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Mathematically Optimal Locations of In-motion Wireless Power Transfer System on Expressways

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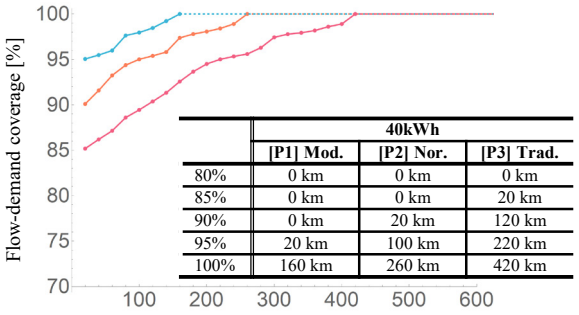
In-motion Wireless Power Transfer (A3)

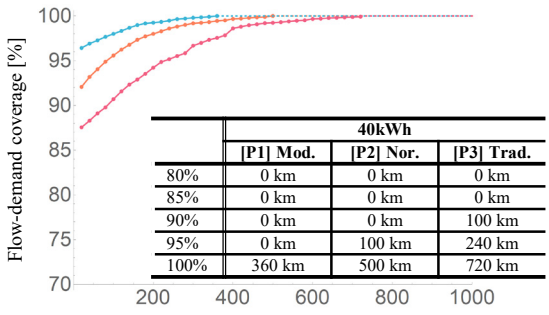
The popularization of electric vehicles (EVs) is limited by their driving range and long charging times. To address this, in-motion wireless power transfer systems (WPTSs) are currently attracting attention as a new power supply system. In-motion WPTSs have coils embedded under the road to transfer power from the WPTSs to EVs while driving. However, the main drawback of WPTSs is its large investment, especially in supporting the long-distance trips of EVs on expressways.

Therefore, this paper proposes a new mixed-integer programming model (MIP) to determine the optimal location of WPTSs for maximized total feasible flow demand. By focusing on long-distance trips on expressways, we proposed the first flow-capturing model for WPTS locations that can (i) solve for the distance of WPTS installed as continuous variables, and (ii) solve problems based on real-scale data using a general MIP solver. Our method is extended to a discussion of WPTS installations on expressways in Japan. We found that WPTS has strong potential as an EV power supply system in terms of coverage and economic rationality. In particular, WPTS has economic rationality not only in busy networks but also in sparsely populated networks that connect urban and rural areas. Thus, this study clarified the important insights of WPTSs in improving their effectivity to narrow down the demand and ensure the flexibility in the locations of WPTS



	40kWh		
	[P1] Mod.	[P2] Nor.	[P3] Trad.
80%	0 km	0 km	0 km
85%	0 km	0 km	20 km
90%	0 km	20 km	120 km
95%	20 km	100 km	220 km
100%	160 km	260 km	420 km

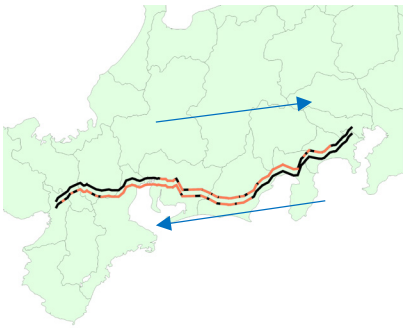
(a) [N1] Tokyo–Osaka, [D1] 40 kWh



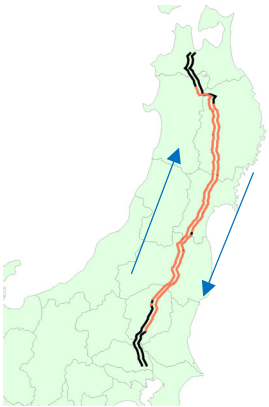
	40kWh		
	[P1] Mod.	[P2] Nor.	[P3] Trad.
80%	0 km	0 km	0 km
85%	0 km	0 km	0 km
90%	0 km	0 km	100 km
95%	0 km	100 km	240 km
100%	360 km	500 km	720 km

(b) [N2] Tokyo–Aomori, [D1] 40 kWh

Fig. 1 Relationships between the WPTS installation distance and the coverage of flow demands



(a) [N1] Tokyo–Osaka, Coverage=100%
(Total WPTS distance = 340 km)



(b) [N2] Tokyo–Aomori, Coverage=100%
(Total WPTS distance = 600 km)

Fig. 2 Optimal Locations of WPTS for [P1] Normal and [D2]30kWh