

OPTIMIZATION OF EV FLEET CHARGING STATION PLACEMENT WITH MATSIM



HELMUT SCHMIDT
UNIVERSITÄT

Universität der Bundeswehr Hamburg

Authors - Yash Ghayal¹, Maik Plenz², Andreas Stadler³, Amra Jahic⁴, SiZhong Hu⁵,
Timofey Volotskiy⁶, Yaroslav Smirnov⁷, Detlef Schulz⁸



1 Yash Ghayal, Helmut-Schmidt-Universität/Universität der Bundeswehr Hamburg, Germany

2 Maik Plenz, Helmut-Schmidt-Universität/Universität der Bundeswehr Hamburg, Germany,

3 Andreas Stadler, Helmut-Schmidt-Universität/Universität der Bundeswehr, Hamburg, Germany

4 Amra Jahic, Helmut-Schmidt-Universität/Universität der Bundeswehr Hamburg, Germany,

5 SiZhong Hu, Helmut-Schmidt-Universität/Universität der Bundeswehr Hamburg, Germany,

6 Timofey Volotskiy, Replan GmbH, Berlin, Germany

7 Yaroslav Smirnov, Replan GmbH, Berlin, Germany

8 Detlef Schulz, Helmut-Schmidt-Universität/Universität der Bundeswehr Hamburg, Germany

Presented by - Yash Ghayal

- Motivation
- Research question
- Study
- Methodology
- Results
- Conclusion
- Future scope

- EV adoption increasing - effective charging infrastructure is needed.
(i.e. more than 5 million public chargers worldwide, +30% ↑ in 2024¹)
- EV charging - affects peak loads and energy demand.
- Poor charging locations - user convenience ↓ and grid impact.
- EVs ↑ - Charging demand ↑ - Peak loads ↑ - Smart placement of EV charging stations
(user convenience + grid stability).

- How EV public charging station placement can be optimized and what are its impact on energy demand and peak loads across the city?
- Minimize walking distances between agent activity locations to charging stations and study its effect on -
 - I. Charging accessibility (i.e. walking distances and charging events)
 - II. Energy impacts (i.e. district level energy demand, peak loads and temporal energy demand)

- Agent based simulation platform - MATSim²
- 2024 public charging stations with 2030 charging demand (more charging plugs).
- 3,04,600 EVs from the open Hamburg MATSim scenario using a 50% demand sample, scaled results on a typical workday.
- Baseline scenario - charging stations with 2214 plugs.
- Optimized scenario - optimized charging station placement with same number of plugs.

- Goal - To improve accessibility of public EV charging.
(Walking-distance-based accessibility, inspired by Hamburg-takt-concept³)
- Process - City districts divided into small hexagonal zones, charging stations are assigned in these zones.
- Model - MATSim (Multi-agent transport simulation) for tracking agent activity and charging demand.
- Charging decision - based on SoC, charging station selection - based on monetary charging costs and walking-time disutility.

- **Step 1 - Compute zone priorities (probability)**

- For each hexagon zone z -

- Calculate avg.walking distance -

distance(z) = avg. walking distance of agent activities to nearest charging stations in that zone(z)

- Calculate excess walking distance relative to Target (D_o) -

excess(z) = $\max(0, \text{distance}(z) - D_o)$

- Calculate zone priority (probability) - (sort hexagons in descending order)

$$\text{probability}(z) = \frac{\text{excess}(z)}{\sum_u \text{excess}(u)}$$

- **Step 2 - Assigning new chargers**

- Assign chargers per zone -

- Calculate desired chargers (want) per zone -

$$\text{want}(z) = \left(\frac{\text{Sessions}(z)}{k} \right) + 1$$

where, k = scaling parameter (i.e. sessions per new plug),

and $\text{want}(z) = \min(\text{want}(z), M)$, M is min no of new plugs allowed in single zone

- Calculate actual chargers (take) considering total budget N and max per zone M

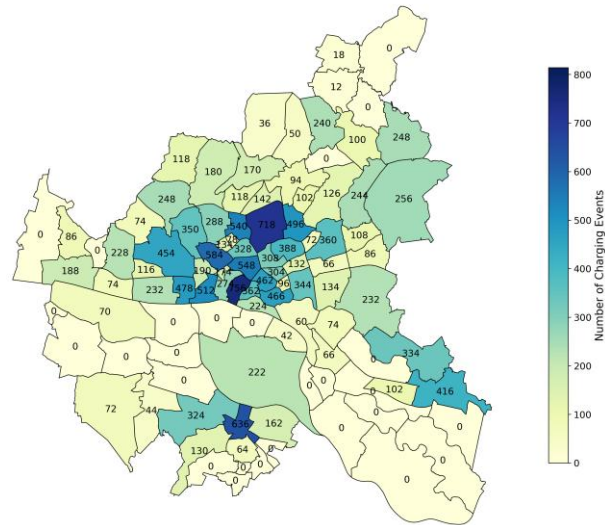
$$\text{take}(z) = \min(\text{want}(z), R)$$

R = Remaining plugs to assign

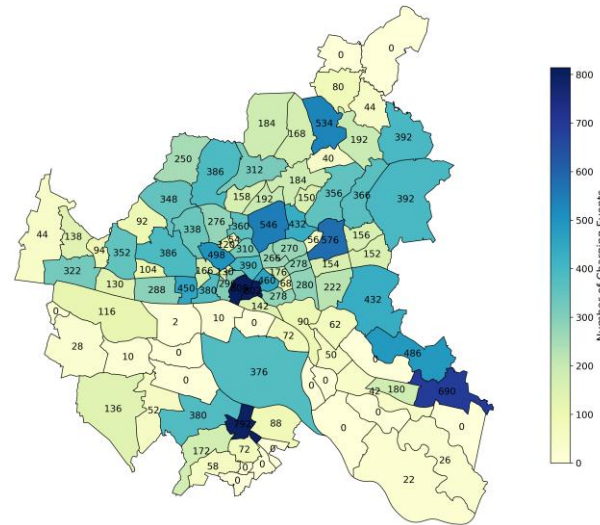
- **Step 3 - Iterative accessibility optimization**
- Assign $\text{take}(z)$ chargers to each hexagonal zone
- Update charging network (with newly assigned plugs per zone)
- Re-run MATSim simulation and recompute walking distances
- Iterate until min. walking distance D_o is achieved or number of iterations are reached.

Charging events

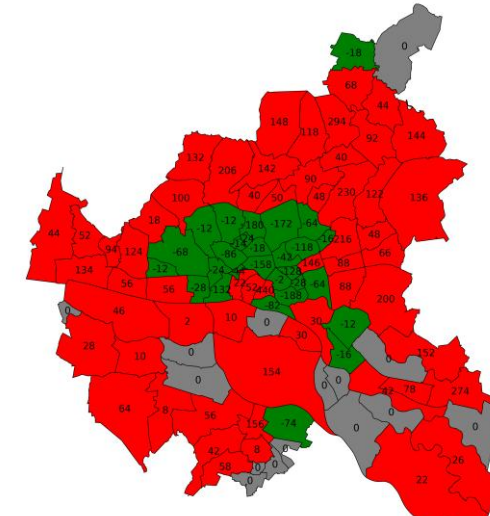
Charging Events per District - Baseline Scenario



Charging Events per District - Walking Distance Optimization

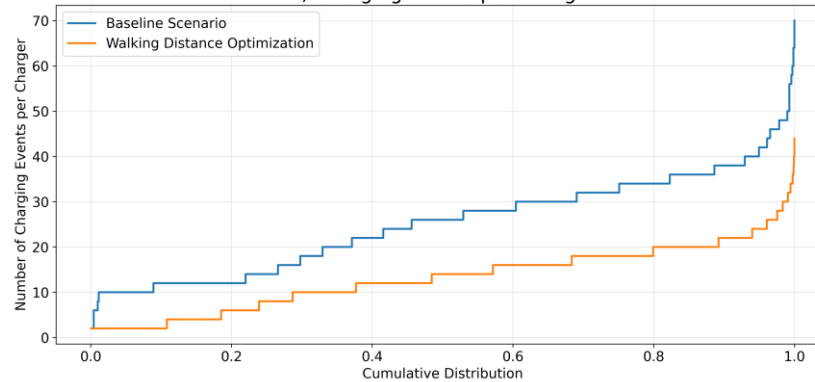


Delta Charging Events (baseline vs optimized)

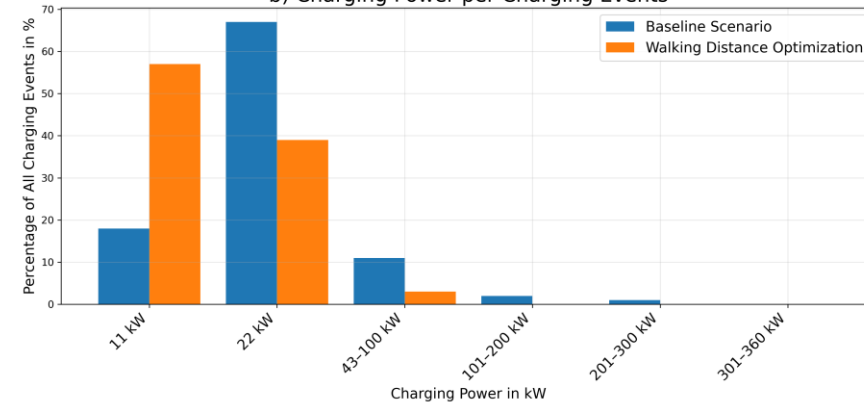


Charging events
per charger -
median ↓ 46 %,
std. dev ↓ 36 %

a) Charging Events per Charger



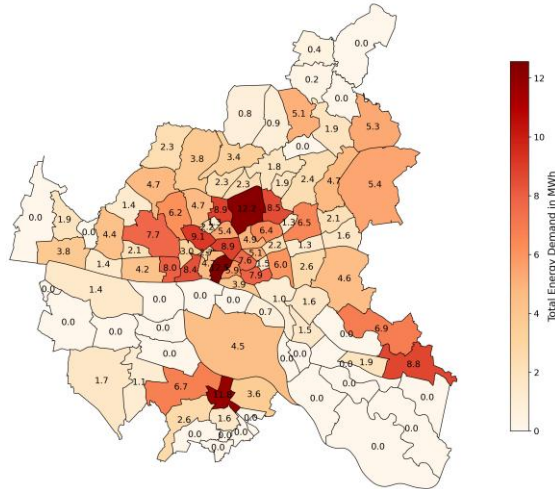
b) Charging Power per Charging Events



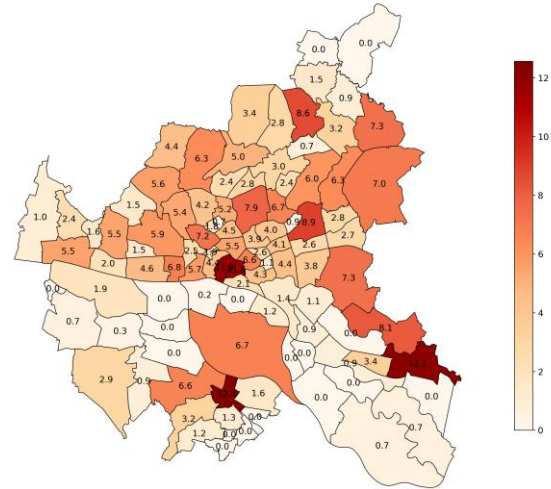
Results - spatial charging demand and peak loads

Energy demand in MWh

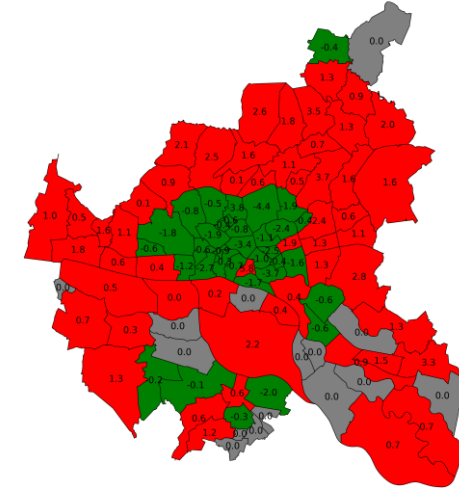
Energy Demand per District in MWh - Baseline Scenario



Energy Demand per District in MWh - Walking Distance Optimization

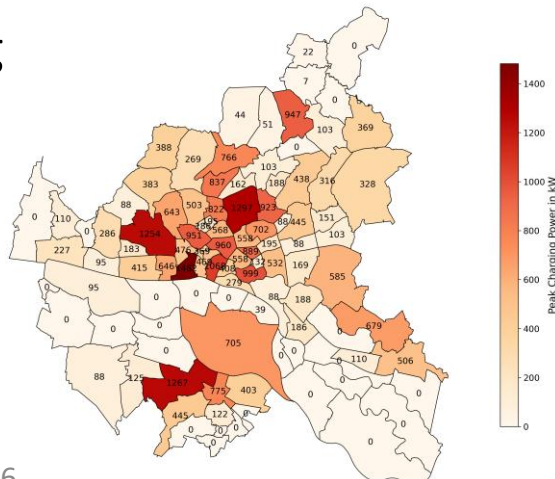


Delta Energy Demand in MWh (baseline vs optimized)

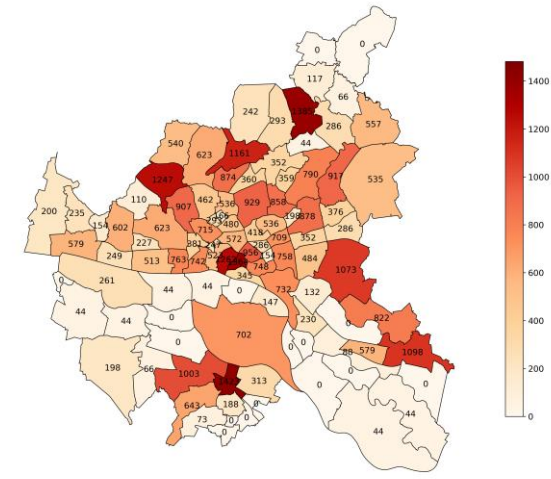


Peak charging power in kW

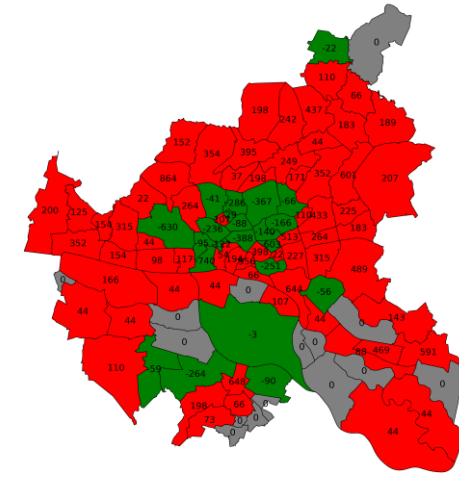
Peak Charging Power per District in kW - Baseline Scenario



Peak Charging Power per District in kW - Walking Distance Optimization



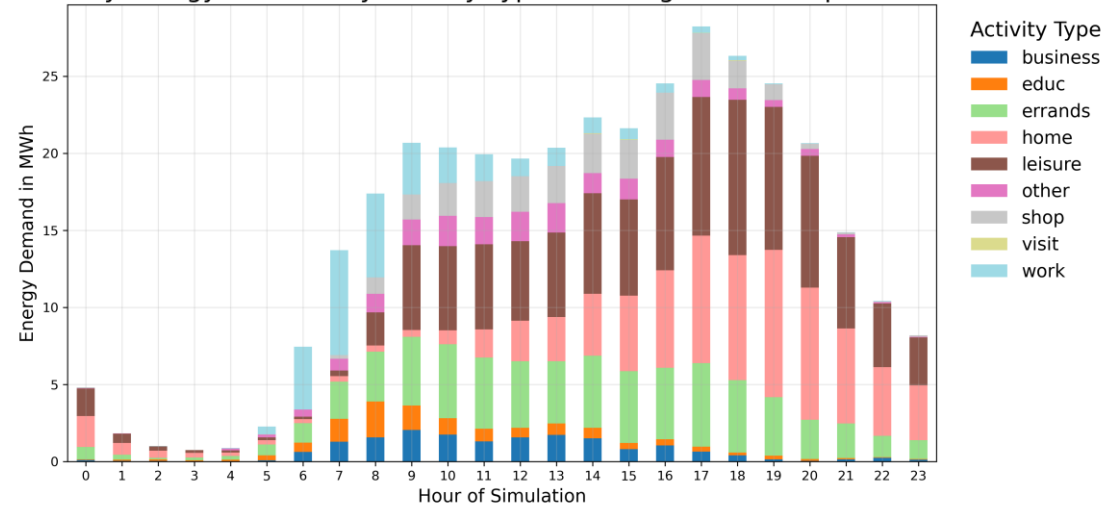
Delta Peak Charging Power in kW (baseline vs optimized)



Results - temporal charging demand and peak loads - optimization

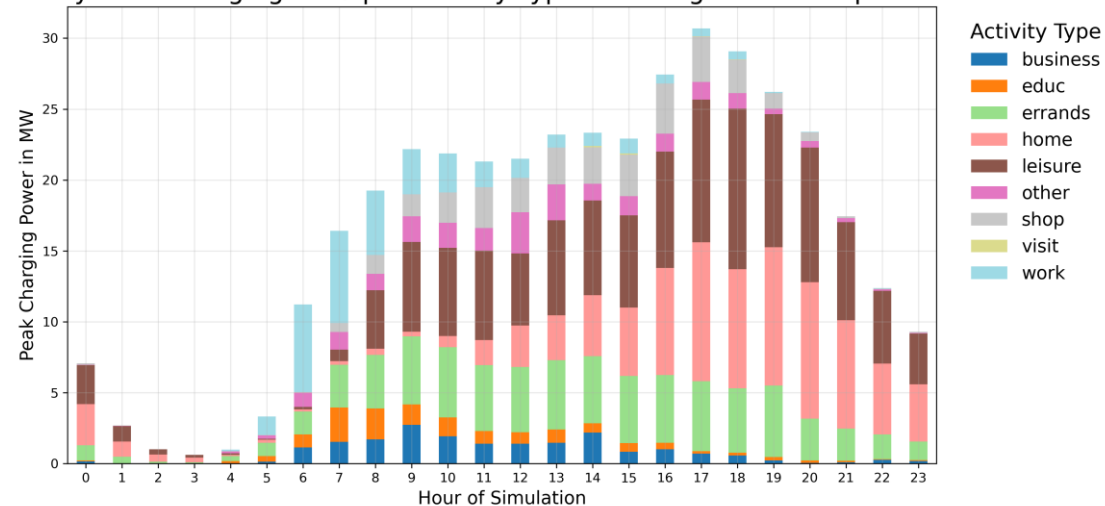
Temporal
energy
demand
in
MWh

Hourly Energy Demand by Activity Type - Walking Distance Optimization



Temporal
peak
charging
load
in
MW

Hourly Peak Charging Load per Activity Type - Walking Distance Optimization



- With the walking distance minimization,
 - Walking distances between agent activities and charging stations reduced.
 - Charging events redistributed - peripheral districts \uparrow , central \downarrow
 - Peak loads and energy demand shifted - grid stress in central areas reduced.
 - Extreme utilization of individual chargers reduced, while total energy is almost same.
 - Temporal peaks - early-morning (work), evening (home/leisure), night (very less).

- Apply to multiple locations / cities.
- Include full-year data, seasonal mobility patterns and future urban growth scenarios.
- dynamic pricing consideration, renewable energy integration.
- multi-modal simulations with accessibility optimization.

- ¹ IEA (2025), Global EV Outlook 2025 Expanding sales in diverse markets, International Energy Agency, July 2025.
- ² Horni Andreas, Nagel Kai, Axhausen Kay, „Multi-Agent Transport Simulation MATSim“, London: Ubiquity Press, 2016.
- ³ Hochbahn AG. Der Hamburg- Takt – Bundesförderprogramm unterstützt Modellprojekt zur Stärkung des ÖPNV in Hamburg, <https://www.hamburg.de/politik-und-verwaltung/behoerden/bvm/projekte-und-initiativen/awht-191768>.

Thank you!

Questions ?