

Agent-based simulation of electric taxicab fleets

Joschka Bischoff, M.Sc. | bischoff@vsp.tu-berlin.de

Dr. Michal Maciejewski | maciejewski@vsp.tu-berlin.de

Motivation

- Current Battery electric vehicles (BEV) have a range of 100-200km
- For urban taxi services, this range is more than sufficient to serve single requests
- Overall daily mileage of a single vehicle is usually higher than vehicle range, so taxis will need to recharge at some point
- Agent based simulation may help to estimate the consequences of BEV taxi fleets for both drivers and passengers

Motivation

- Which influence does a BEV taxi fleet have on a small town's quality of taxi service?
- What happens if taxi demand suddenly increases?
- How much additional charging infrastructure is needed for taxi services?
- Can taxi dispatch by battery state of charge (SOC) be more efficient?

Related work

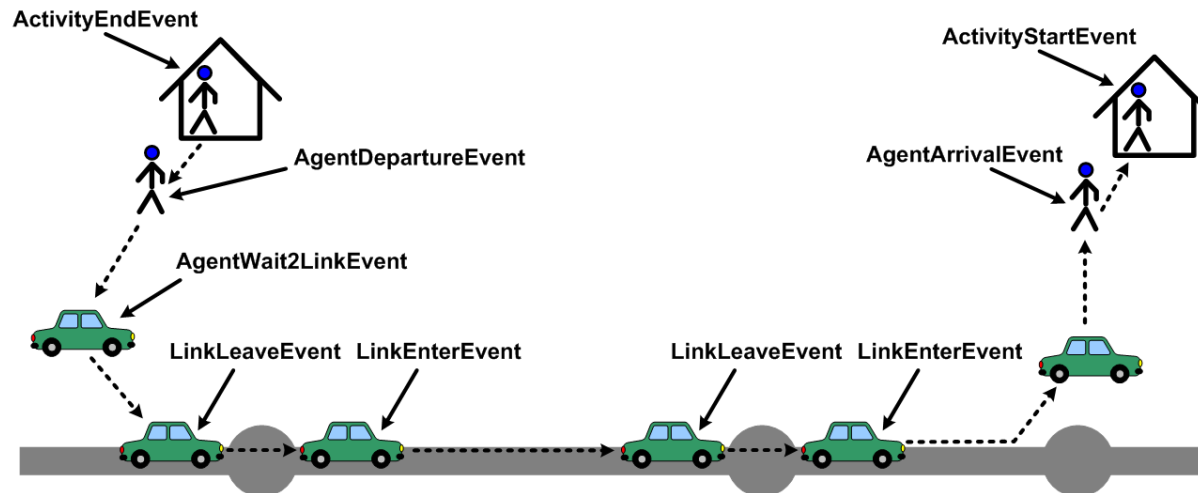
- Some research has been done for Singapore, Seoul and Taipeh
- As far as the authors know, passenger perspective has not been part of this research.
- So far, no combination with a dynamic traffic simulation has been made.

Electric taxis worldwide

- Small fleets of BEV taxis can be found worldwide, e.g. Amsterdam, Tokyo and Tartu (s. below)
- Large scale operations in Shenzhen (600 cars?)

Introducing MATSim

- Multi Agent Transport Simulation
- Simulating peoples' behaviour over the day over multiple iterations
- People optimize their plans according to utility functions and stick to the plan that suites them best
- Dynamic congestion model



General Concept: Taxis in MATSim

- Taxi allocation in MATSim is dynamic according to demand
- Taxi driver agents do not have ordinary MATSim plans to follow
- After serving a request, taxis return to nearest taxi rank, unless there is an immediate follow-up request
- A driver's schedule may look like this:
 - Ra → Re → Re → Ra → Re → Ra → Re → Re → Ra
 - Ra – rank
 - Re – request

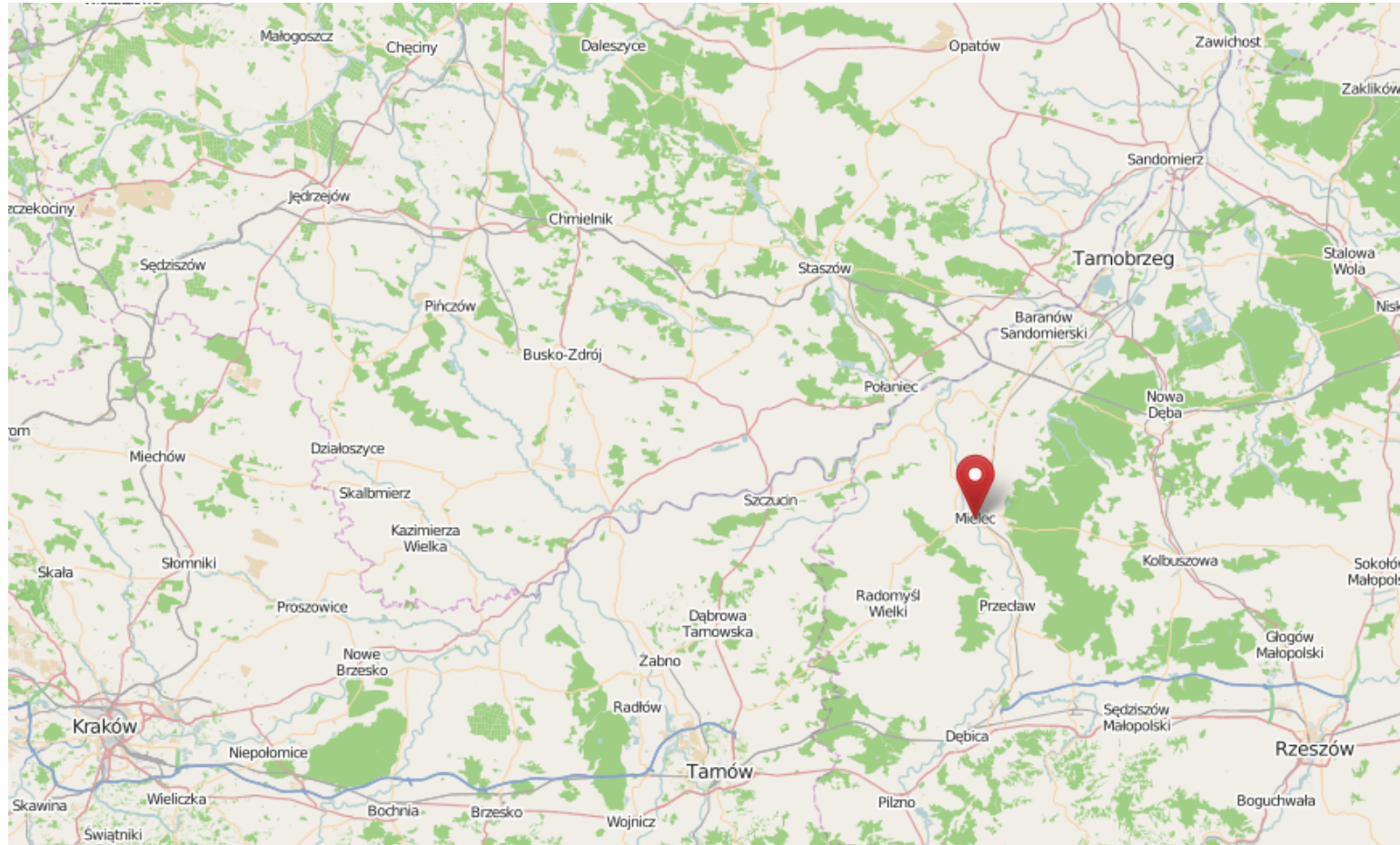
General Concept: electric vehicles in MATSim

- Energy consumption is tracked on link to link base
- It is assumed that vehicles start their day at 100% SOC
- Charging may take place at any taxi rank
- Taxis will be dispatched only to customers if SOC is sufficient

Scenario

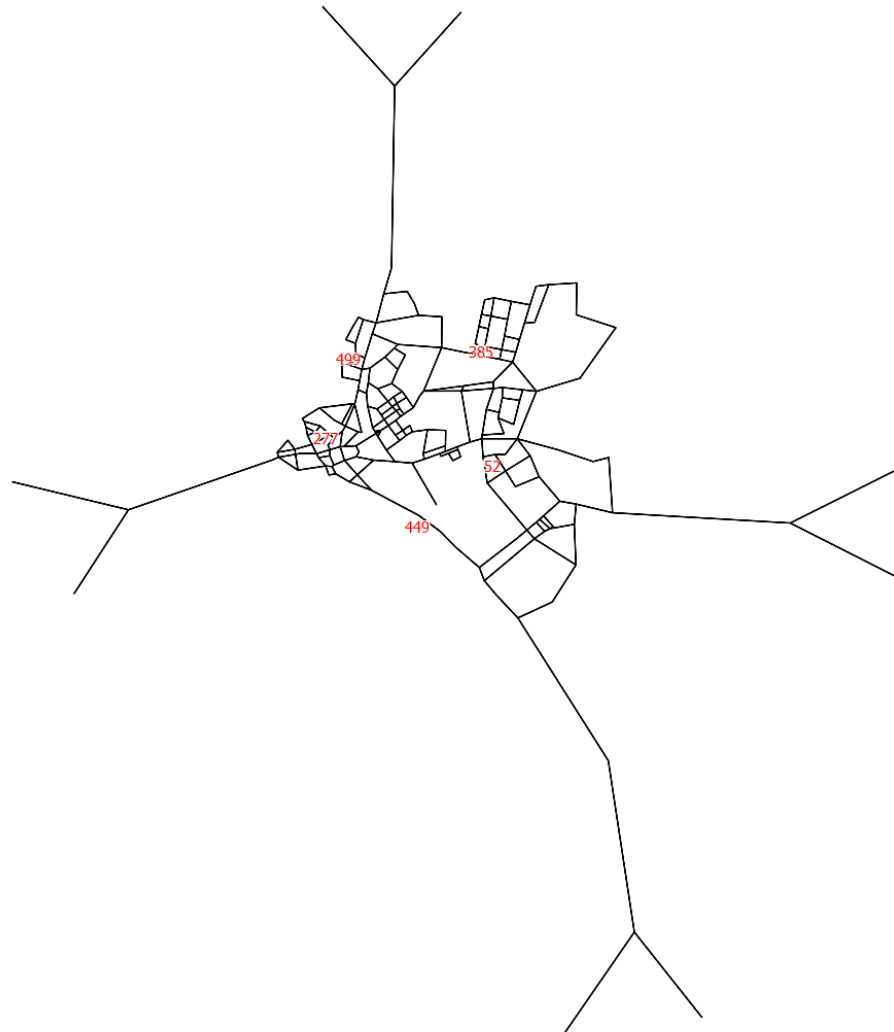
- Based on Polish town of Mielec
- Two peaks around 9:00 and 17:00
- Overall, 42'000 trips
 - initially 1528 taxi trips (5% of inner city trips)
- 50 taxis in service
- 5 taxi ranks
- 126 revenue km per taxi
- Two fleet cases:
 - fleet of gasoline powered cars
 - Fleet of BEV (Nissan Leaf, 20 kWh battery, 50kW fast charging possible)
 - 30 min of charging result in 80% SOC (CHAdeMO)

Network



(OSM)

Network



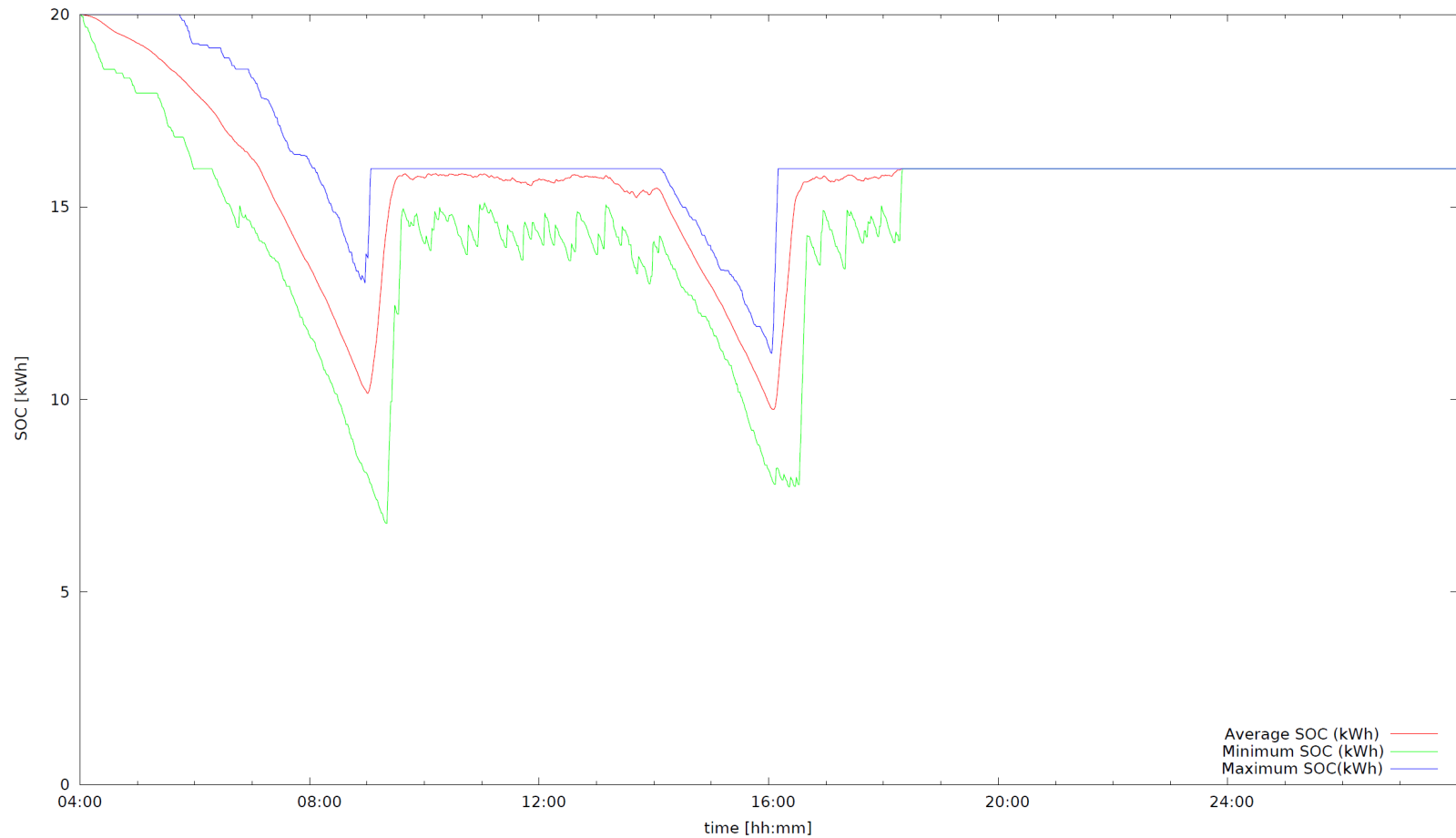
Experiments

Name	Taxi demand [%]	Chargers per rank	Charging power [kW]	Dispatch strategy	Fleet types
STD	5	10	50	FIFO	Gas, BEV
INC	5 – 11	10	50	FIFO	Gas, BEV
CHRG	5	1	50	FIFO	BEV
DISP	5	1	22	FIFO, SOC	BEV

Results: Everyday operations (STD)

- BEV usage has no negative impact on quality of service for taxi customers
- Average waiting time for a taxi 7:12min
- Average total daily mileage: 270km
- Taxis can recharge during times of weak demand

Fleetwide SOC (STD)



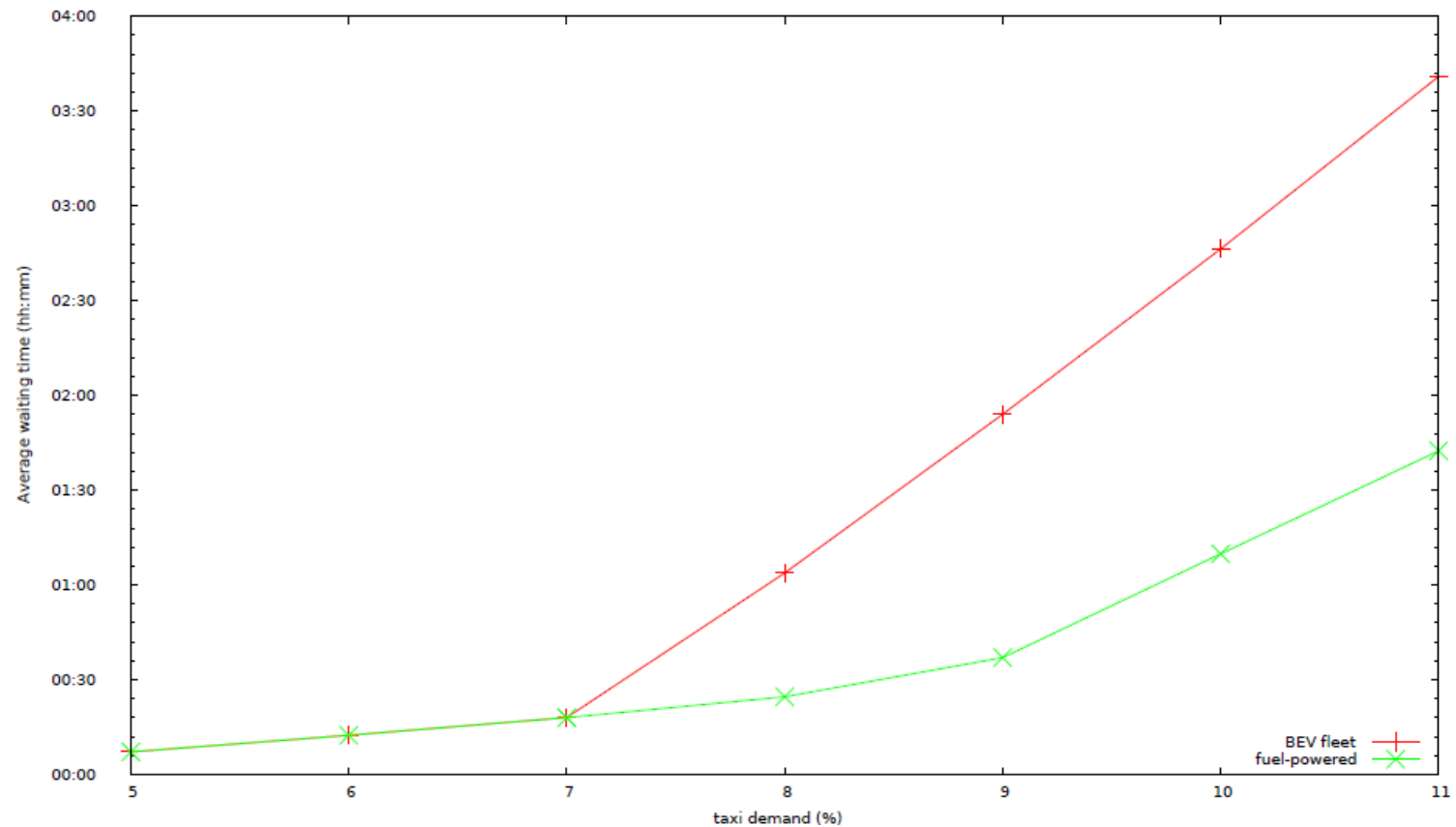
Results: Increased taxi demand (INC)

Name	Taxi demand [%]	Chargers per rank	Charging power [kW]	Dispatch strategy	Fleet types
STD	5	10	50	FIFO	Gas, BEV
INC	5 – 11	10	50	FIFO	Gas, BEV
CHRG	5	1	50	FIFO	BEV
DISP	5	1	22	FIFO, SOC	BEV

Increased taxi demand

- Big events, bad weather or disruptions in public transit trigger sudden peaks in demand for taxi trips
- Until a certain threshold, an electric powered taxi fleet is able to compete with an ordinary powered one very well.
- Further increasing the demand will result in far higher waiting times for customers of electric vehicles

Increased taxi demand: waiting times



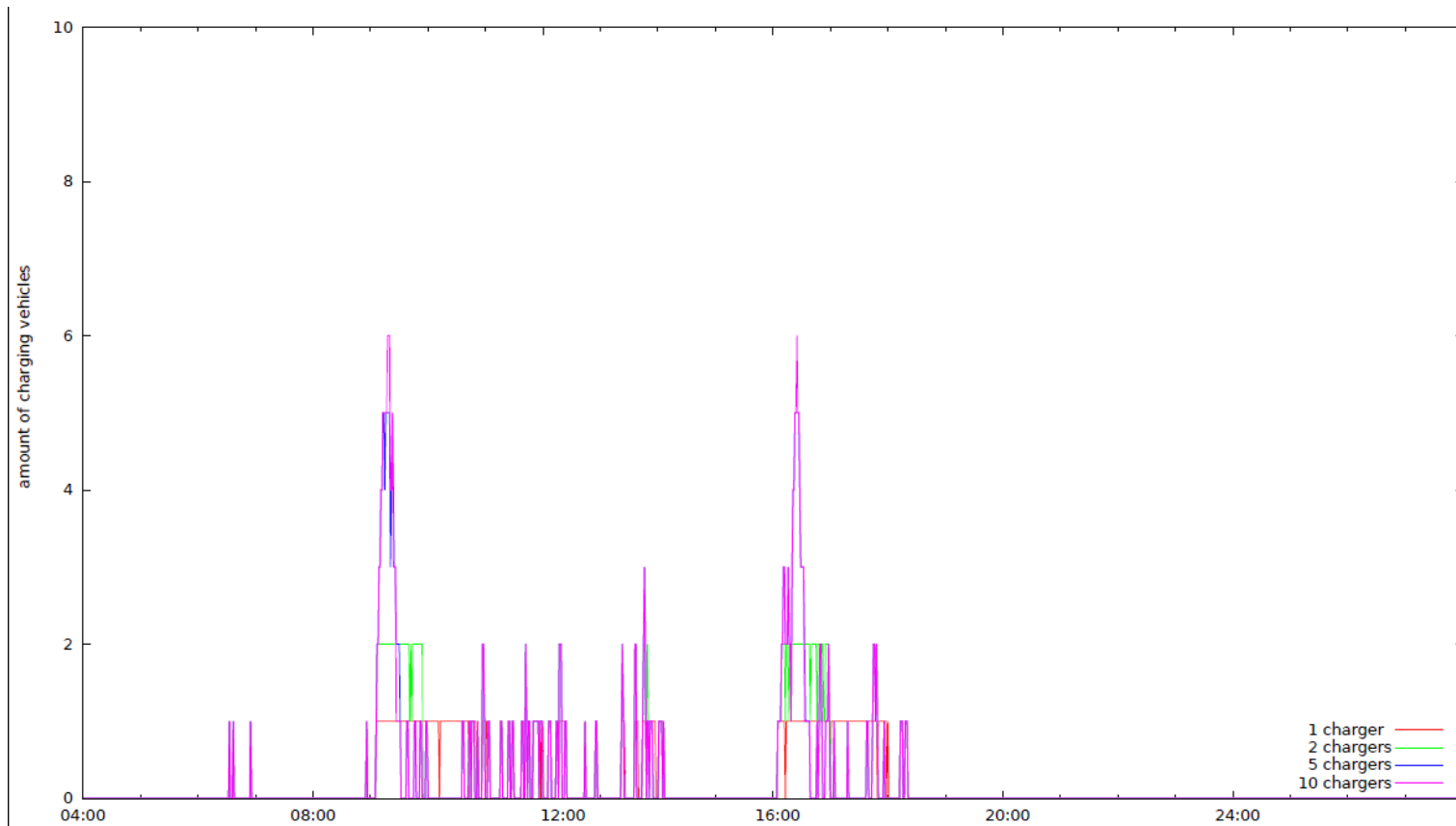
Results: Charging outlet supply (CHRG)

Name	Taxi demand [%]	Chargers per rank	Charging power [kW]	Dispatch strategy	Fleet types
STD	5	10	50	FIFO	Gas, BEV
INC	5 – 11	10	50	FIFO	Gas, BEV
CHRG	5	1	50	FIFO	BEV
DISP	5	1	22	FIFO, SOC	BEV

Results: Charging outlet supply (CHRG)

- In previous experiments, charger amount was unlimited
- Reducing the amount of chargers to 5, 2 and one per rank
- No influence on quality of service
- different request-to-taxicab assignment
- No charging peaks anymore

Results: Charging outlet supply (CHRG)



Results: Modifications in taxi dispatch (DISP)

- Taxis are usually dispatched out of ranks by FIFO
- Can a dispatch by SOC produce better results if charging is slow?
- One charger per rank with only 22kW power (e.g. during winter)
→ Wait times for taxis increase to 7:57 min
- Dispatch by SOC reduces waiting times (7:24 min), however some taxi drivers lose revenue
 - Hard to communicate
 - Could only work for companies, not for individual drivers

Conclusion

- BEV may be used in small cities for taxi operations
- No significant behavioural changes for drivers or customers needed
- Sudden demand peaks are harder to serve with BEV
- Ongoing work: Real world taxi demand in Berlin
- How can a taxi operator use ist electric fleet the most efficient ?