Project Research — Development of a Supply/Demand Infrastructure for Next-generation Electric Power

Acceleration of Electrification with Electric Vehicles and Secondary Battery Systems

Background and Objective

As measures against global warming, the introduction of a low-carbon electric power supply and the promotion of energy conservation are important. Moreover, the electrification of the public welfare and transportation sections, which have been increasing in energy consumption carbon dioxide emissions, is effective for energy conservation.

In this project, a hybrid energy storage battery system with a heat pump hot water supply system for residences is proposed toward electrification for public welfare services with the utilization of secondary battery technologies. Moreover, in transportation, while the policy for the acceleration of the popularization of electric vehicles (EV) and for the preparation of a charging infrastructure is shown, charging technologies should be developed with safe and high performance.

Main results

1 Hybrid Energy Storage Battery System with a Heat Pump Hot Water Supply System for Residences

We proposed an optimized control method for residential hybrid energy storage battery systems with a heat pump hot water supply system, which takes into consideration not only technical factors such as outside temperature, energy loss due to the start-stop of the heat pump and the radiation of heat from the hot water tank, but also time-of-day electricity fees. Through our new control method, heat storage management using a heat pump depends on the residual heat in the hot water tank every hour instead of the conventional daily total heat mass usage, such that the efficiency of operation can be enhanced, due to the elimination of the need for further energy charges.

2 Acceleration of the Popularization of EVs

(1) Advancement of analysis on the effect of a charging infrastructure by traffic simulator

The shorter drive range of an EV compared to a gasoline vehicle is the critical disadvantage for wide diffusion of EV in the market. To overcome this disadvantage, it is important to comprehend the drive range of EVs in various operation conditions, to construct an infrastructure network, and to find suitable usage for EVs. Here, a Japanese nationwide database of charging infrastructures has been constructed, and that database contains information such the number of installations per prefecture, location, business hour, and the operating company of the charging infrastructure. Using the database, we have made clear the effect of the installation number and business hour of the charging stations on the number of EVs running out of electricity by using a traffic simulator developed at CRIEPI.

(2) Development of an EV driving mileage simulation code

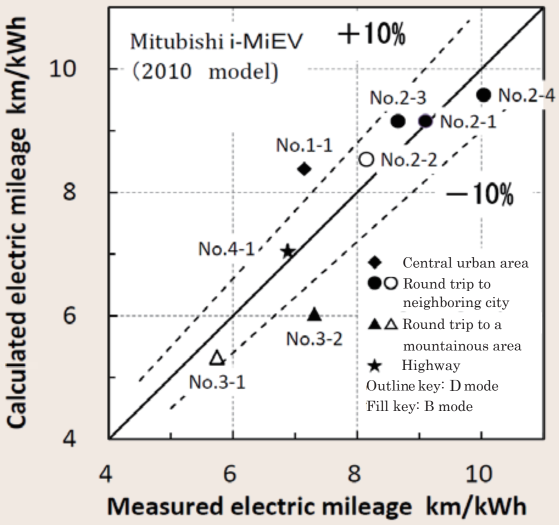
Simulation codes for the EVs currently on sale were developed from EV driving data (Fig. 1). This simulation considered both the regeneration of energy from braking and altitude changes on driving course. This simulation code can evaluate the changes of driving mileage against the battery capacity mounted on EVs (Fig. 2)(M11023).

(3) Development of a bi-directional inductive charging technology

A wireless vehicle-to-home (V2H) module, through the use of a bi-directional inductive power transfer setup, was developed. We tried to connect the module directly to a conventional power conditioner and demonstrated the operation of a stand-alone AC power supply until 1.2 kW with an efficiency of 92% was successfully achieved (Fig. 3)(H11028).

(4) Potential penetration of EVs for domestic use

We identified the potential penetration rates of EVs considering their demerits compared to gasoline-powered vehicles, such as shorter mileage, higher initial cost, and the installation of a charging infrastructure by analyzing data collected through a Web-based questionnaire survey. Even if the initial EV price is reduced to that of a gasoline-powered vehicle and if the mileage per charge is extended to 300 km, the rate is only 2.3%. In order to promote EVs, it is important to extend the mileage, lower the price, and enhance driver understanding regarding the installation of chargers at home (Y11032). In addition, we found that the success of EV adoption with vehicle-to-home power systems is reliant on the price decline of such systems (Y11021).



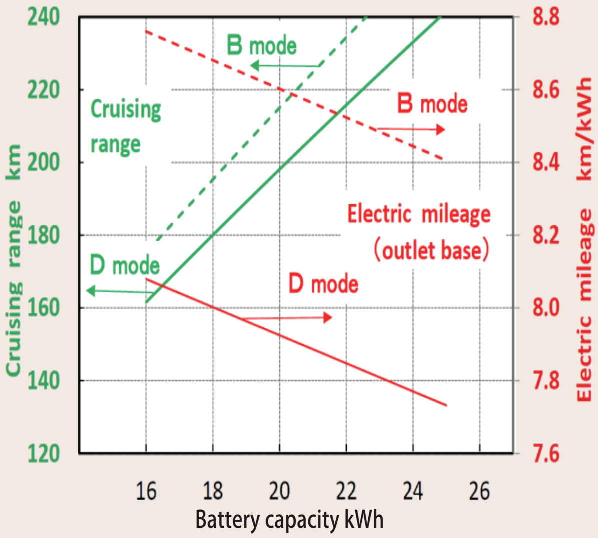
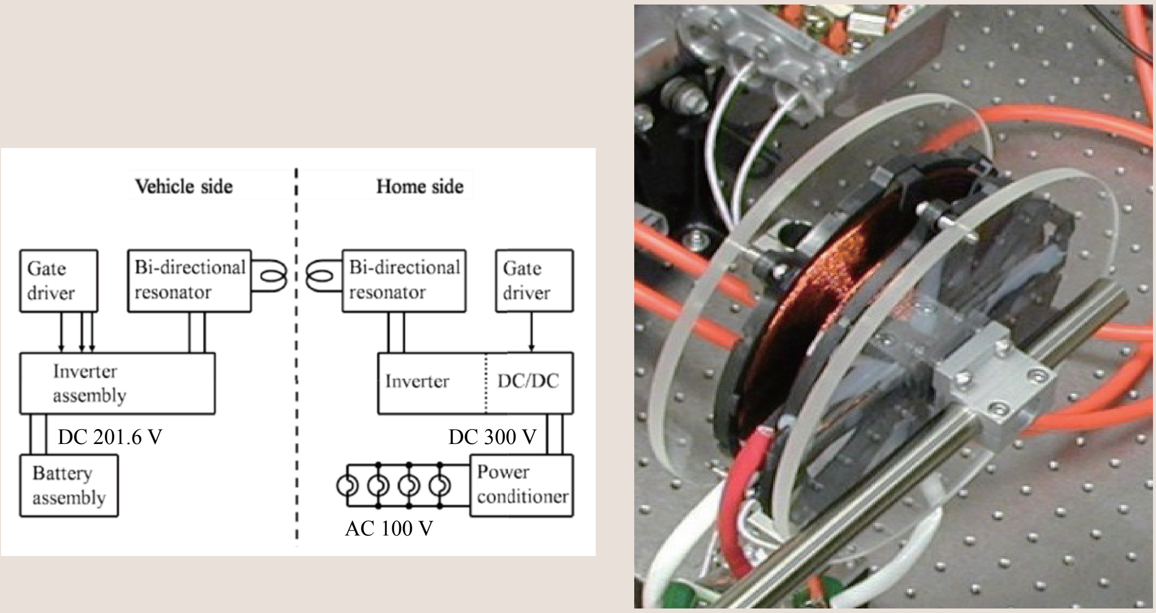


Fig. 1: Comparison of driving mileage calculated by the simulation code and measured during EV driving

Simulation code can predict in ±10% of accuracy electric mileage except for extreme traffic congestion (No. 1-1) and mountain slope (No. 3-2). *D mode: Usual mode, B mode: high energy regeneration mode

Fig. 2: Evaluation of driving mileage against the battery capacity mounted on EVs

The possibility of the cruising range distance extension in consideration of the increase in weight of vehicle was examined by making battery capacity into a parameter supposing the improvement in performance of EV. (Calculation case was No. 2-3 in Fig. 1)



(L) Block diagram of an experimental setup

(R) Spiral coils assembled in an inductive power transfer setup

Fig. 3: Wireless vehicle-to-home module connected to a conventional power conditioner

A wireless vehicle-to-home (V2H) module, through the use of a bi-directional inductive power transfer setup, was developed. We attempted to connect the module directly to a conventional power conditioner and successfully demonstrated the operation of a stand-alone AC power supply. This technique adds the advantage of mobile storage to the EV without weight increase.