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Contributing to an energy and resource saving society through dynamic wireless power transfer for xEV

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Increasing battery capacity to extend the driving range of battery electric vehicles (BEVs) causes issues such as resource constraints, increased weight, longer charging times, and higher CO_2 emissions. To address these challenges, this study aims to realize a BEV-based society premised on battery downsizing by adopting Dynamic Wireless Power Transfer (DWPT).Following highway-focused energy prediction and trip simulations conducted last year, this study investigates DWPT specifications for urban operation, targeting continuous driving with maintained or increasing state of charge.

As an assumed deployment pathway for urban DWPT systems, we envision expansion from public transportation (buses) to commercial vehicles (taxis and delivery vehicles), and eventually to privately owned cars; therefore, this paper focuses on buses and taxis. To minimize roadside DWPT installation, we primarily consider charging during long stops at bus stops and signalized intersections. A key challenge for achieving infinite driving is that a 16-ton route bus at an ambient temperature of 0°C is predicted to have three times worse energy efficiency than under mild conditions (16–18°C); thus, we identify DWPT locations where received energy exceeds consumption even at 0°C.

In this study, we rode route buses and taxis as passengers on eight routes in Tokyo and Nagoya and collected speed profiles as well as stop locations and durations at bus stops and intersections. Although infinite driving was initially estimated to be feasible using the average stop duration at bus stops/intersections, actual stop times are not constant, and speed and ambient temperature—both of which strongly affect energy consumption—vary over time; moreover, the spacing between selected DWPT sites is not uniform. To evaluate feasibility under these variations, we conducted trip simulations that track the time history of traction energy consumption and DWPT charging.

Figure 1 shows the trip simulation results for the Nagoya Station–Chayagasaka route, a central Nagoya corridor with a dedicated bus lane. Five major bus stops and one major intersection were selected as DWPT sites, corresponding to an installation ratio of 1.5%. Since the battery energy at the end of the trip under 0°C conditions was +2 kWh relative to the initial value, we judged that infinite driving can be achieved. On this route, a dedicated bus lane runs in the median and is located immediately before intersections; because buses tend to stop for extended periods due to both passenger boarding/alighting and signal waiting, the required DWPT installation ratio along the route was reduced.

Figure 2 summarizes the societal contributions of urban DWPT.

The first contribution is battery downsizing; in this study, urban infinite driving is examined with one-third of the conventional battery capacity, thereby reducing concerns related to CO_2 emissions from battery production and disposal, environmental impact, and charging wait times.

The second contribution is the potential for infinite driving of BEVs enabled by DWPT in urban areas. While the installation ratio required to drive 500 km by DWPT on highways was approximately 35%, the ratio for achieving infinite driving in urban areas is around 5% because charging is mainly performed during vehicle stops.

The third contribution is vehicle weight reduction, estimated at 600 kg for buses and 200 kg for taxis, leading to additional benefits such as resource conservation and improved vehicle dynamics.

The fourth contribution is energy savings due to weight reduction; for buses and taxis that frequently operate in urban areas, a significant efficiency improvement of approximately 3.5 W/kg is expected.

The fifth contribution is mitigation of battery degradation, as DWPT enables operation while maintaining the state of charge within the 20–80% range; visualizing this stable SOC behavior is also enhances driver confidence.

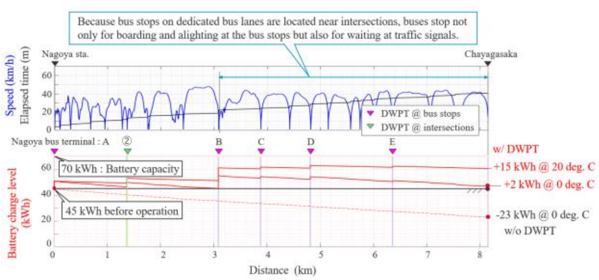

Fig.1 Trip simulation for Nagoya route bus

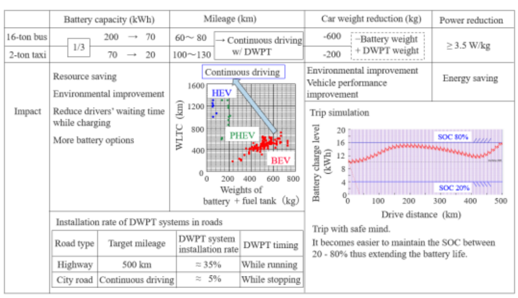

Fig.2 Social impacts of urban DWPT