Simulating Electric Road Systems as charging infrastructure in MATSim with EV-Contrib: EV user charging behavior on long-distance trips

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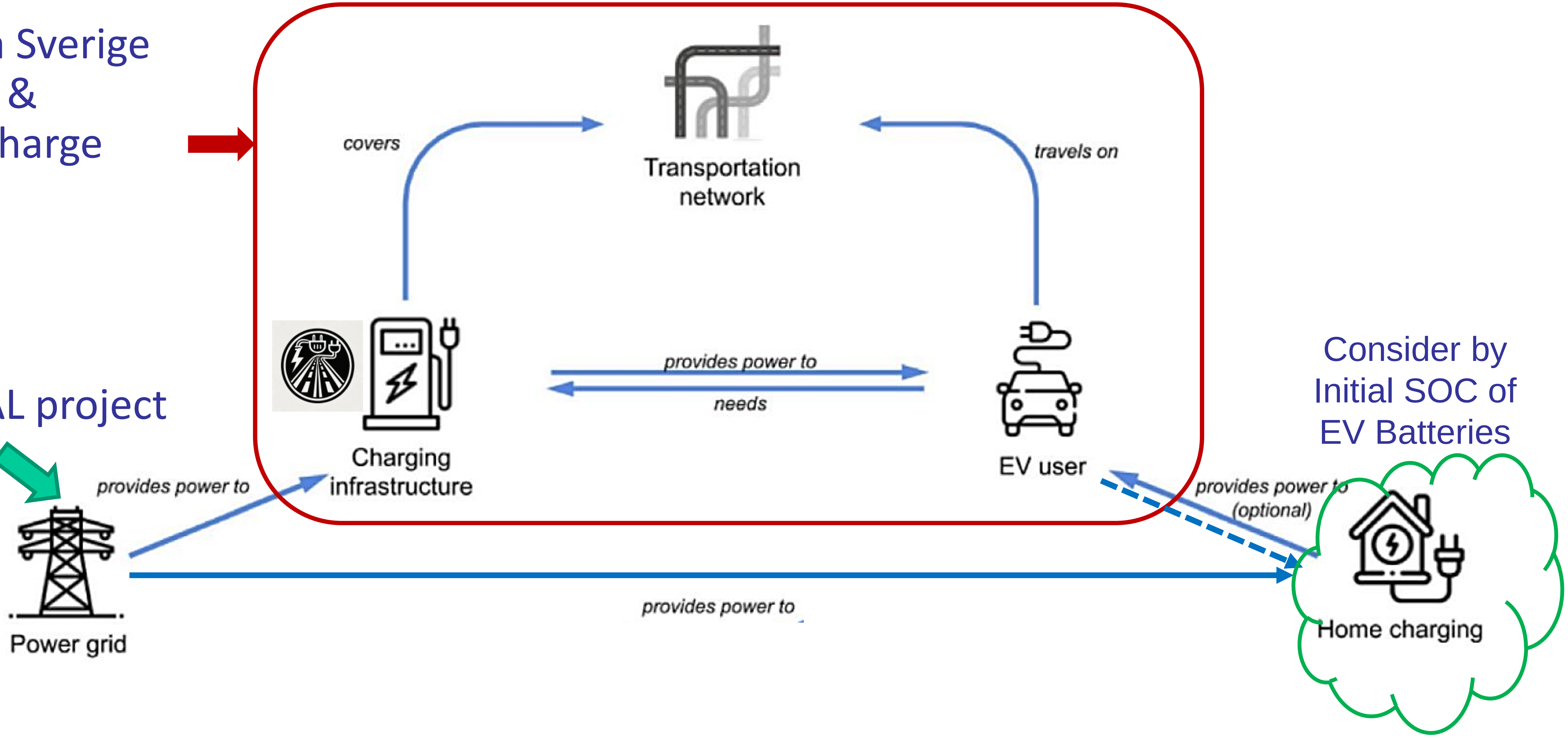
Agenda

- Introduction
- Electric Road System
- Methodology
- Result

The Electromobility System Framework

Ladda Sverige
&
E-charge

ACTUAL project



Consider by Initial SOC of EV Batteries

Metais, Marc-Olivier, et al. "Too much or not enough? Planning electric vehicle charging infrastructure: A review of modeling options." Renewable and Sustainable Energy Reviews 153 (2022): 111719.

Charging infrastructure needs for light and heavy vehicles in Sweden (“Ladda Sverige”)

- How many electric road systems (ERS) are needed to satisfy the charging demand compared to fast charging stations in terms of location, size, power, and cost?

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What is Electric Road Systems?

- Electric Road System (ERS) is an infrastructure that allows electric vehicles (EVs) to charge while driving

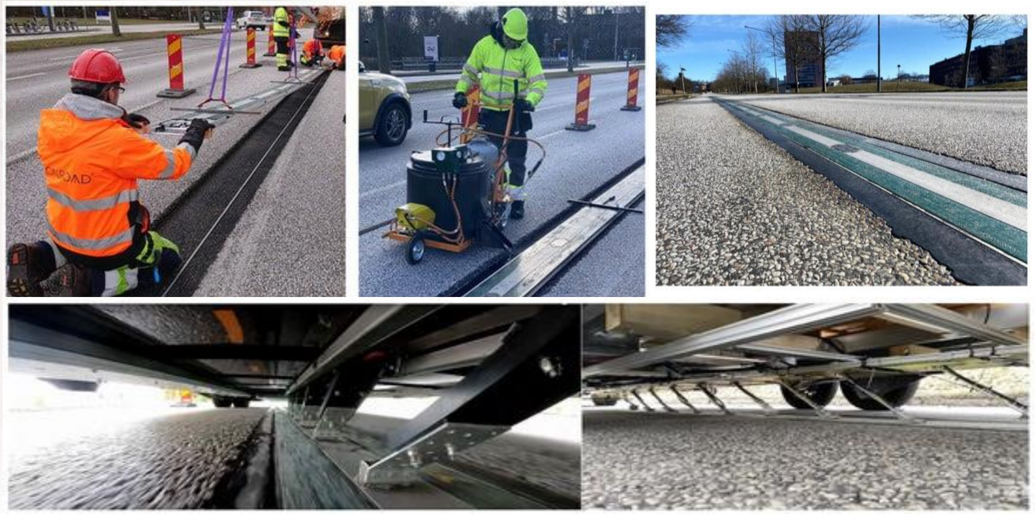
Fast Charging Stations:

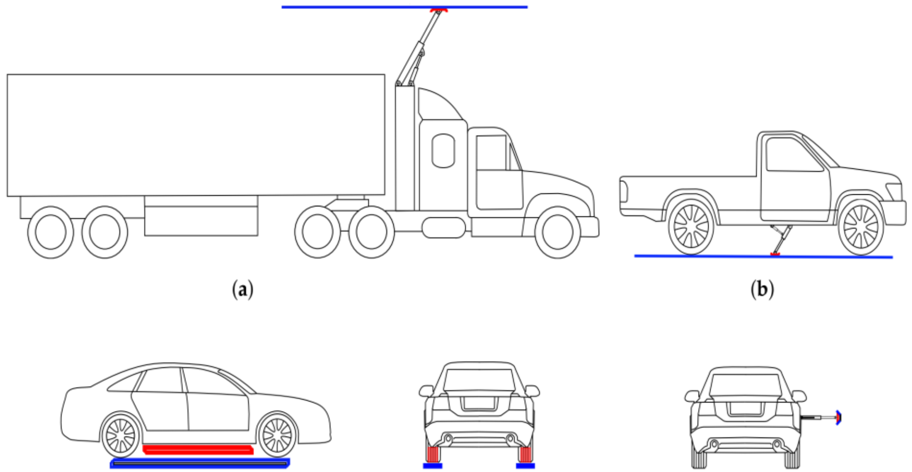
- Vehicles stop and connect to a charger for a quick recharge.
- Typically requires at least 20-30 minutes for an 80% charge.

Electric Road Systems (ERS):

- Vehicles charge continuously while driving.
- No need for stops, as charging happens on the go.

https://www.evolutionroad.se/en/electric-roads/electric-road-technologies/





https://doi.org/10.3390/wevj15020059

DOI: 10.1109/TVT.2024.3362533

doi:10.3390/9010009

Implementing ERS within MATSim’s EV Contrib

- Placement of ERS on Roadways
- Technical Aspects of Energy and Power Delivery
- Behaviour and Usage Patterns of EV users

ERS Network

Key Factors for Placement

- ❖ Traffic volume
- ❖ Travel patterns

TEN-T core → 3270 km

TEN-T → 6698 km

Available Energy From ERS

$$E_{ERS} = P_{ERS} * TT_{EV} * K_{ERS}$$

E_{ERS} is available energy from ERS in kWh

P_{ERS} is the provided power by ERS in kW

TT_{EV} is the travel time an EV traverses on the link in hours.

K_{ERS} is the share of the link length that is actually electrified by ERS installation, is approximately between 50 -70 %

- It is not possible to electrify entire roads due to engineering challenges at crossings, tunnels, and curves.

EV users' Charging Behaviour on the ERS network

- There are two approaches to modeling charging logic for ERS usage, primarily focused on long-distance travel.

Approach 1: Fixed SOC Threshold

Description:

- Based on the state-of-charge (SOC) level of the EV battery during the trip.

Mechanism:

- Charging is initiated when the SOC falls below a certain threshold.
- Charging continues until the SOC reaches a specified upper limit.

Advantages:

- Simple and easy to implement.

Challenges

- not optimize energy usage and charging efficiency.

EV users' Charging Behaviour on the ERS network

Approach2: Minimize ERS Usage

Description:

- Minimize ERS usage while ensuring EV reaches destination with desired final SOC.

Mechanism:

- Identify the route, calculate each link’s energy consumption, and determine ERS availability.
- Backward pass for SOC Threshold Determination.
  - Start from the destination to determine SOC thresholds for ERS-equipped links.
  - Ensure the EV reaches the destination with the desired final SOC.
- Forward Pass to determine ERS Utilization
  - Start from the origin with an assumed initial SOC and monitor SOC.
  - Use ERS only if SOC falls below the pre-defined SOC threshold on ERS-equipped links in the backward pass

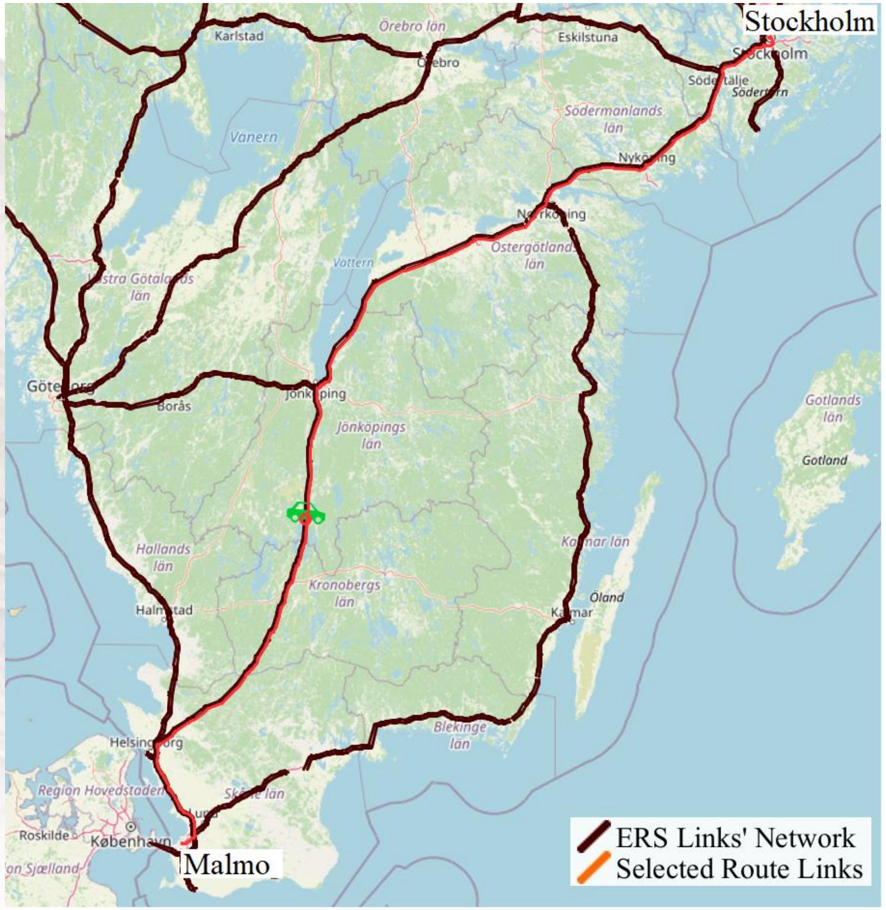
Advantages:

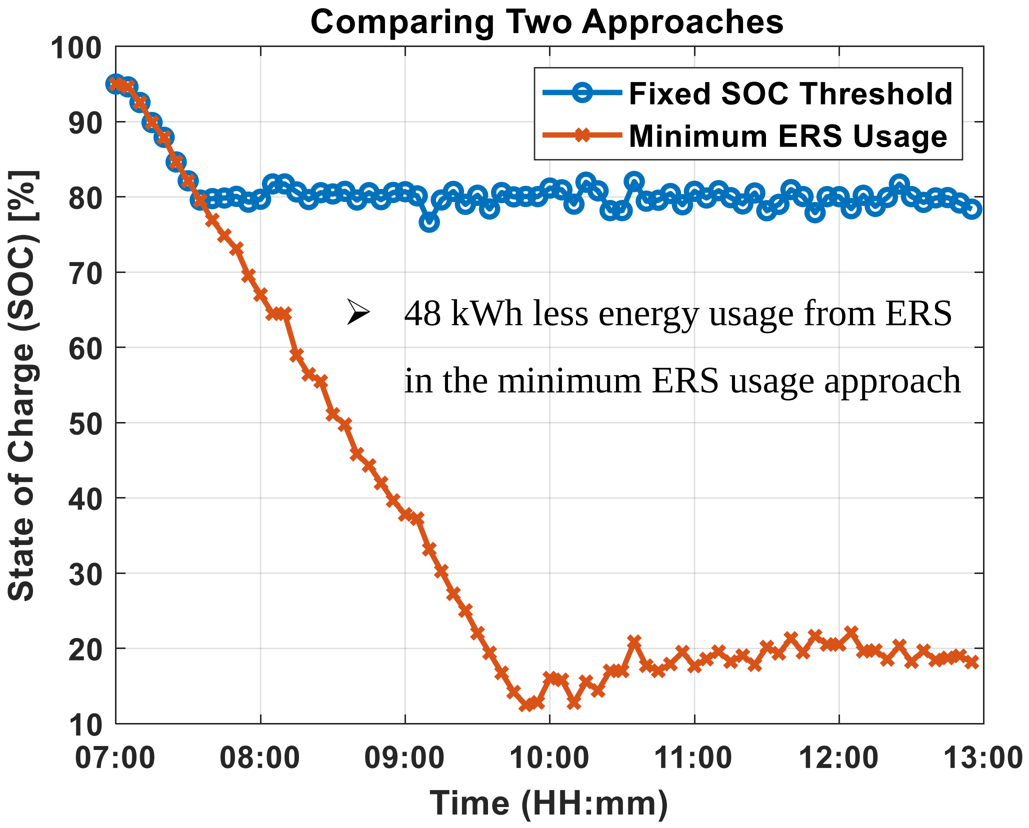
- Minimizes ERS usage.

Challenges

- Requires detailed route mapping and SOC monitoring

Two approaches Comparison





- Selected route for a long-distance trip (entirely covered by ERS), from Malmo to Stockholm (613 km).
- The considered ERSs have 150kW power capacity with K_ERS=50%.
- The trip starts at 7:00 and ends at 13:00.
- The EV has a battery capacity of 80 kWh with an initial SOC of 95%.
- It is assumed that there is a home charging option at the destination, so the desired final SOC is set to 15%.

Two approaches Comparison for TEN-T Network

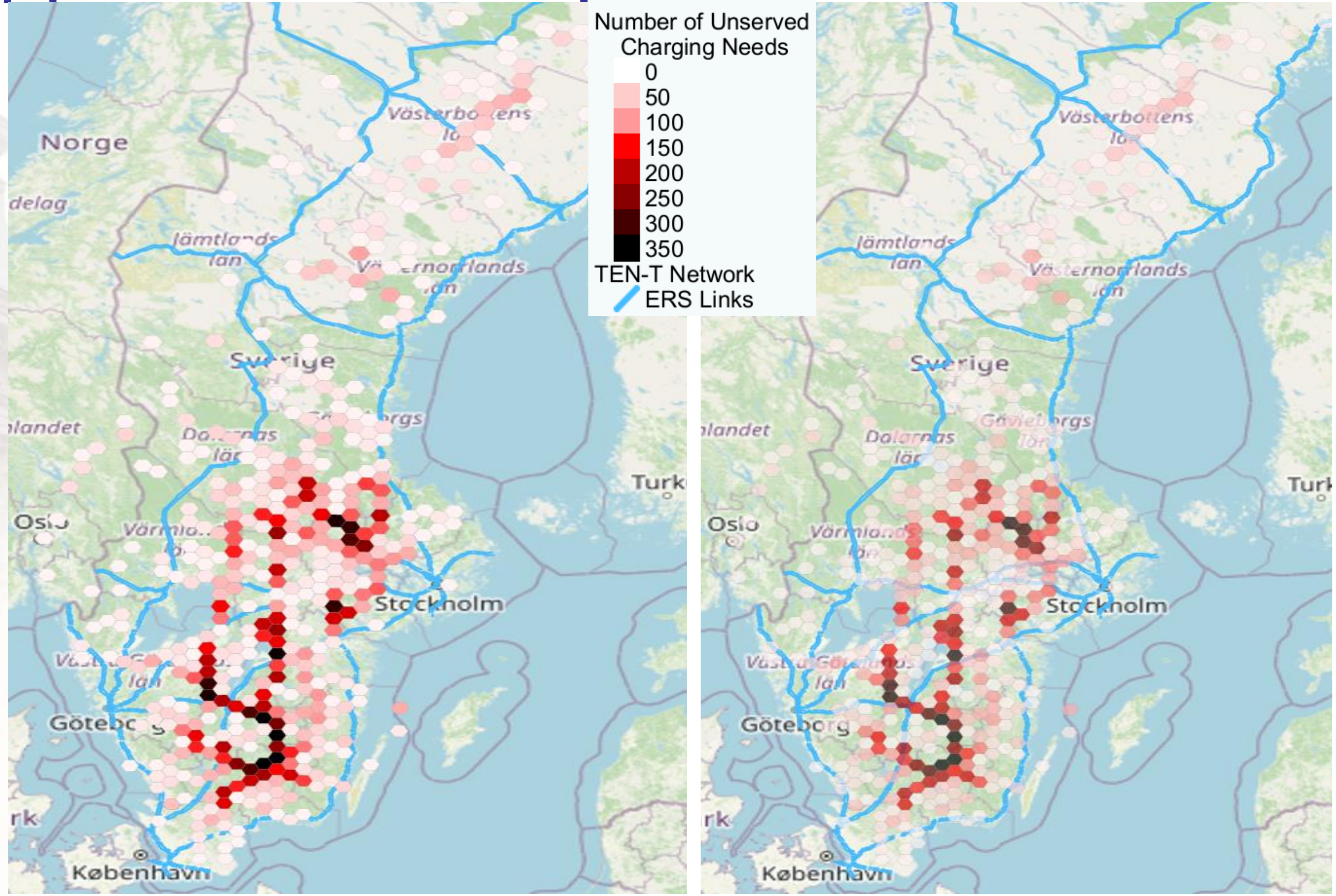
Fixed SOC Threshold

P_ERS=150 kW

K_ERS = 50%

Coverage= 91.8%

SOC_Thr=80%



Minimize ERS Usage

P_ERS=150 kW

K_ERS = 50%

Coverage= 92%

Two ERS Networks with M2

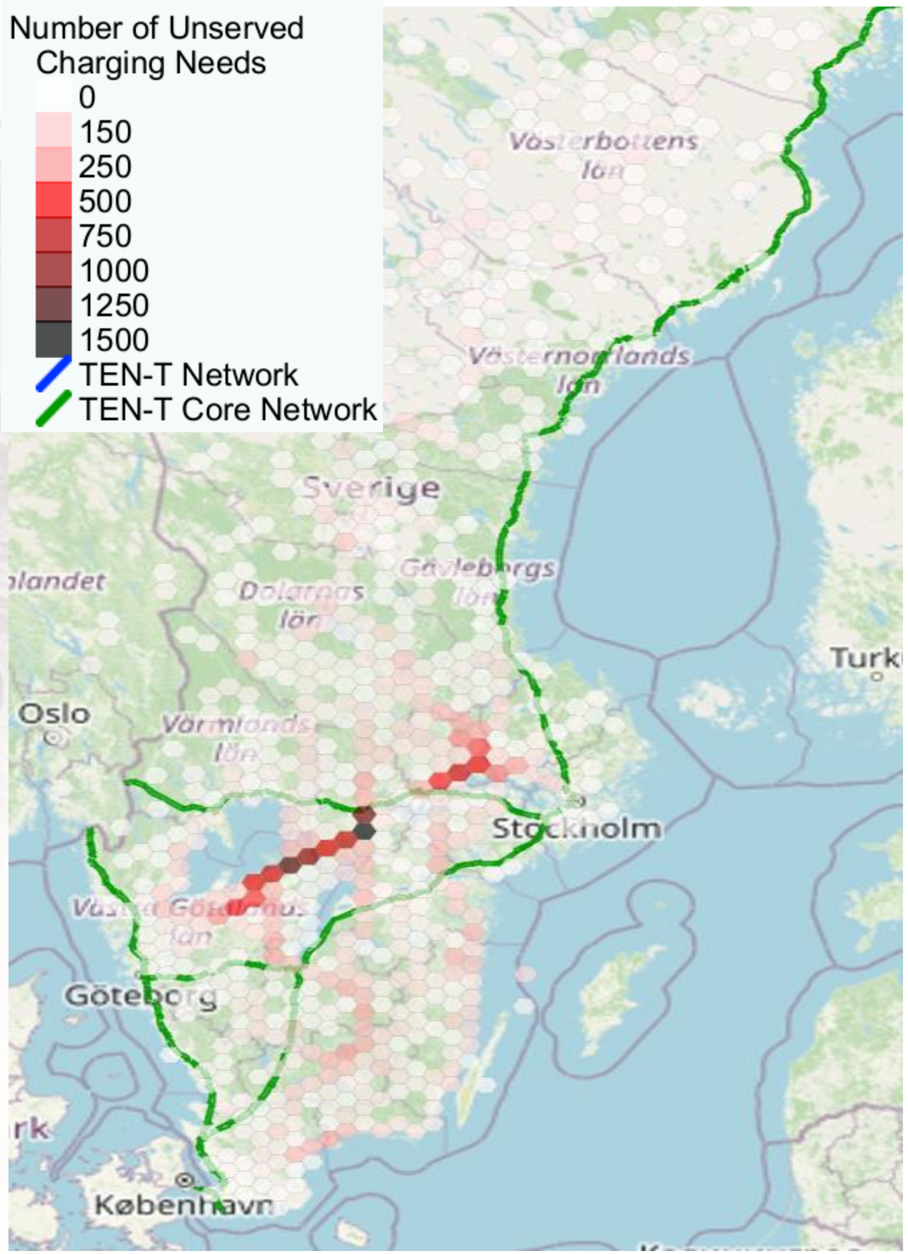
TEN-T core

3270 km

P_ERS=150 kW

K_ERS = 50%

Coverage= 81%



TEN-T

6698 km

P_ERS=150 kW

K_ERS = 50%

Coverage= 92%

Future Works

- Develop a scenario for both the Fast-charging station and ERS.
  - ✓ *Implement charging logic in the presence of both charging options.*
- Cost assessment for different ERS network implementations.
- Incorporating trucks into the simulation to better understand ERS performance for heavy-duty vehicles.

Thank you for listening

- Questions?

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