

E-Car-Sharing: Modeling, Planning, Incentives

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Topic

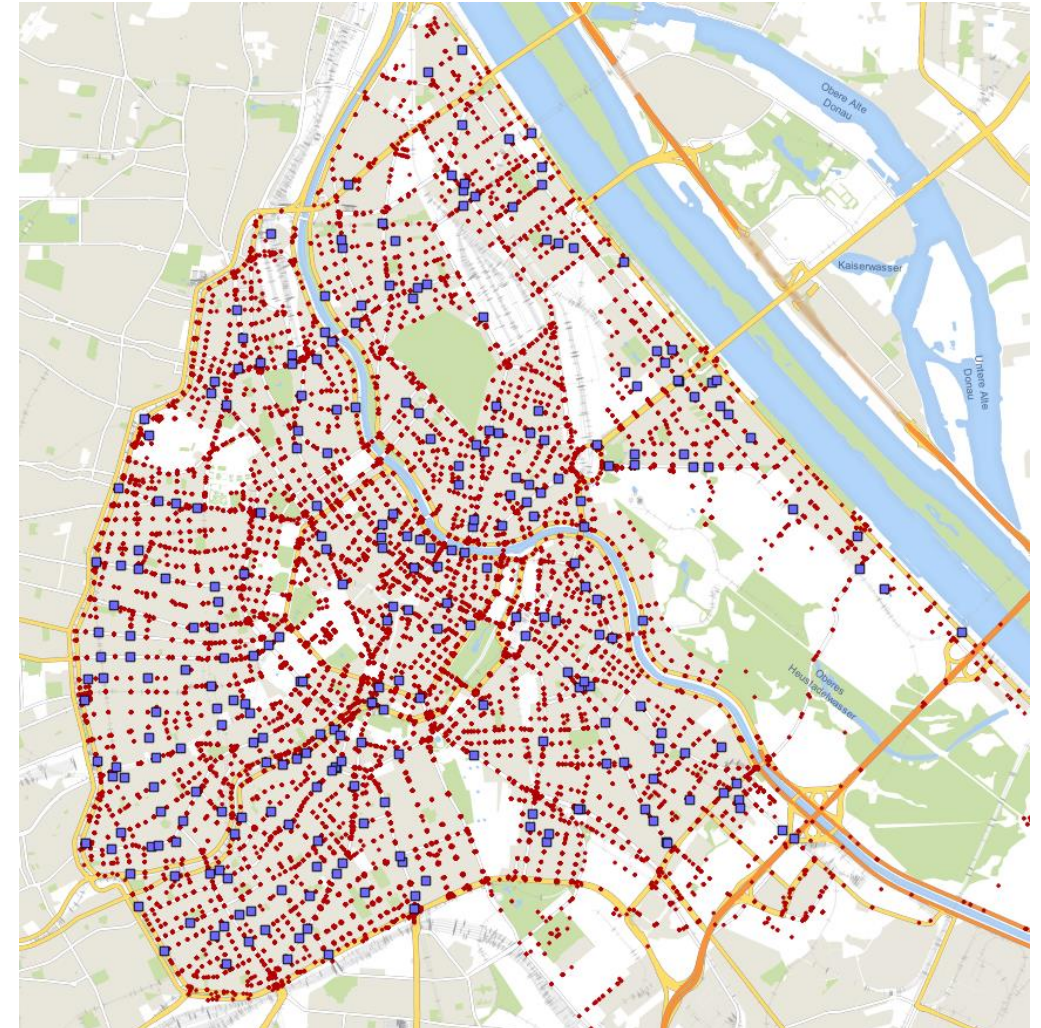
- Methods and strategies for **optimized planning and operating** e-car sharing systems
- **Strategic level**
 - recharging stations
 - fleet configuration
- **Tactical level**
 - incentives
- **Operational level**
 - relocation and recharging



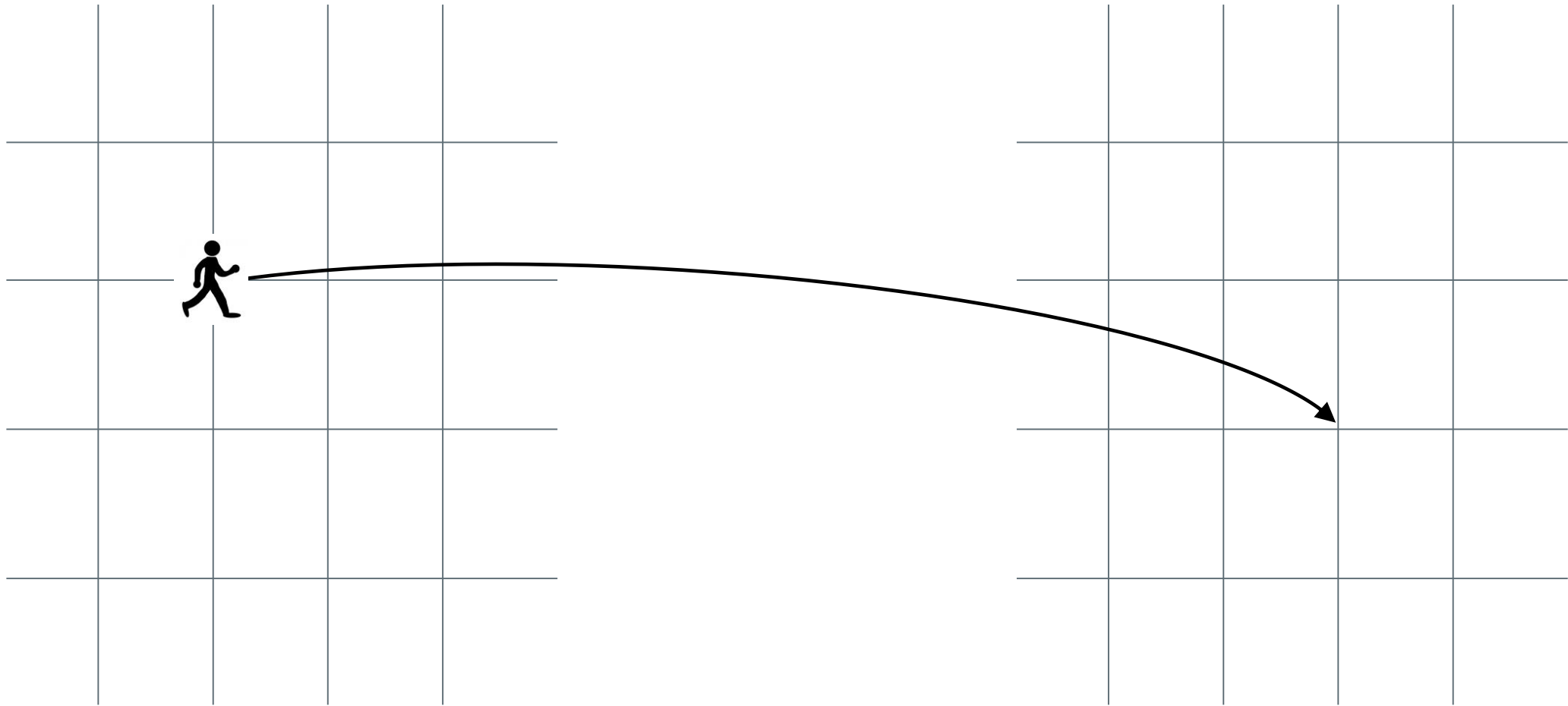
Viennese Use Case

- **Input**
 - Business area + road network
 - Recharging stations can be built on certain street junctions
 - Investment budget (for cars + stations)
 - Demand prediction for user trips

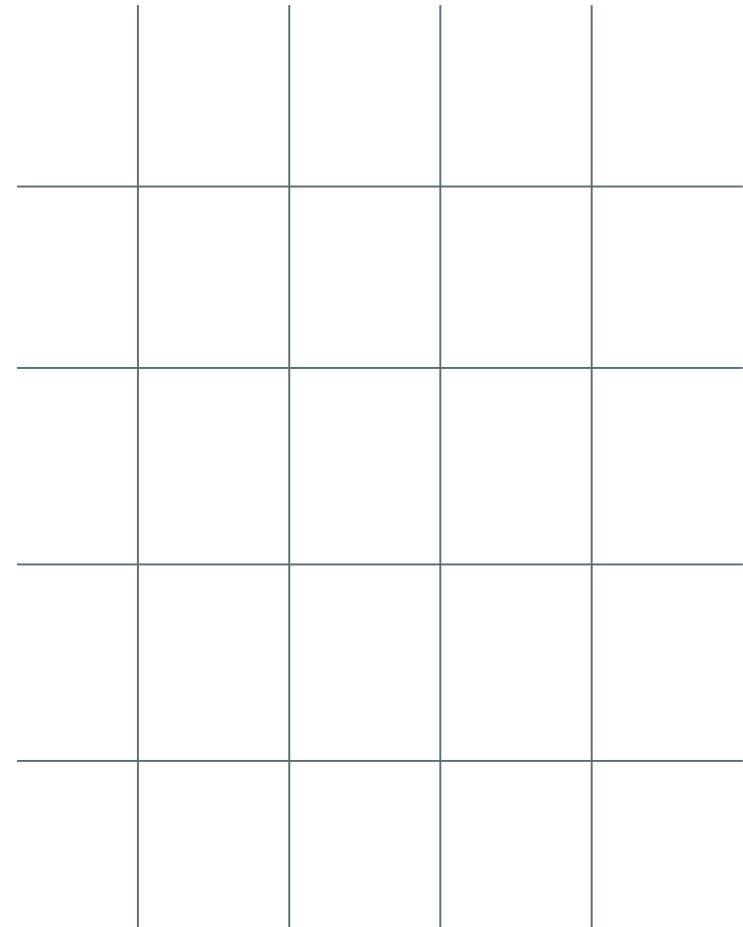
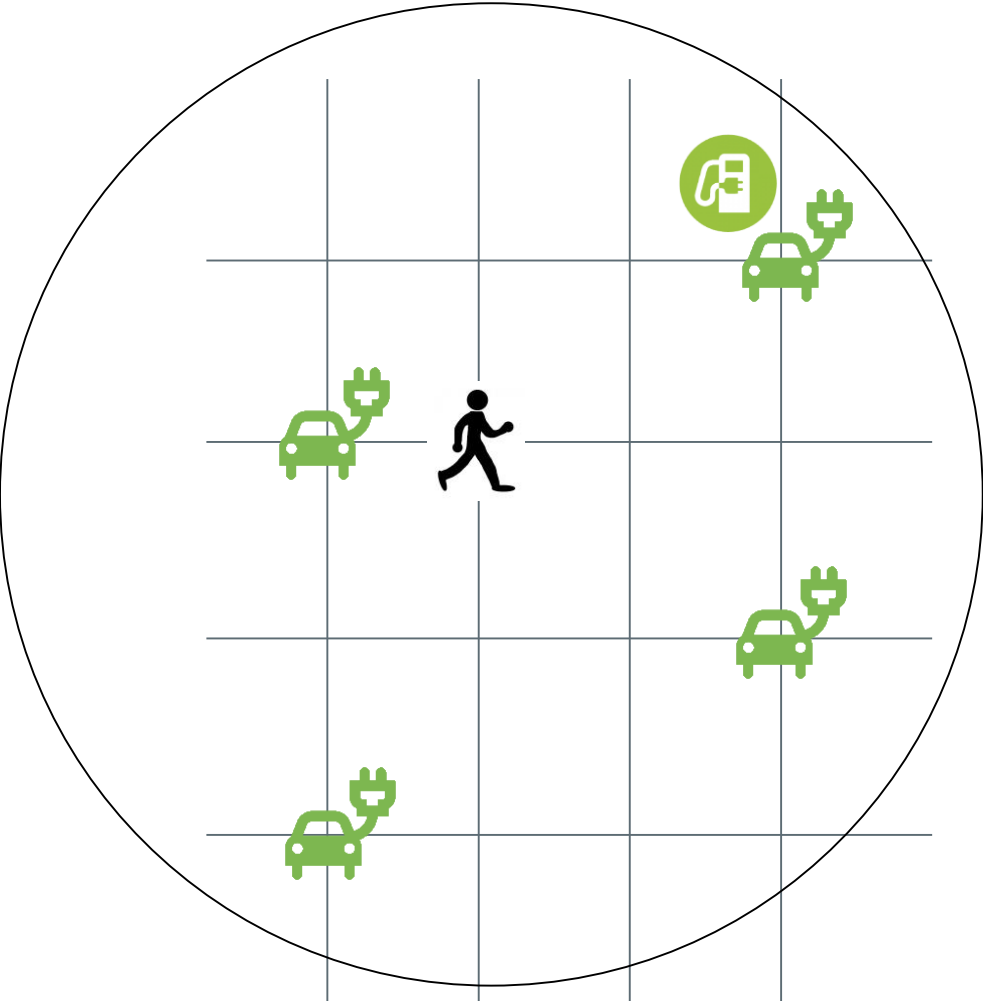
- **Goal**
 Maximize the **expected profit** by
 - Balancing the **number of cars and stations**
 - Planning the **locations for recharging stations**
 - Choosing the right **incentives**



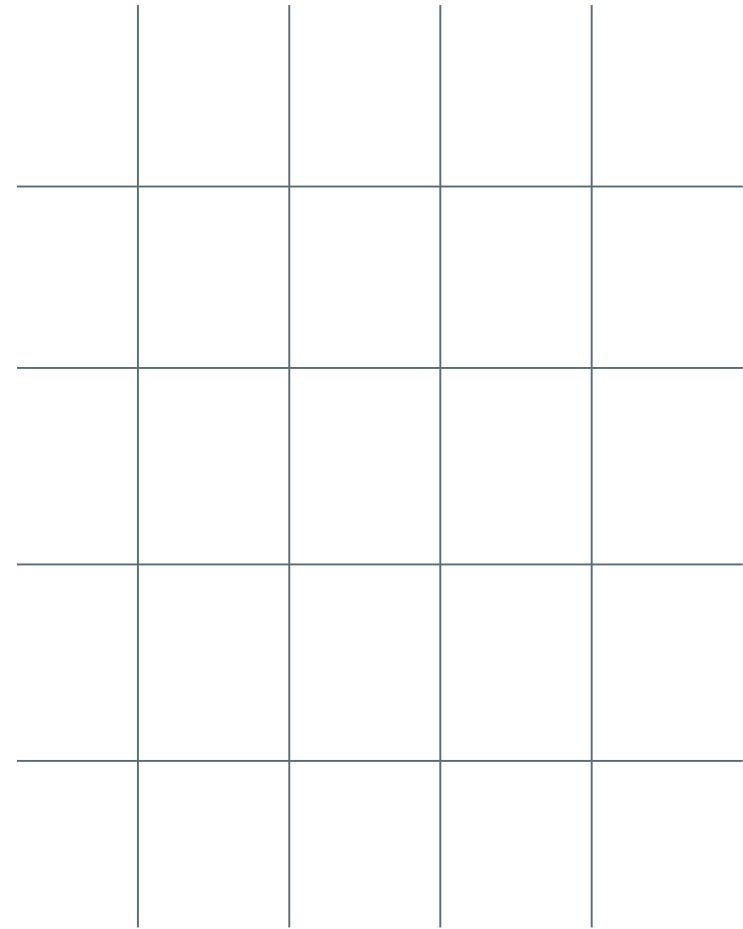
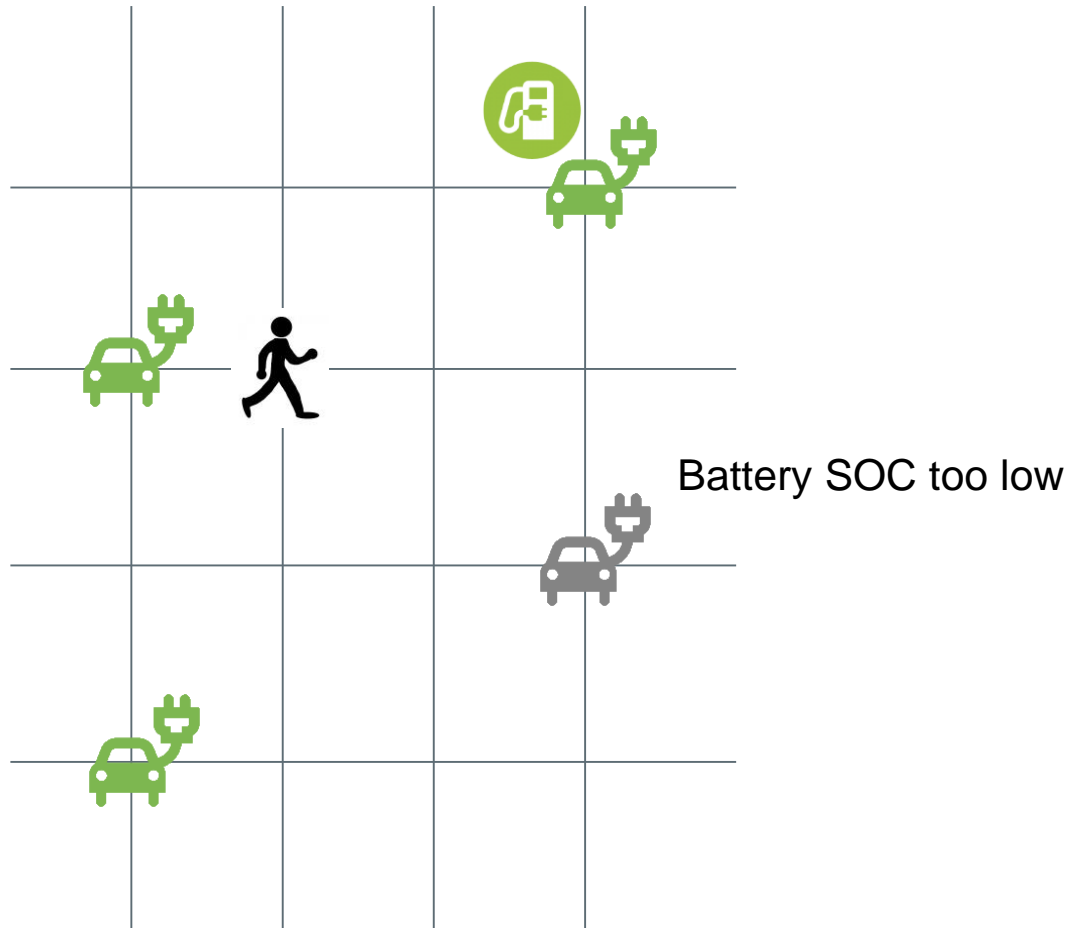
Modeling User Choices



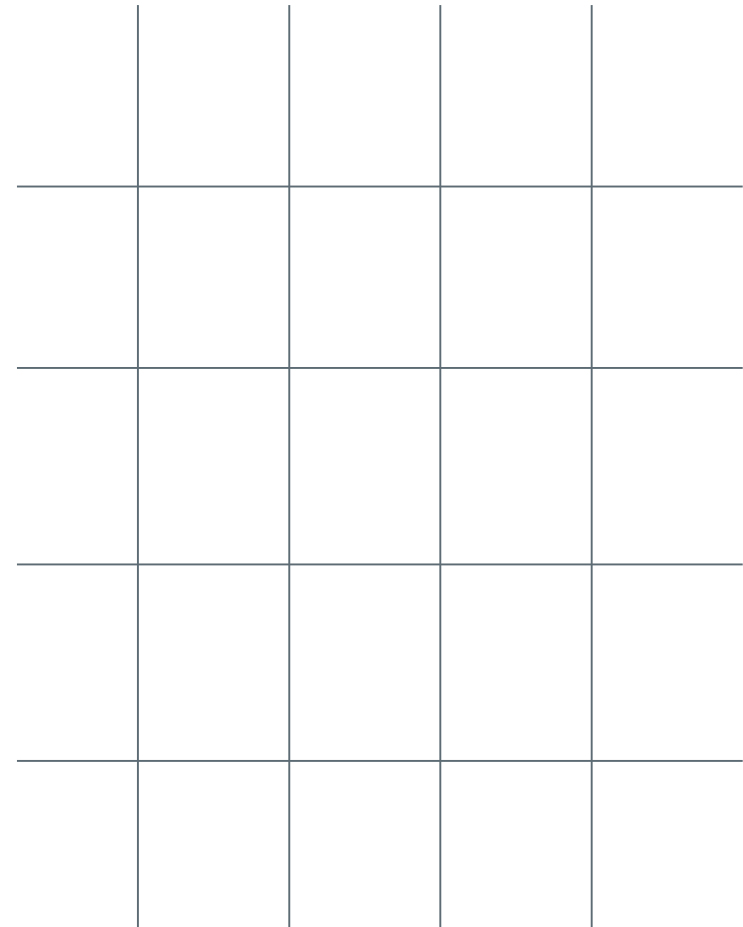
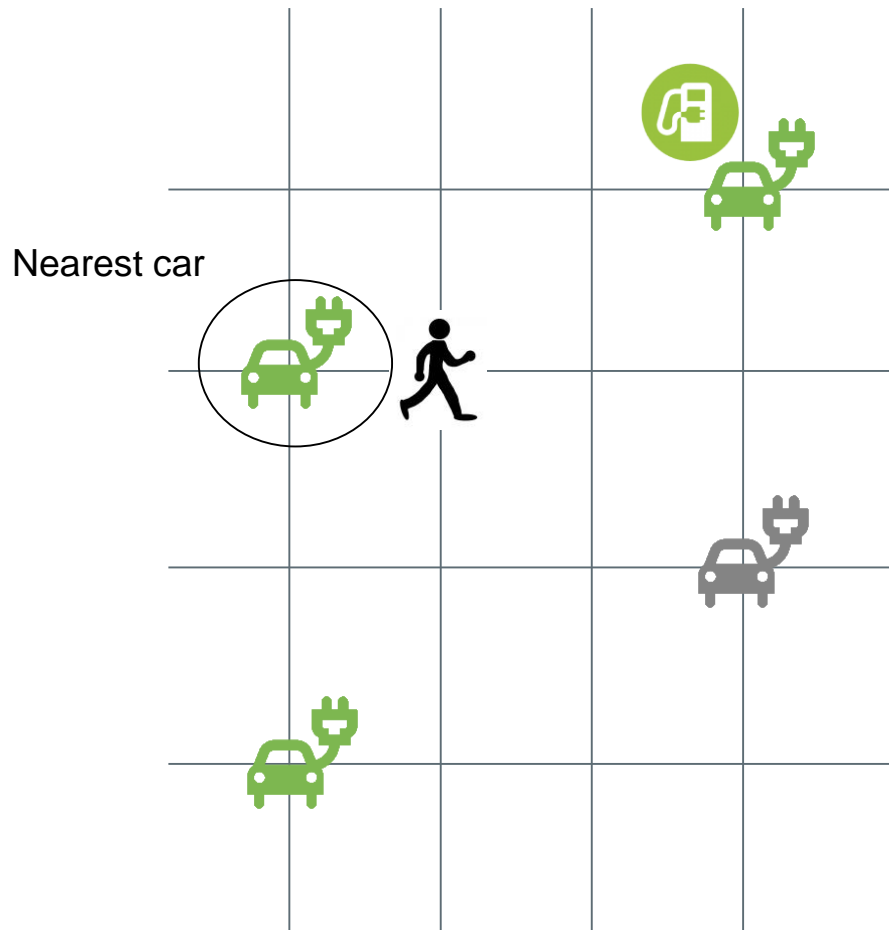
Modeling User Choices



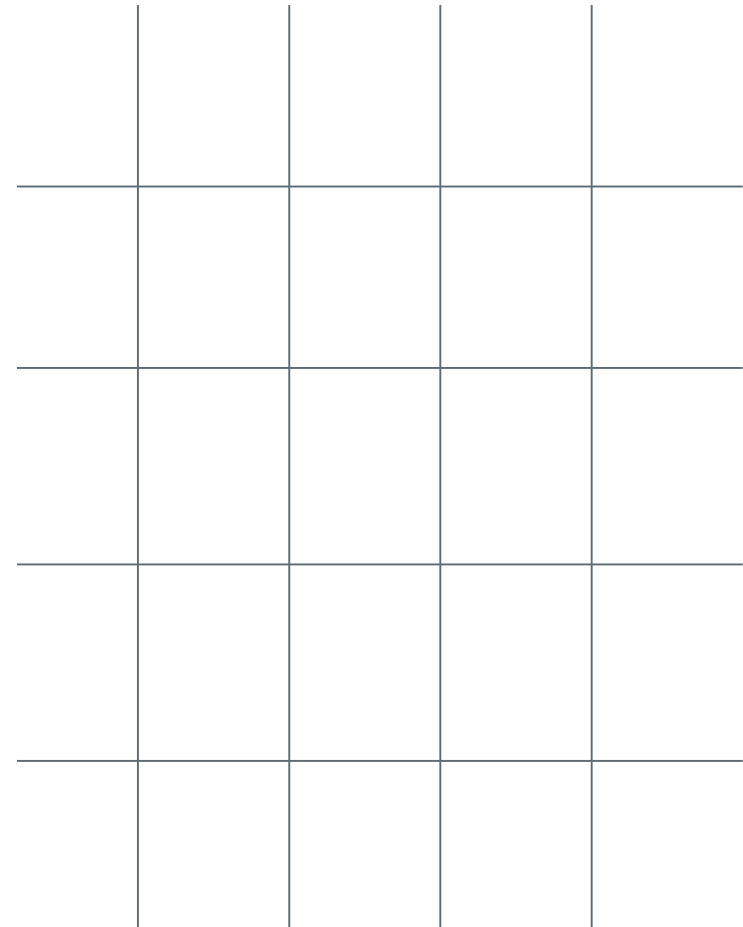
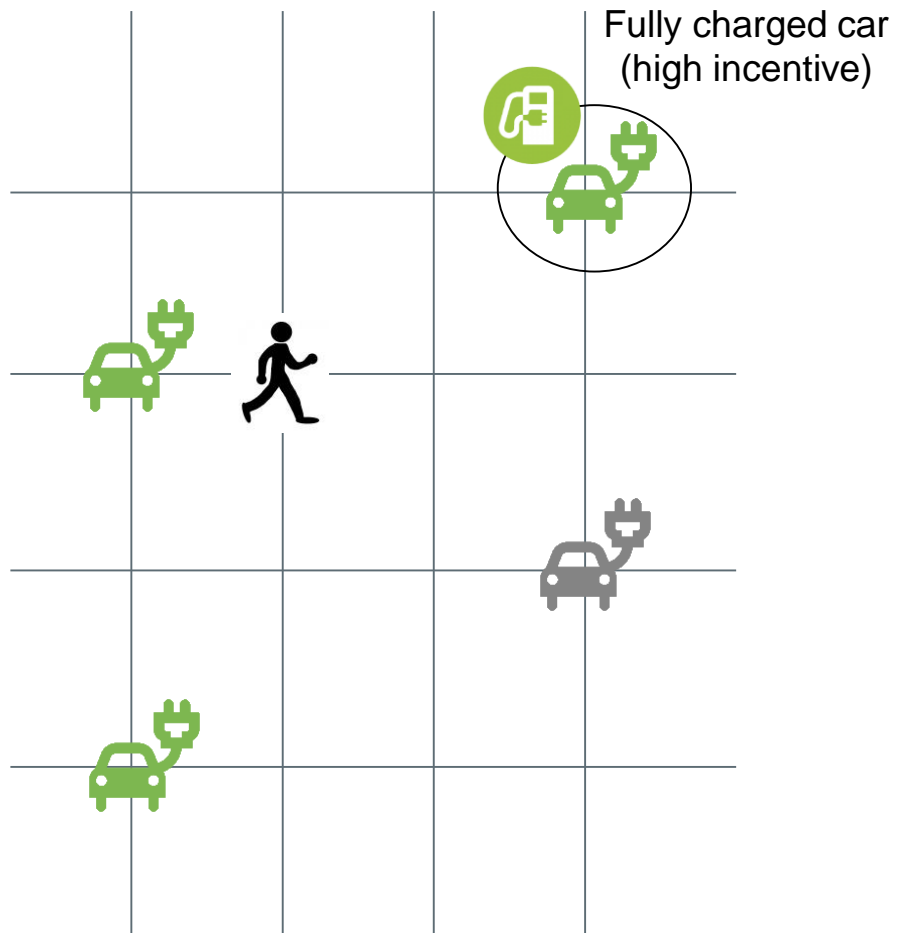
Modeling User Choices



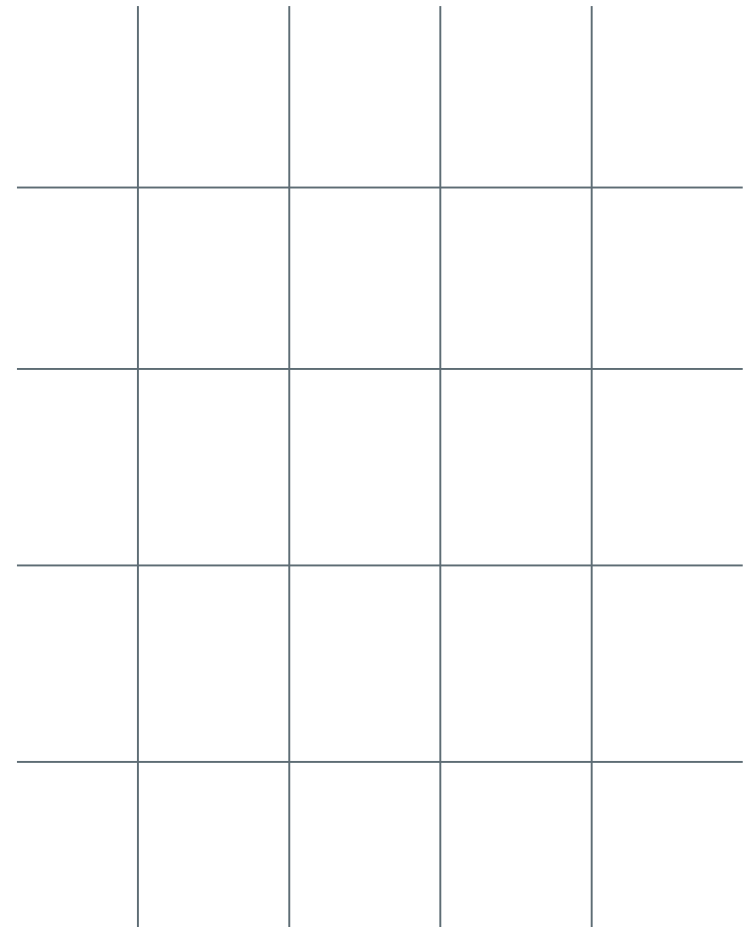
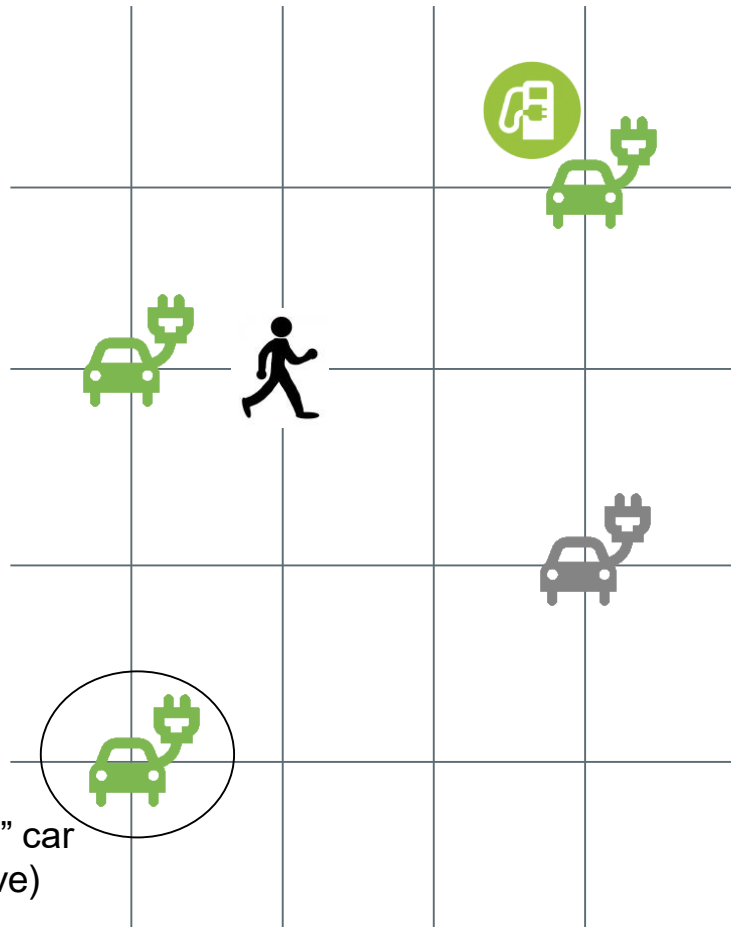
Modeling User Choices



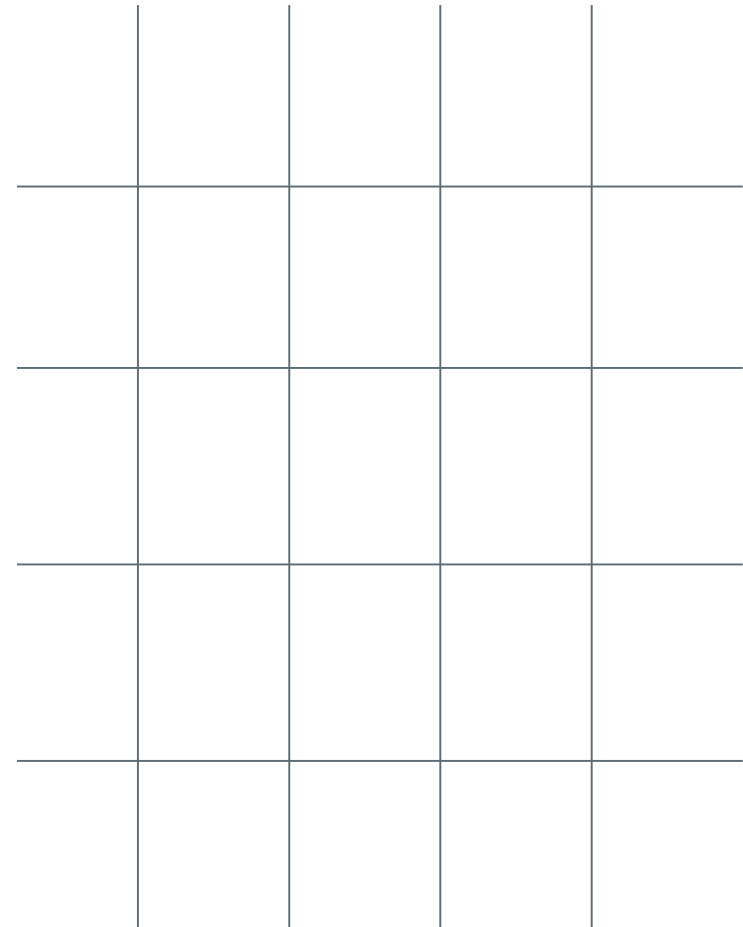
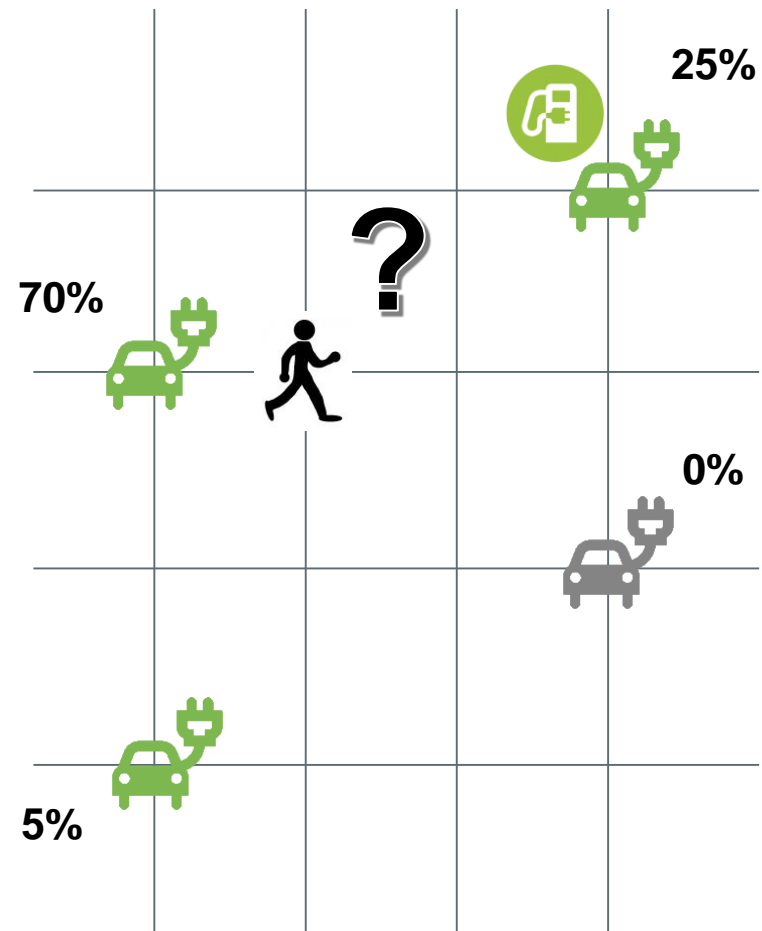
Modeling User Choices



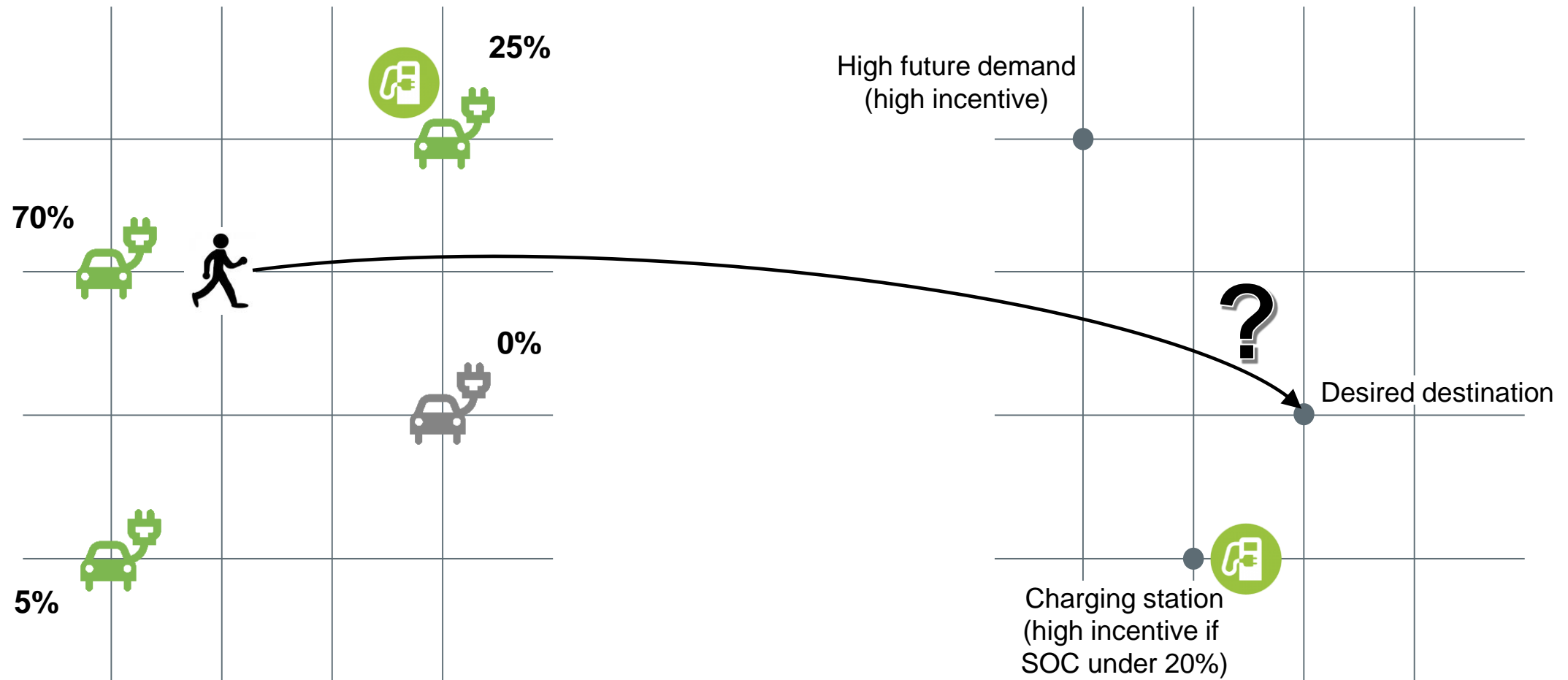
Modeling User Choices



Modeling User Choices



Modeling User Choices




Incentives and User Acceptance

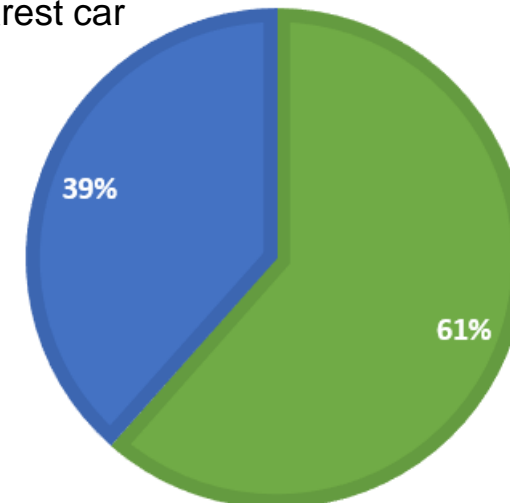
- **Questionnaire**
 - Income
 - Typical car-sharing usage behavior
 - Goodies/incentives that are appealing

- Computation of “**shadow wages**” – value of time

- **Results**
 - ~**39%** of the users are **not likely to accept goodies** at all for taking detours (shadow wage of 66 EUR/h)
 - ~**61%** of the users will **potentially accept goodies** for taking detours (shadow wage of 28 EUR/h)
 - **Amount of incentive** that is reasonable, e.g.:
 - 10 min for charging a car
 - max 25% reduction for taking a stranded car

Online questionnaire by 

Always pick up
nearest car



Depends on incentive
and detour distance

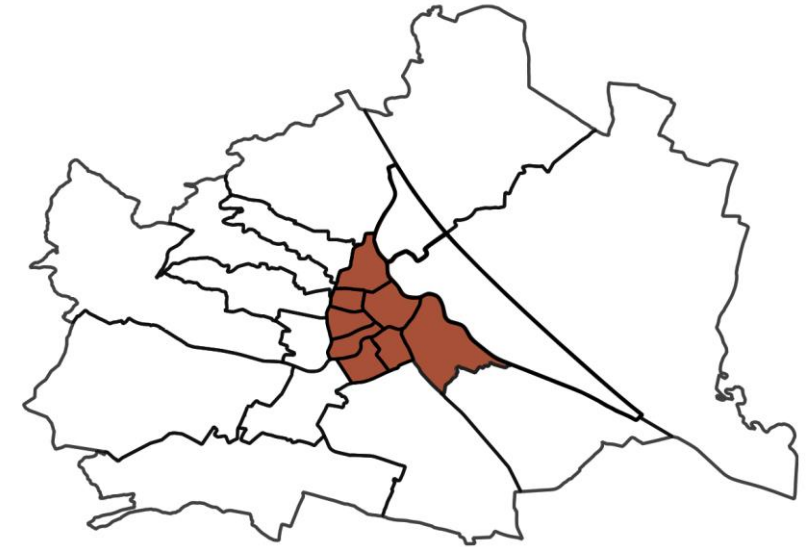
Computational Experiments

- **Scenario settings**

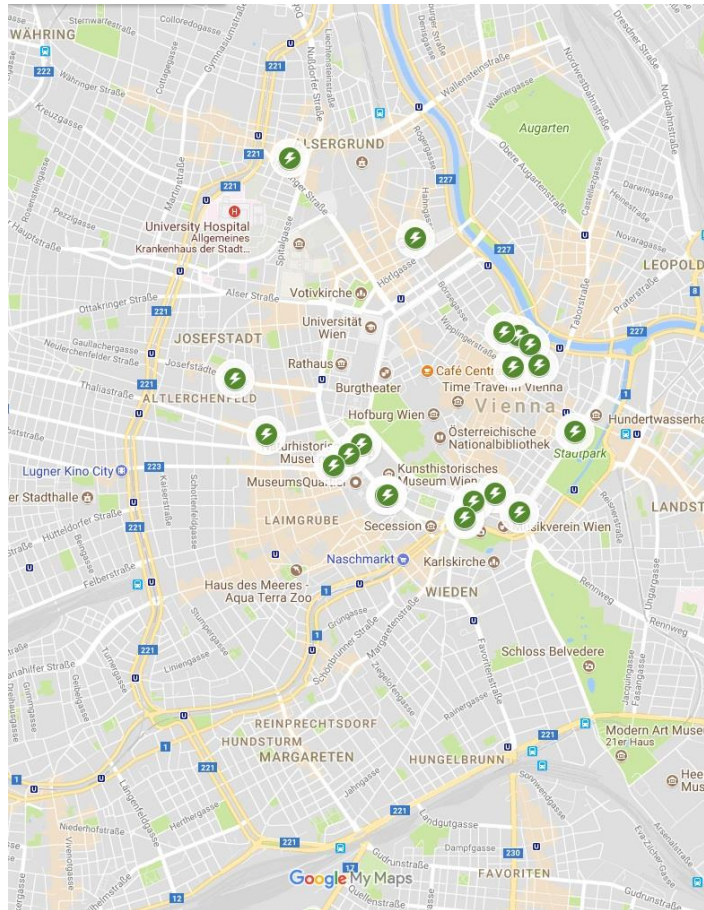
- Investment budget of **500k – 1M Euro**
- Different business area sizes
- Vehicle fleet: **Smart ED** with average **50% SOC**
- Users are willing to **walk 3 min** to a car / to their destination
- Demand model based on **Taxi data**

- **Solution algorithm**

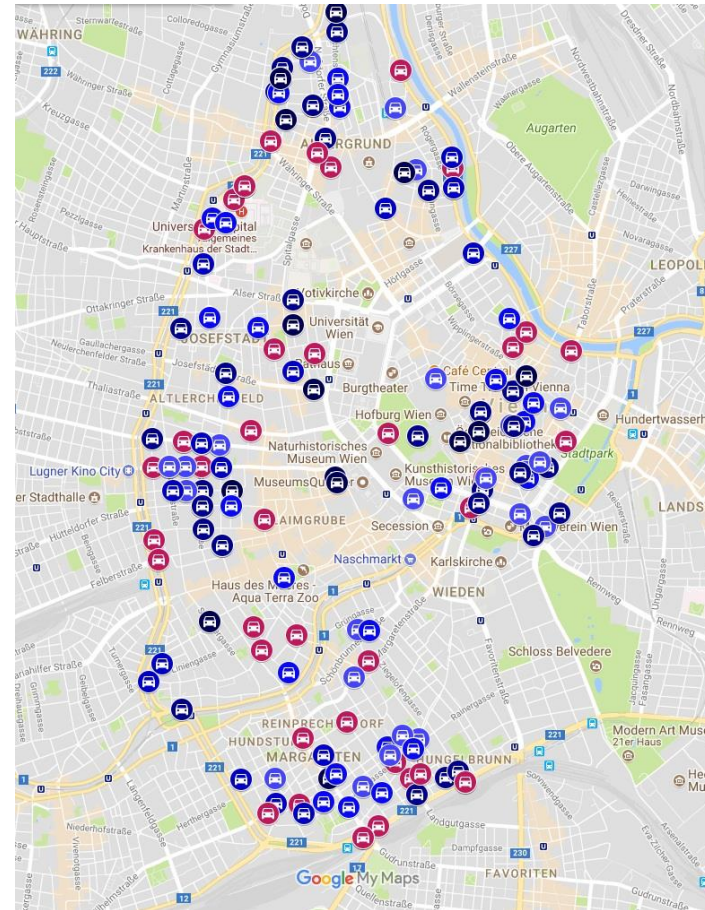
- Variable Neighborhood Search
- Solution evaluation with **Monte Carlo Sampling**
- Simulation for **one week of operation**
- **Maximize the expected profit**



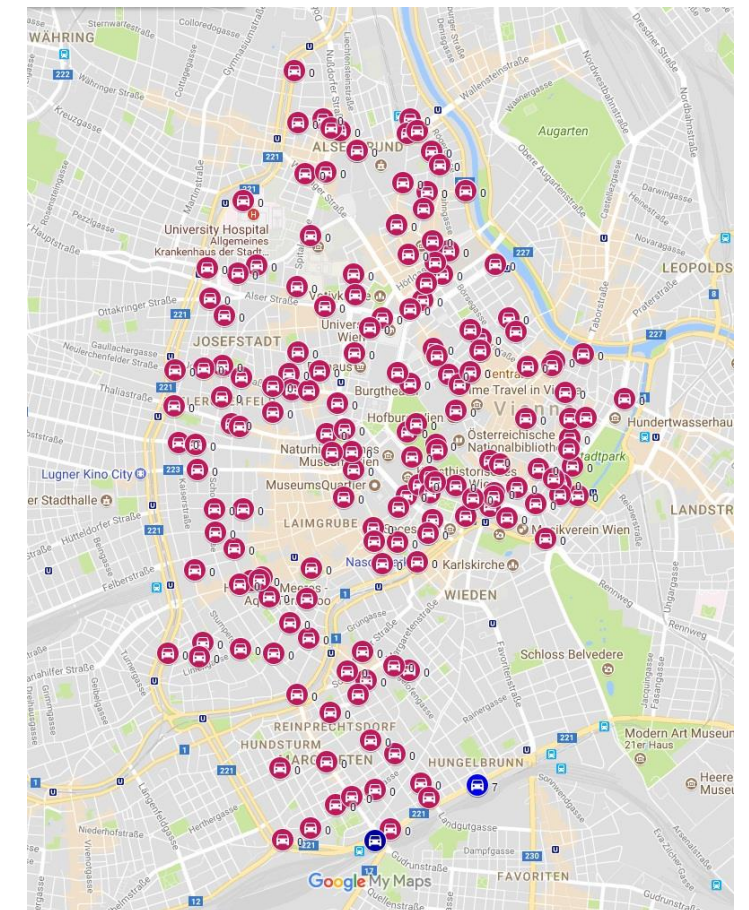
Results



Recharging stations location



Cars after one week, with incentives
SOC: full – empty



Cars after one week, without incentives
SOC: full – empty

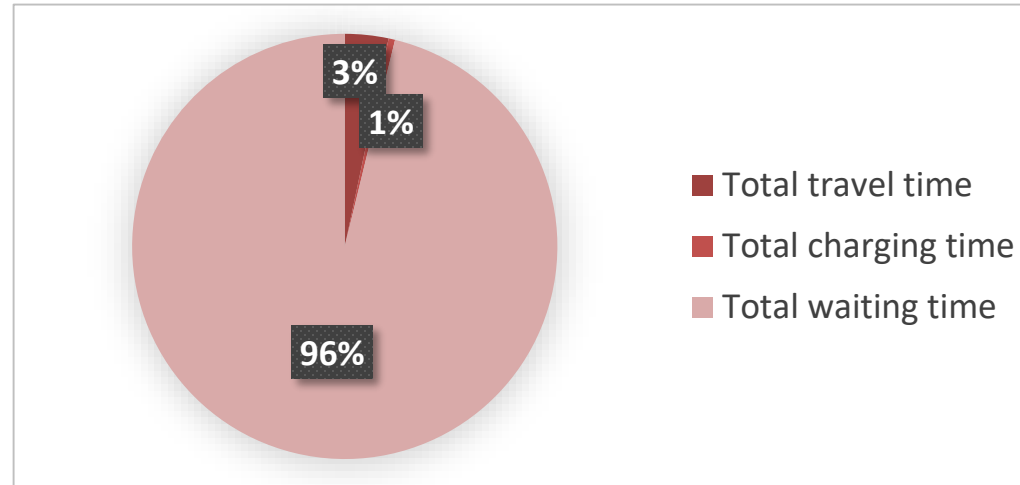
Car Statistics

- **Average usage of one day**

- Number of trips: 7
- Total travel time: 53 min
- Total charging time: 9 min
- Total waiting time: 23 h

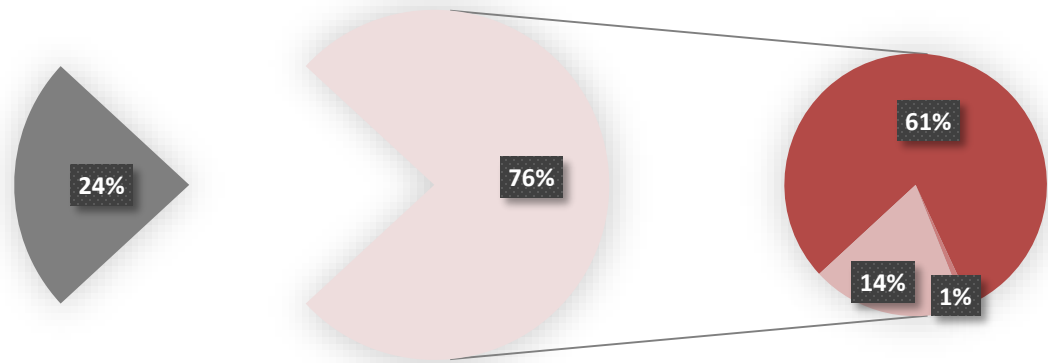
- **Average SOC**

- Begin of scenario: 50%
- End of scenario: 45%
- End of scenario (without incentives): 1%



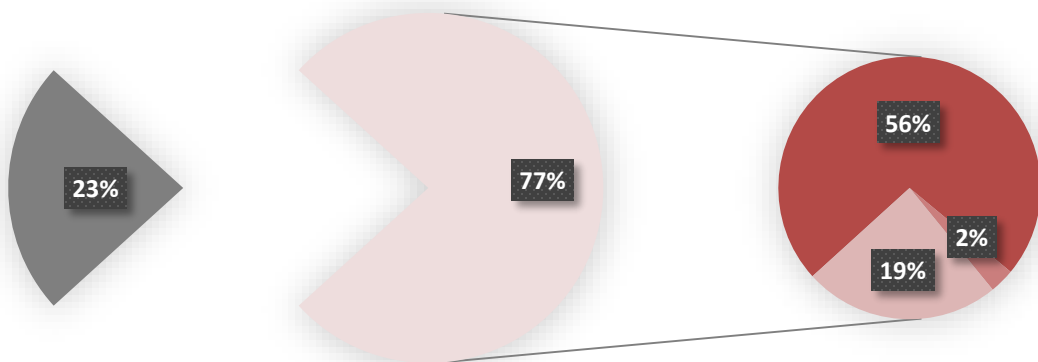
Accepted Trips Statistics

Pickup locations



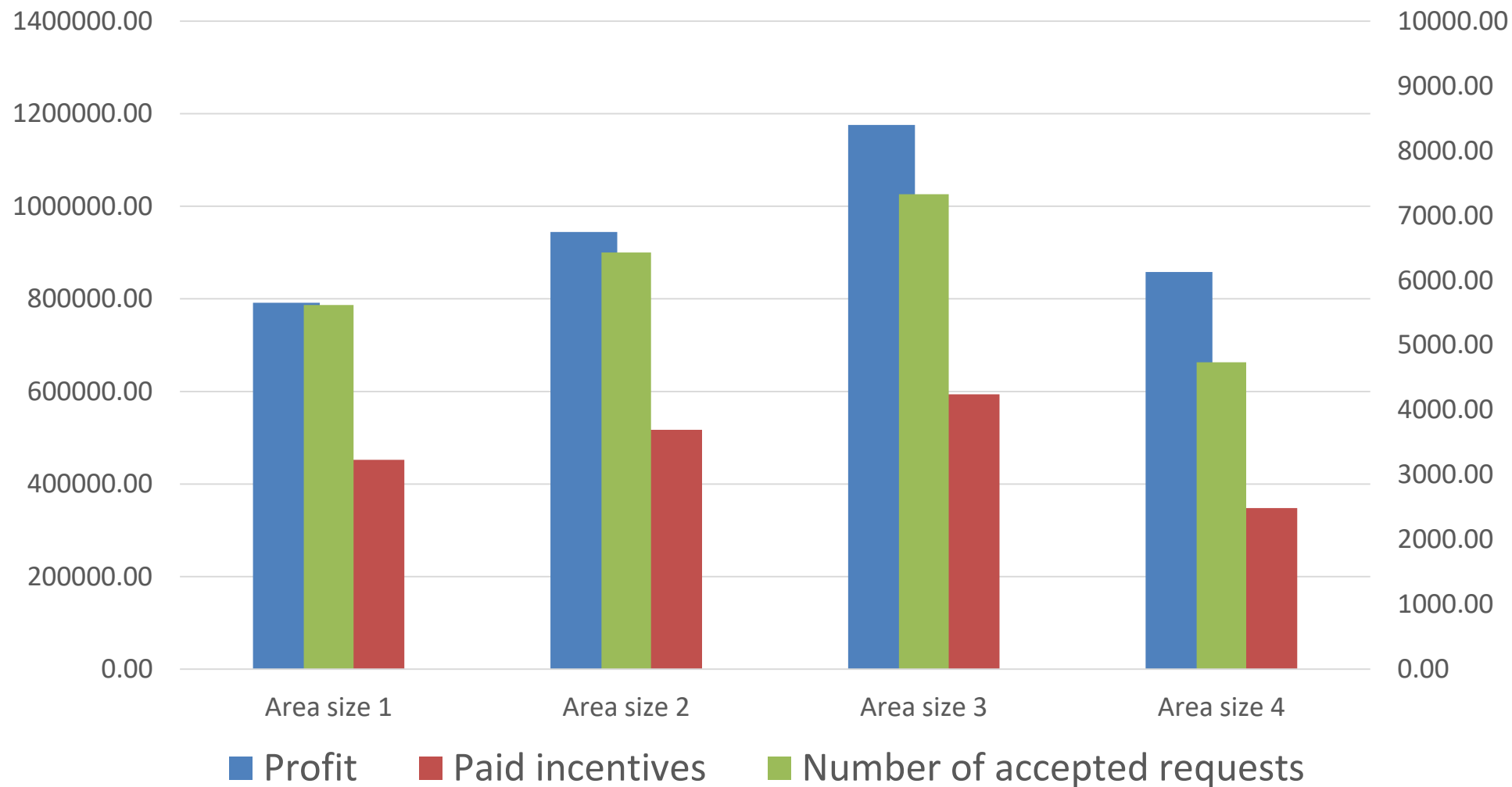
- Unfulfilled requests
- Nearest car
- Fully charged car from a station
- Car with incentive

Return locations



- Unfulfilled requests
- Desired destination
- Charging station
- Other incentivized location

Profit, Number of Trips, and Paid Incentives



Conclusions

- **Method for modeling, optimizing and simulating free-floating e-car sharing systems**
- Each area size requires a **minimum budget** to make it work
 - **Network effect** → necessary density of cars
 - **Charging stations** → necessary amount of chargers
- Applying the **right incentives** is essential on operational level
 - Less staff personnel required for recharging
 - Less staff personnel required for rebalancing

THANK YOU!

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