Electric Road Systems: A case study on the bridge of Öresund

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This report investigates the potential of implementing an electric road system (ERS) on the bridge of Öresund, comparing it to a system of static chargers. Assuming all truck traffic would be electrified, 150 Heavy-Duty (HD) and 1 140 Light-Duty (LD) trucks would be required for an ERS to be financially equivalent to a static charger system.

As the number of electric vehicles steadily increases, it is important to address the question of how these vehicles will be charged. The current Swedish charging infrastructure consists of 2 550 public static chargers. For the entire vehicle fleet to be electrified it would take over 50 000 public fast chargers, which is equivalent to an increase of 1860%. Utilising an ERS as well as a reduced battery size, made possible by vehicles charging whilst driving, is a significantly cheaper option (20 billion compared to 45 billion SEK/year), see Table 1.

Table 1. Comparison an electrification of Sweden's vehicle fleet with or without ERS

Costs [Billion SEK/year]	With ERS	Without ERS
Batteries cars	10	38
Batteries trucks	2	6
Charging Infrastructure	8	1,12
Total	**20**	**45**

This thesis investigates the potential of electrifying the bridge of Öresund through the use of an ERS, and further compares it to a static charger system. By analysing the traffic flow across the bridge and simulating different vehicles (HD truck, LD truck and car), an estimate of the charging ability was obtained. Simulations show that HD trucks can charge between 5-55 kWh, LD trucks can charge 10-12 kWh, and cars 6-8 kWh. The charging is dependent on the available power from the road (P_{ERS}) as well as the vehicle weight. If the power (P_{ERS}) is higher, more charging power is available. Furthermore, the heavier the vehicle is, the higher the drive power is - and subsequently less power is available for charging (see figure 2 for an example of a HD truck).

If the ERS is to be beneficial for vehicles, it is a prerequisite that the charging energy corresponds to a substantial amount compared to the vehicle's normal daily consumption. As such, shorter routes are more beneficial because of the finite distance and energy available on the bridge.

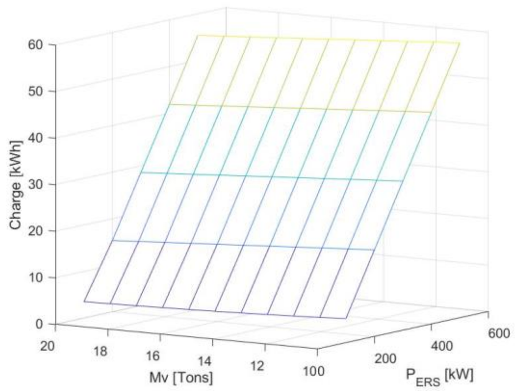

Figure 2. Simulation of a HD truck from SE to DK. Charge increases with increasing P_{ERS} and a decreasing vehicle weight.

Haulage contractors have contributed to this study by supplying their schedules, routes, and vehicle data. Utilizing their material, normal daily routes (drive cycles) for each type of vehicle class was assumed. They vary in both distance and frequency to represent the diverse behaviour of the vehicles.

Assuming that all the vehicles crossing the bridge have identical drive cycles (or at least of similar distances), a comparison of what it would cost using either an ERS - or a static charging system - can be estimated. The calculation includes the cost of batteries, static chargers, the ERS technology, and upgrades to the electrical system on the bridge to be able to supply the power. If only truck traffic was electrified, it would take 150 HD trucks and 1 140 LD trucks for the two systems to have the same cost. If all traffic was electrified on the other hand, the ERS would be the most financially beneficial seeing as the HD trucks are capable of the biggest possible reduction in battery size (in kWh´s). However, electrifying all traffic would call for major reinforcements of the electrical grid system on the Öresund bridge as it does not currently have the electrical capacity needed to implement such a system.

A sensitivity analysis, varying the distances of the drive cycles, shows that the battery size is the main driver of rising costs. Longer distances demand more energy in terms of bigger batteries or more complementing static charging, thus reducing the benefit of an ERS.

To make a certain conclusion regarding the potential of an ERS, more research is needed into identifying the traffic flow and the possibility for upgrading the electrical system. However, it could set a precedent for the rest of the industry when it comes to electrification of the transportation sector.