when the charge of PHEVs starts in the evening, that effect is not obtained (Figure 2).
3. The analysis reveals that the electric demand in Japan after 2030 would increase by 1% for PHEV60 and 0.4% for PHEV20, respectively, where it is assumed that PHEV is introduced into the Japanese market at a similar pace to the present HEV (Figure 3).
4. The spread of PHEV60 over all Japanese vehicles enables reduction of the 42.4 million kilo liters of gasoline. The effect on reduction of CO_2 emissions corresponds to 98 million ton by electricity from nuclear power or renewable energy and 64 million ton by electricity from LNG power plants. Those values are equivalent to 38% and 25% of CO_2 emissions from the category of transport in Japan in 2003.

This study is carried out as the collaboration between CRIEPI and the University of Tokyo.

Further Developments

The performance of PHEV applied here is based on the one optimized by a US driving cycle. This should be improved by the Japanese driving cycle, and its effects on the results should be made clear.

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Reference R.Hiwatari, et.al., 2006, “Effect of Plug-in Hybrid Electric Vehicle on Electric Demand in Japan” CRIEPI Report L05008, (In Japanese)

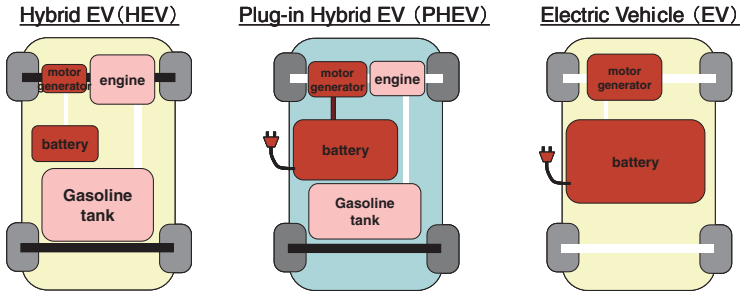

Fig.1 Comparisonbetween a parallel hybrid EV(HEV), a plug-in hybrid EV(PHEV), and Electric Vehicle(EV)

The Plug-in Hybrid EV has a larger battery and motor than the parallel hybrid EV, and can be charged from the electric grid.

Table 1 The performance of PHEV optimized by EPRI*, and the annual electric demand for PHEV, the reduction of CO_2 emission for vehicles, and CO_2 emission for generation of a natural gas fired power plant for PHEV to charge in Japan, in the case when all vehicles in Japan are replaced by PHEV

Vehicle type			PHEV20	PHEV60
Performance	Engine peak power (kW)		61	38
	Motor rated power (kW)		51	75
	Battery rated capacity (kWh)		5.9	17.9
	Vehicle mass (kg)		1664	1782
	Fuel economy (km/L)	Gasoline only	18.5	19.3
		Electric only(equivalent gasoline liter)	49.8	48.4
Annual electric demand for PHEV (billion kWh)			41.2	79.3
Reduction of CO_2 emission (million ton)			51	98
CO_2 emission from generation by NG fired power plant (million ton)			18	34

*The performance of PHEV optimized by EPRI is referred to "Comparing the Benefits and Impacts of Hybrid Electric Vehicle Options", EPRI, Palo Alto, CA:2001, 1000349.

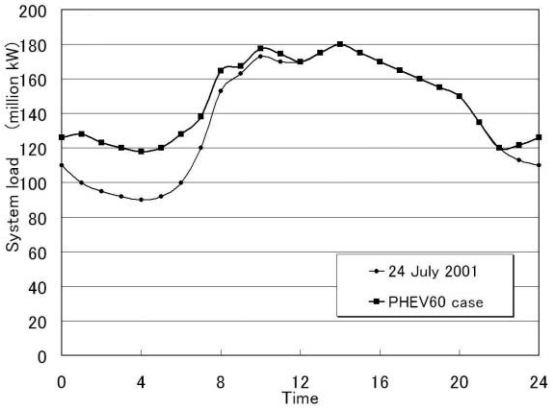

Fig.2 The load leveling of the PHEV60 charge on the system load in Japan, *in case that the charge of PHEVs starts at midnight based on 24 July 2001*

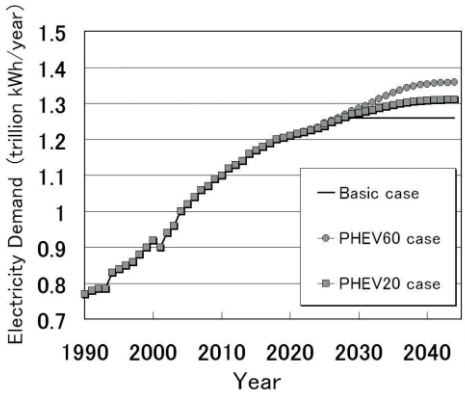

Fig.3 Electric demand prediction taking PHEV introduction into consideration

Basic case before 2030 is based on "gthe prospect of demand and supply for energy in Japan by 2030" (Ministry of economy, trade and industry). After 2030, the annual increment is assumed to be 0%.PHEV is assumed to be introduced in 2010 at a similar sales pace to Hybrid vehicles.