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Research on a method of installing 450kW Electric Road System on highways (1st report)

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Truck transport accounts for more than 90% of Japanese freight transport and CO2 emissions from truck transport account for about 40% of Japanese transport sector. Therefore, from the viewpoint of CO2 reduction, there is a great need for electrification of truck transport. In particular, heavy-duty trucks that play inter-city transportation emit a large amount of CO2 because the total mileage per day is long, so the effect of CO2 reduction by electrification is big. From the viewpoint of decarbonization, the introduction of electric vehicles (EVs) is one of the options, but it's known that it's difficult to put heavy-duty EV trucks to practical use because of the energy density of the battery. One solution to this problem is an Electric Road System (ERS) that is the infrastracture for charging EVs while driving, and a method is being developed to handle the high power of heavy-duty EV trucks. In this research, we report the result of examining the optimum ERS installation method on highways and the result of the simulation of charging a heavy-duty EV truck while driving in the initial stage of introducing ERS. The total length of highways in Japan is 9021 km, and it's necessary to install ERS on all highway lines in order to be able to use ERS without worrying about running out of electricity. However, it 's difficult to install ERS on all highway lines immediately in terms of cost and time, so it's necessary to gradually expand the ERS installation sections. Then, we classify the process of installing ERS on all highway lines into four stages, and in the initial stage of introduction, we considered a method (Electric Energy Balance Levering method: EEBL method) to always increase and level the electric energy balance between each interchange (IC). And we simulated the charging a heavy-duty EV truck while driving when the ERS is installed by the EEBL method.

In the EEBL method, the ERS installation rate was about 22% for both lines of inbound and outbound. There was no difference in the electric energy consumption rate and no significant difference in the charge electric energy and the battery electric energy balance between inbound and outbound lines. In the electric energy balance per 1km travel between each IC, there was a difference of 0.43kWh/km between the minimum and maximum values on the inbound line (Minimum: -0.04kWh/km, Maximum: 0.39kWh/km), and a difference of 0.36kWh/km on the outbound line (Minimum: 0.02kWh/km, Maximum: 0.38kWh/km). For both lines, there was a variation in the electric energy balance depending on the section. The average electric energy balance per 1km travel was 0.21kWh/km on the inbound line and 0.22kWh/km on the outbound line. In the EEBL method, although the ERS installation distance was determined so that the electric energy balance between each IC would be 0.25kWh/km, about 60% of the sections didn't meet the target for both lines. This is thought to have been caused by a problem with the ERS installation location. The ERS installation location was simply near the center between each IC, but if there is a large down slope in the ERS installation location, regenerative energy will be added in addition to ERS charging, and turned out that the target charge amount could not be obtained because of the problem with battery acceptability.

In the case of the EEBL method considering the slope, the electric energy consumption rate is same as in the case without considering the slope, but the charging electric energy increased by about 4.0% and the battery electric energy balance decreased by about 4.1%. It's considered the reason for the charging electric energy increased is because of the avoidance of decrease in the ERS supply electric energy due to regeneration by avoiding the ERS installation in the down slope section. It's consider the reason for the battery electric energy balance decreased is because of the ERS installation in up slope sections increase (Inbound line: +83.4%，Outbound line: +52.7%) and the ratio of the ERS supply electric energy directly used for driving increased, by avoiding the ERS installation in down slope sections. Because suppressing the battery electric energy balance contributes to improving the battery life, it's very important to consider the slope when examining the ERS installation location. In the electric energy balance per 1km travel between each IC, there was a difference of 0.24kWh/km between the minimum and maximum values on the inbound line (Minimum: 0.15kWh/km, Maximum: 0.39kWh/km), and a difference of 0.23kWh/km on the outbound line (Minimum: 0.15kWh/km, Maximum: 0.38kWh/km). In the EEBL method considering the slope, the variation in the electric energy balance between sections was smaller than without considering the slope. The average electric energy balance per 1km travel was 0.25kWh/km on both lines.

Table1 Simulation Results

	Not considering slopes		Considering slopes	
	Inbound	Outbound	Inbound	Outbound
Road extension [km]	488.8	489.1	488.8	489.1
Number of ERS Installation sections [section]	58	56	58	56
ERS installation total distance [km]	108.0	107.2	107.6	106.7
ERS Installation rate [%]	22.1	21.9	22.0	21.8
Electric energy consumption rate [kWh/km]	1.038	1.037	1.05	1.04
Charging power amount [kWh]	594	606	625	624