SIMULATION OF DAILY CHARGING NEEDS IN ULM / NEU-ULM

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DLR

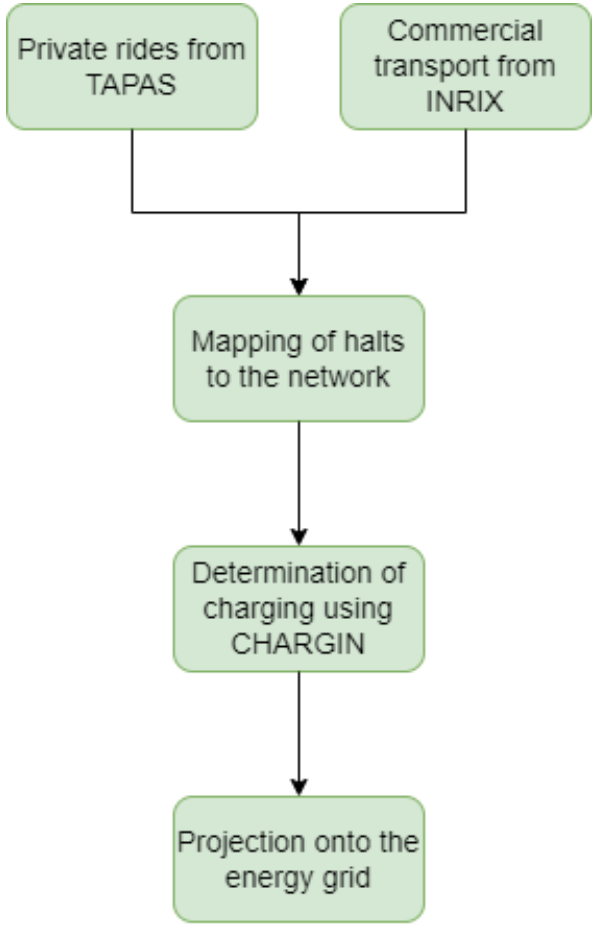
Computation of charging needs in Ulm / Neu-Ulm
Outline and Scope

- The share of battery electric vehicles is assumed to grow in the next years
  - Needed for reducing environmental impacts of transport
  - Possible factor for increasing the resilience of the grid by offering a distributed energy storage
- For a bi-directional interaction between the vehicles and the grid, the latter must be strengthened for accommodating the new needs
- Research questions: which capacities are needed in 2050?

Computation of charging needs in Ulm / Neu-Ulm
Modelling / processing workflow

As depicted right:

- Computation of private rides using the agent-based demand model TAPAS
- Using data from INRIX for modelling commercial transport
- Both are mapped onto the available parking infrastructure
- The model CHARGIN determines when the vehicles charge / discharge
- Charging processes are mapped onto the electricity grid

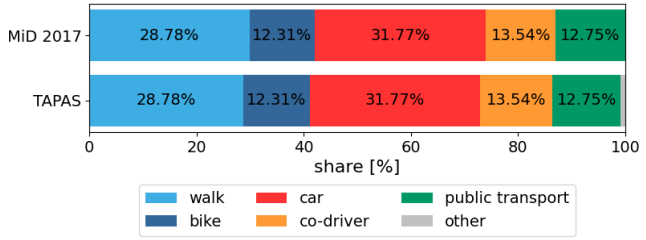


Computation of charging needs in Ulm / Neu-Ulm
Modelling the area

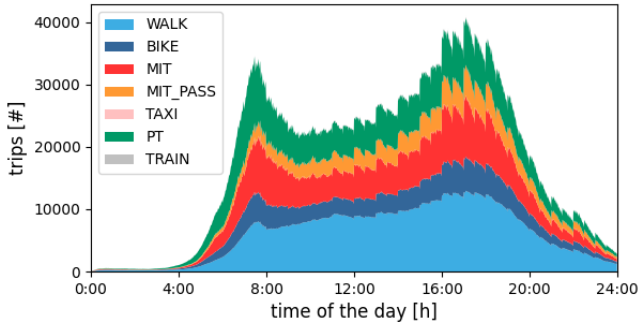
- TAPAS is an agent-based (transport) demand model
  - Replicates every person individually
  - Persons are grouped by households, allowing for modelling shared use of vehicles
  - Activity locations are modelled individually, including capacities
- TAPAS requires different data for replicating the mobility in an area
  - Disaggregated population
  - Disaggregated activity locations (work places, schools, shops, …)
  - Travel-time and distance matrices
- … we built a supporting tool that can generate according data for complete Germany

Computation of charging needs in Ulm / Neu-Ulm
Computing individual (private) mobility in the cities

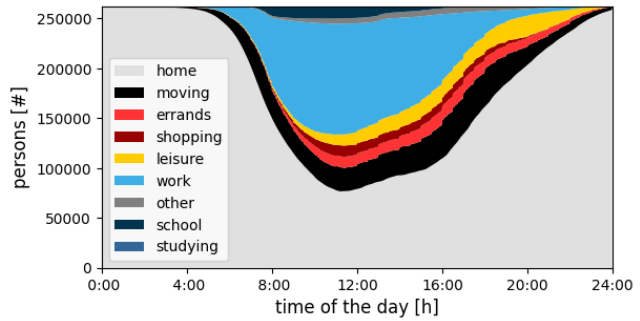
- TAPAS computes the daily mobility for each modelled person
  - Daily plan with single trips
  - Each trip has, among other, information about starting/ending location, start time, trip duration, activity duration at destination, used mode of transport
- The results of the simulation show a good match against numbers from the German national mobility survey MiD (2017) regarding the modal split



modal split comparison simulation / MiD



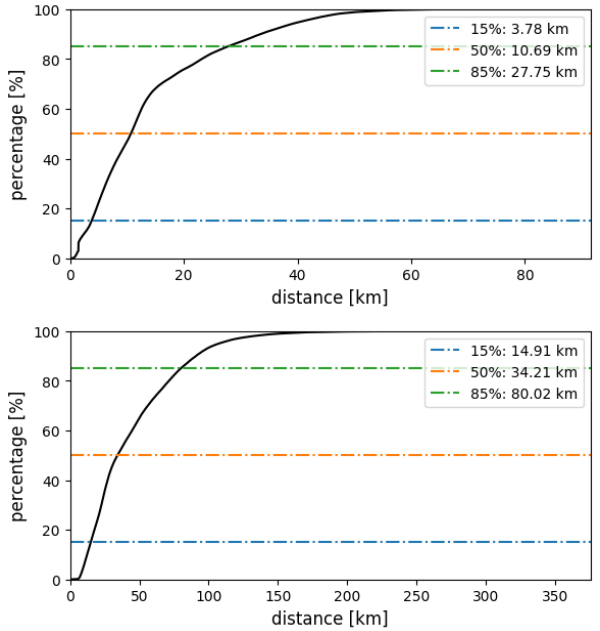
performed trips by mode



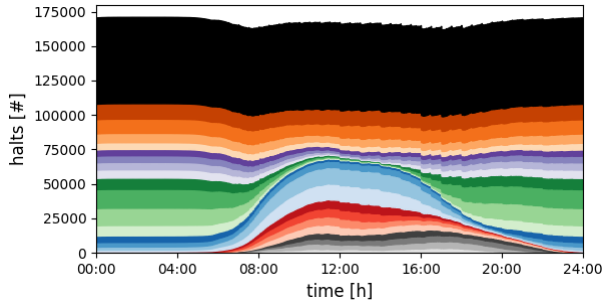
activities during the day

Computation of charging needs in Ulm / Neu-Ulm
Computing individual (private) mobility in the cities

- We use the rides performed using an own, private vehicle (MIT)
- On average, a trip performed using MIT is ~11 km long
- Over a day, a private vehicle travels about 35 km, all vehicles 18,930 km per day if all are electric
  - →about 3,800 kWh are needed for daily recharging (assuming a need of 0.20 kWh/km)
- Yet, private vehicles are not used for most of the time
  - ~40% are not used within the day (MiD; simulation: 37%)
  - Only about 10% max are on the road in parallel
  - →indeed a large battery capacity available for V2G



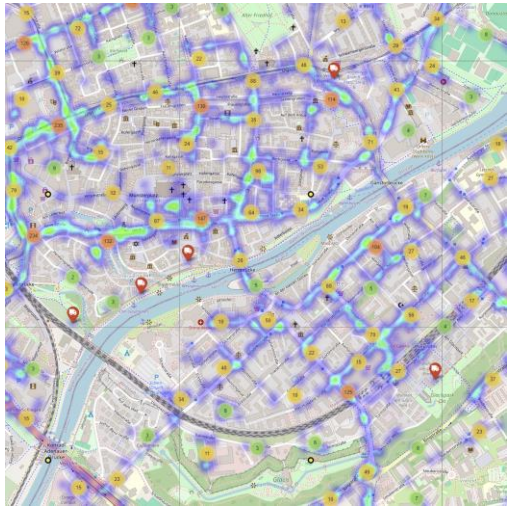
distances of single trips (top) and over a day (bottom)



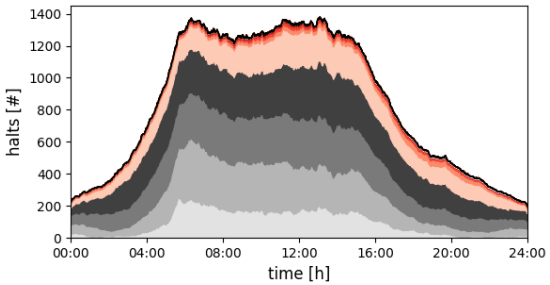
distribution of parking times

Computation of charging needs in Ulm / Neu-Ulm
Data about commercial transport from INRIX

- TAPAS does not model commercial transport
- Data from INRIX were bought to cover it
- About 255,000 stops of heavy-duty vehicles with information about
  - vehicle type (N2 / N3)
  - estimated distance
  - Parking time (for ~50% of the cases)
- Missing information about parking time mainly for longer stays – e.g. over night
- Assumptions: commercial vehicles park during the night



heat map of commercial vehicles' stop positions

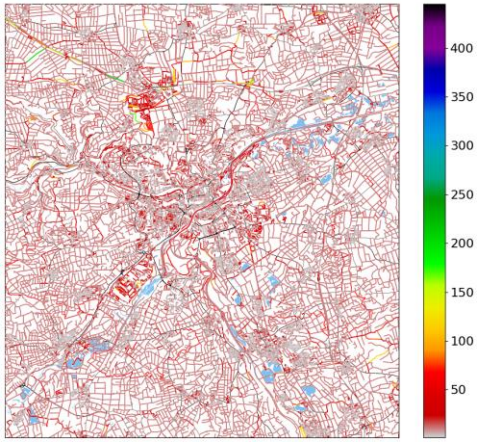


distribution of parking times

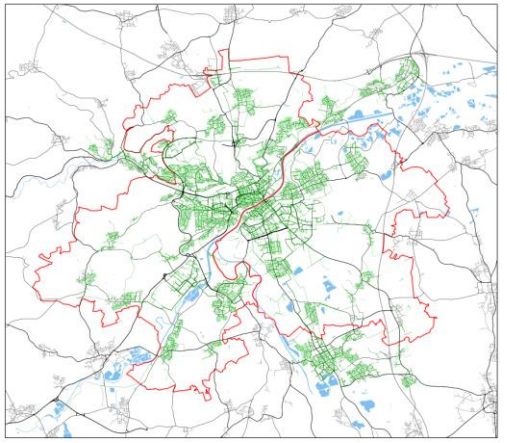
Computation of charging needs in Ulm / Neu-Ulm
Mapping onto the infrastructure

- Parking infrastructure was extracted from OSM
  - For each TAPAS location, parking places in 500 m distance were computed
  - From the ten locations with the highest capacity / distance ratio, a random one is chosen
- A representation of the electrical grid was supplied by the project partner SWUN (grid operators in Um/Neu-Ulm)
  - Consists of low and medium voltage network; both as underground or overhead lines
  - A hierarchy has been built, joining cables at switch stations and transformers
  - A mapping from the parking places to the energy grid was constructed

→ Mapping from TAPAS locations to parking places to energy grid



parking places
(yes, almost everywhere)

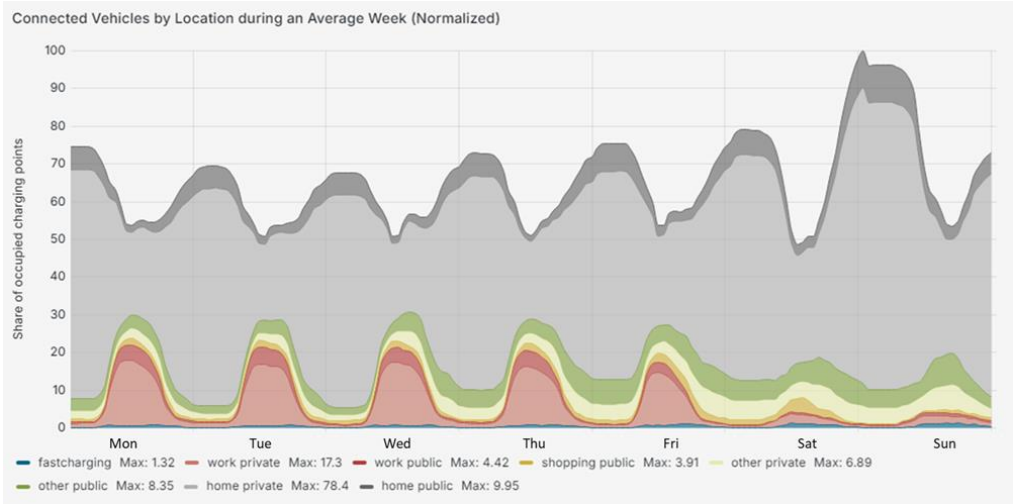

energy grid (green)

Computation of charging needs in Ulm / Neu-Ulm
Computing charging / discharging behavior with CHARGIN

- CHARGIN simulates the charging behavior of individuals
  - Input are trips (as supplied by TAPAS)
  - CHARGIN choses whether a vehicle is charged in dependence of i) halting duration, ii) activity performed at the stop, iii) energy price, iv) charging power at stop
  - The behavior within a complete week is modelled
  - Based on a survey among battery electric vehicle users
- CHARGIN delivers single charging actions, including the location and the consumed energy

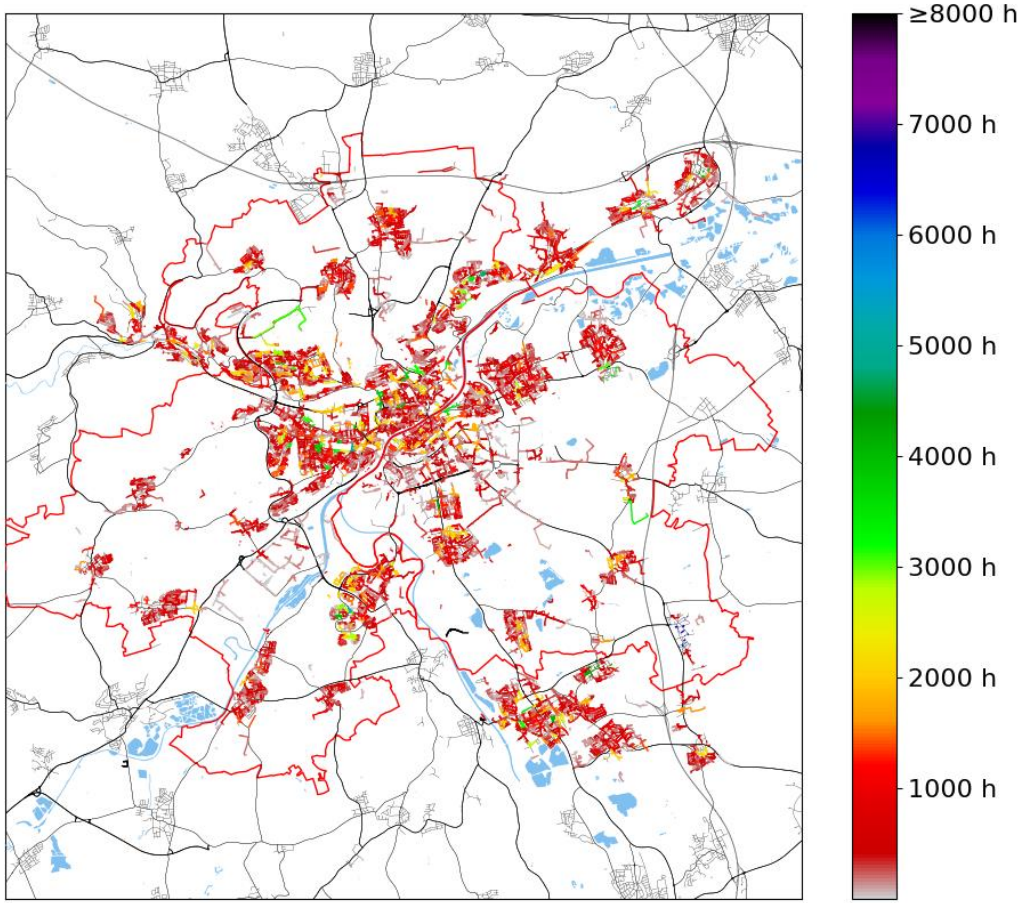
Computation of charging needs in Ulm / Neu-Ulm
Computing charging / discharging behavior with CHARGIN

- Last step: extending CHARGIN by modelling bi-directional charging behavior
- Currently reported data (in addition to common CHARGIN outputs):
  - Connected V2G vehicles
  - Connected power (controlled/uncontrolled)
  - Connected vehicles ready for charging



Computation of charging needs in Ulm / Neu-Ulm
Further (Preliminary) Results

- As to expect, different use patterns of parking spaces (and so of the energy grid) can be found
  - mainly occupied during the night (places of inhabitance)
  - mainly occupied during the day (activity locations)
  - hybrid ones
- Partially big parking places with high potential
  - should be evaluated separately



connected vehicle times per grid line

Computation of charging needs in Ulm / Neu-Ulm
Next Steps

- Further validation
- Methods for scaling the results with fleet sizes
- Extraction of meaningful / usable results
  - Mainly discussions with grid operators about their needs
- Support for the evaluations of business model developed within the project

Impressum

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