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Integration of Optimal Charging Locations into a Transportation Energy Simulation Framework

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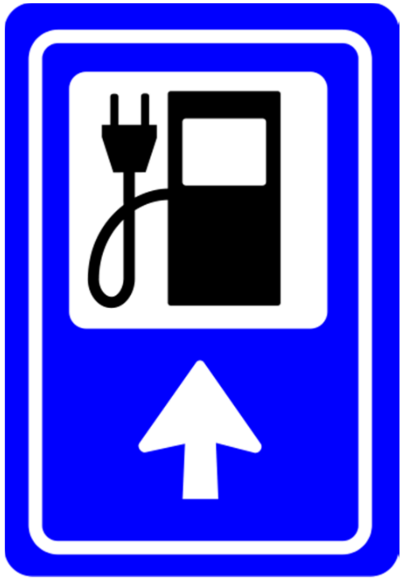
Motivation: Energy Demand Modeling

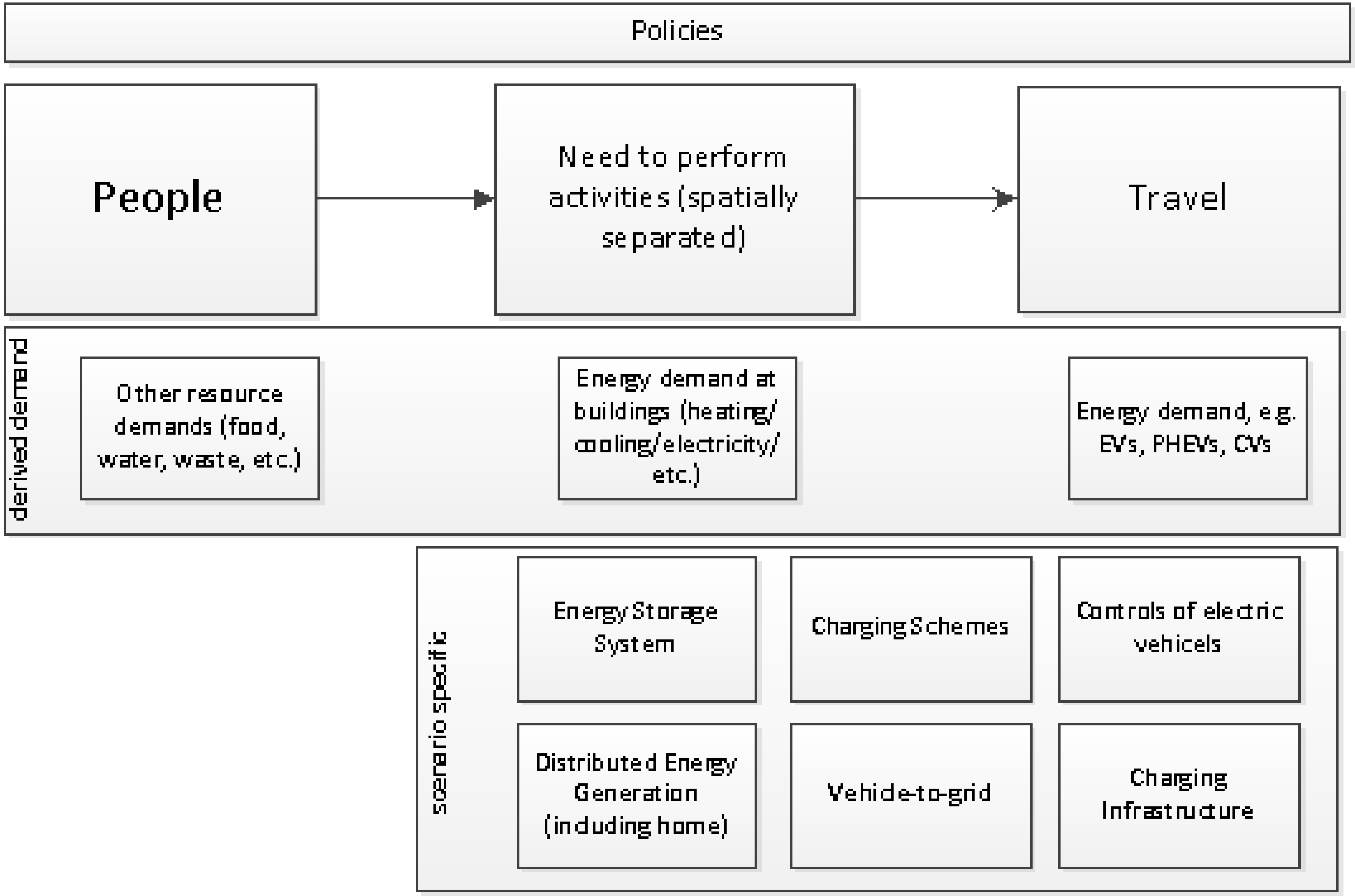
- Case studies integrated modeling of electricity demand and supply related to Evs
  - focus: electricity demand
- Often aggregated models used in this context
  - good for getting an overview of supply and demand
  - smart charging to balance demand and supply
- Disaggregated models needed for uncovering bottlenecks in the electricity network (e.g. power-line constraints and transformer overloads)

Motivation: Charging Infrastructure

- Framework for detailed electricity demand by EVs
- Does not consider specialized public charging infrastructure

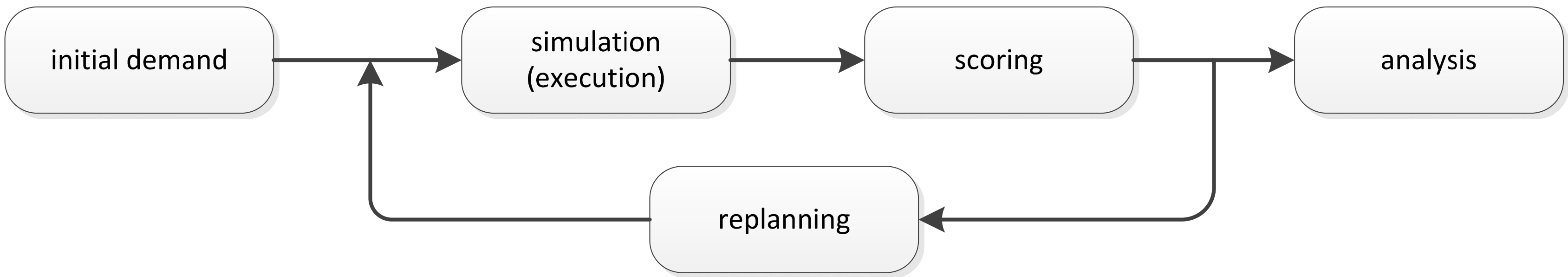


Activity-based Modeling (Bottom-up)

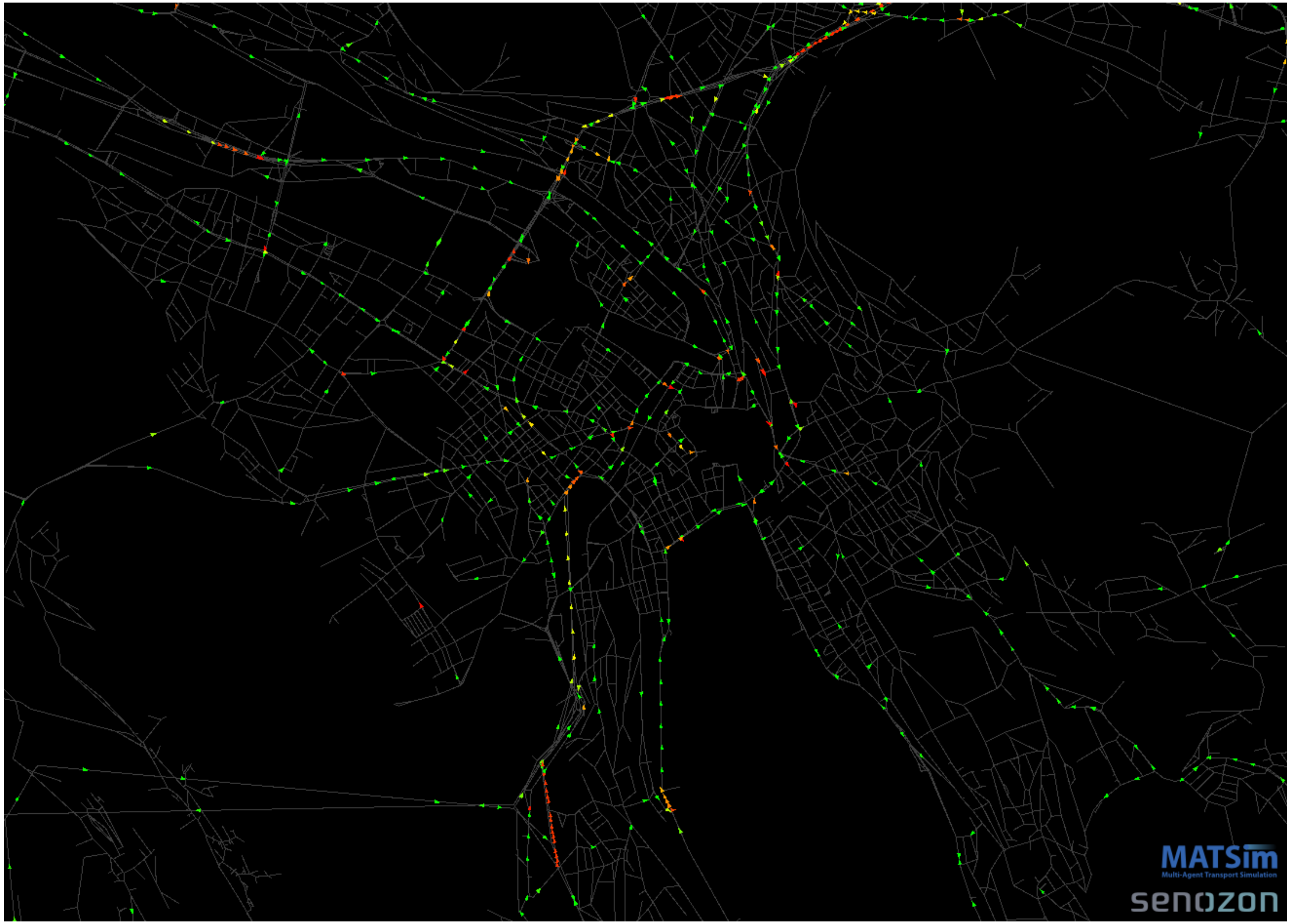


MATSim

- Synthetic population: people -> agents
- Individual preferences (based on survey data)
- Optimization of activity and travel demand for whole day
- Initial plans based on census data/travel diaries
- Plans contain acitivites (work, shopping, education) and trips
- Several transport modes available (car, walk, public transport and bike)
- First step of optimization: simulation

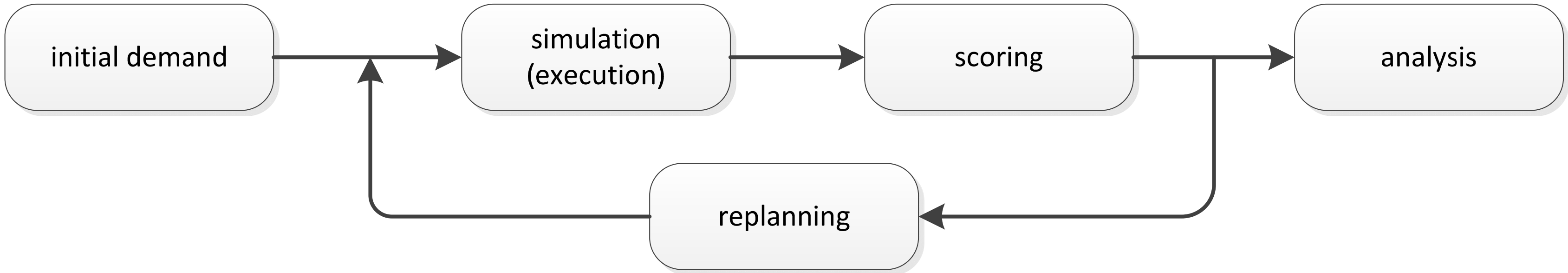


Simulation



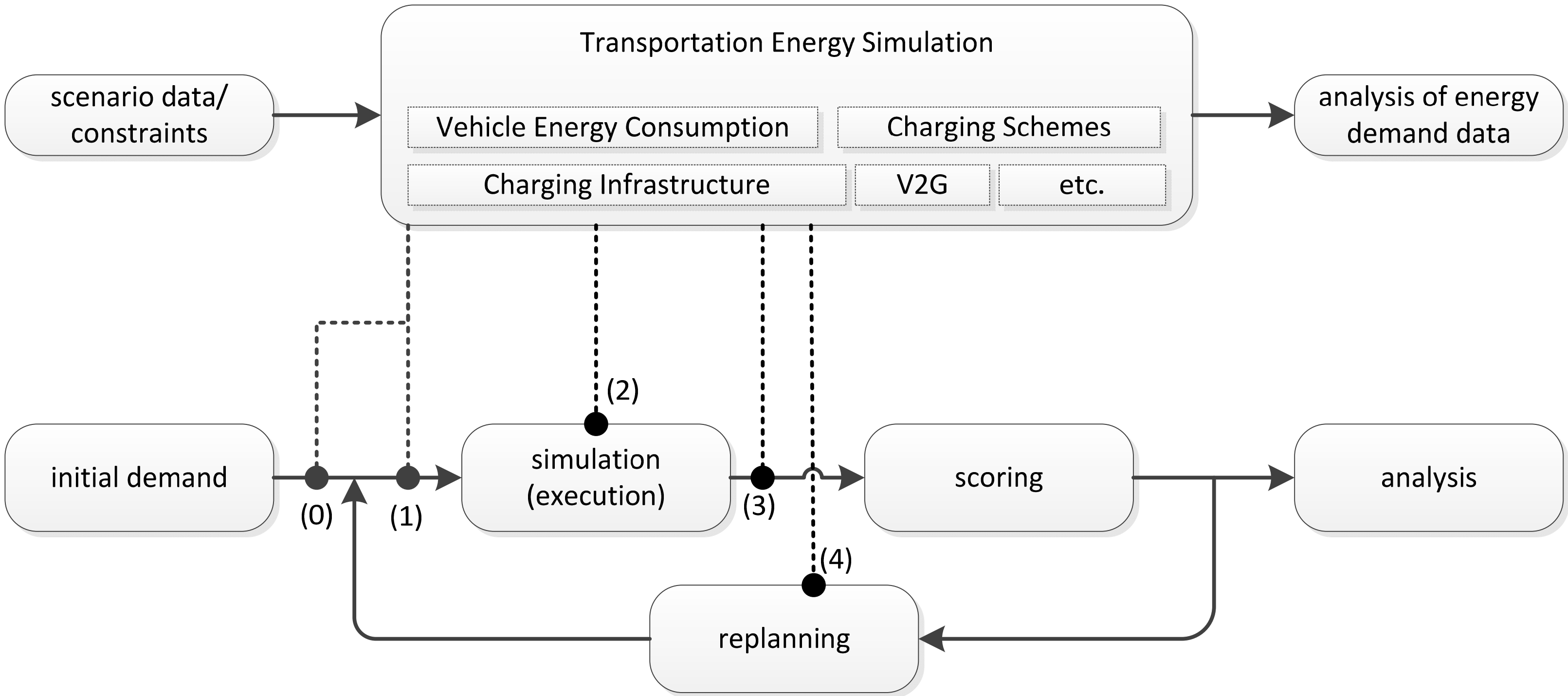
MATSim

- simulated plans are scored
- Lower travel time and performing activities gives better score
- The goal of each agent is to maximize its score
- Iterative process, based on idea of evolutionary algorithm
- Replanning (change travel mode, route, times, etc.)
- Co-existence of several plans
  - Bad plans deleted over time, good plans have higher chance of getting selected for execution -> survival of the fittest
  - Iteration continues -> optimal plans (Nash Equilibrium)



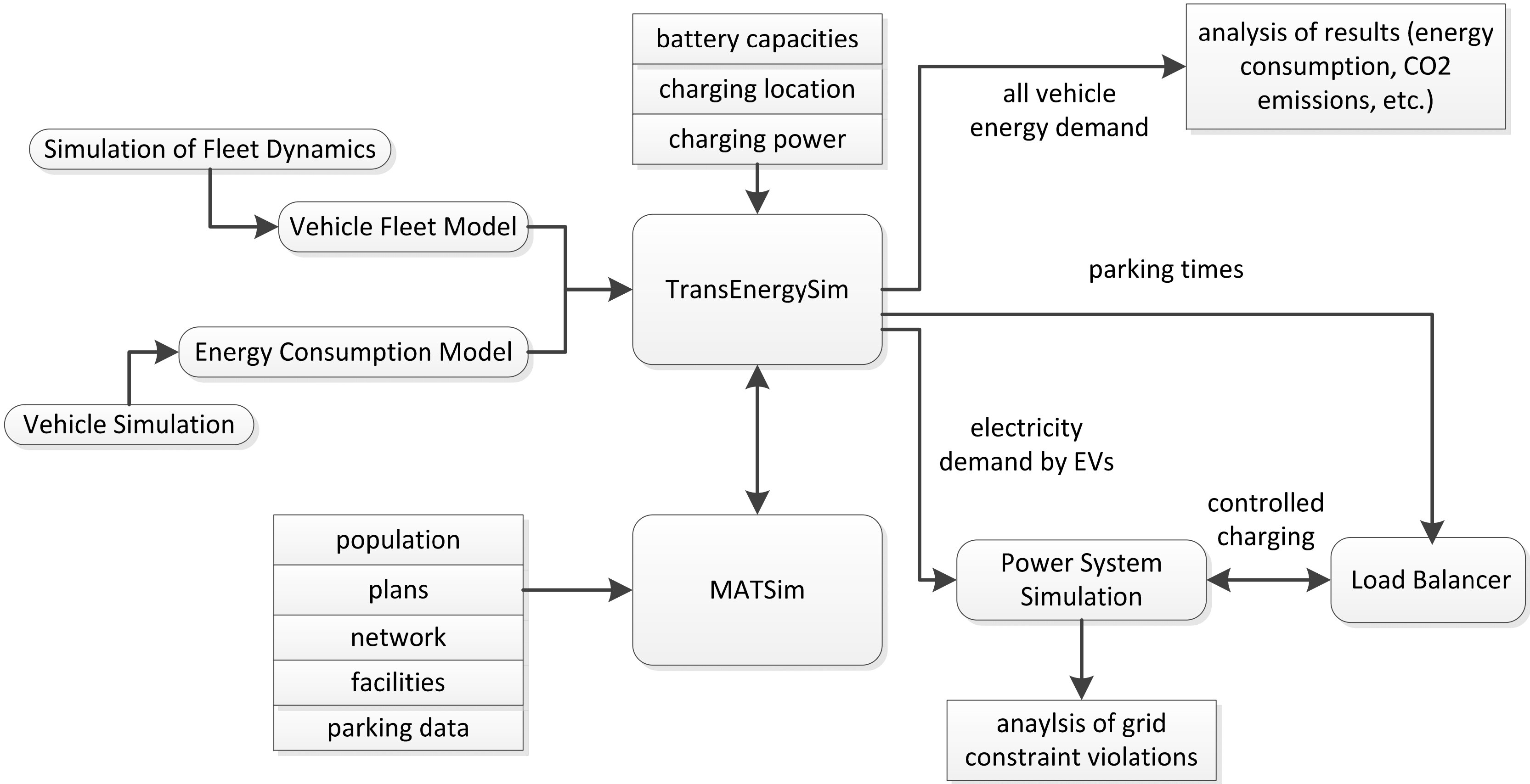
Transportation Energy Simulation Framework (TESF)

- Framework for simulation of EVs
- Extended MATSim with models for EVs
- Framework: basic implementations provided
- open source: www.tesfw.org (planned end 2013)

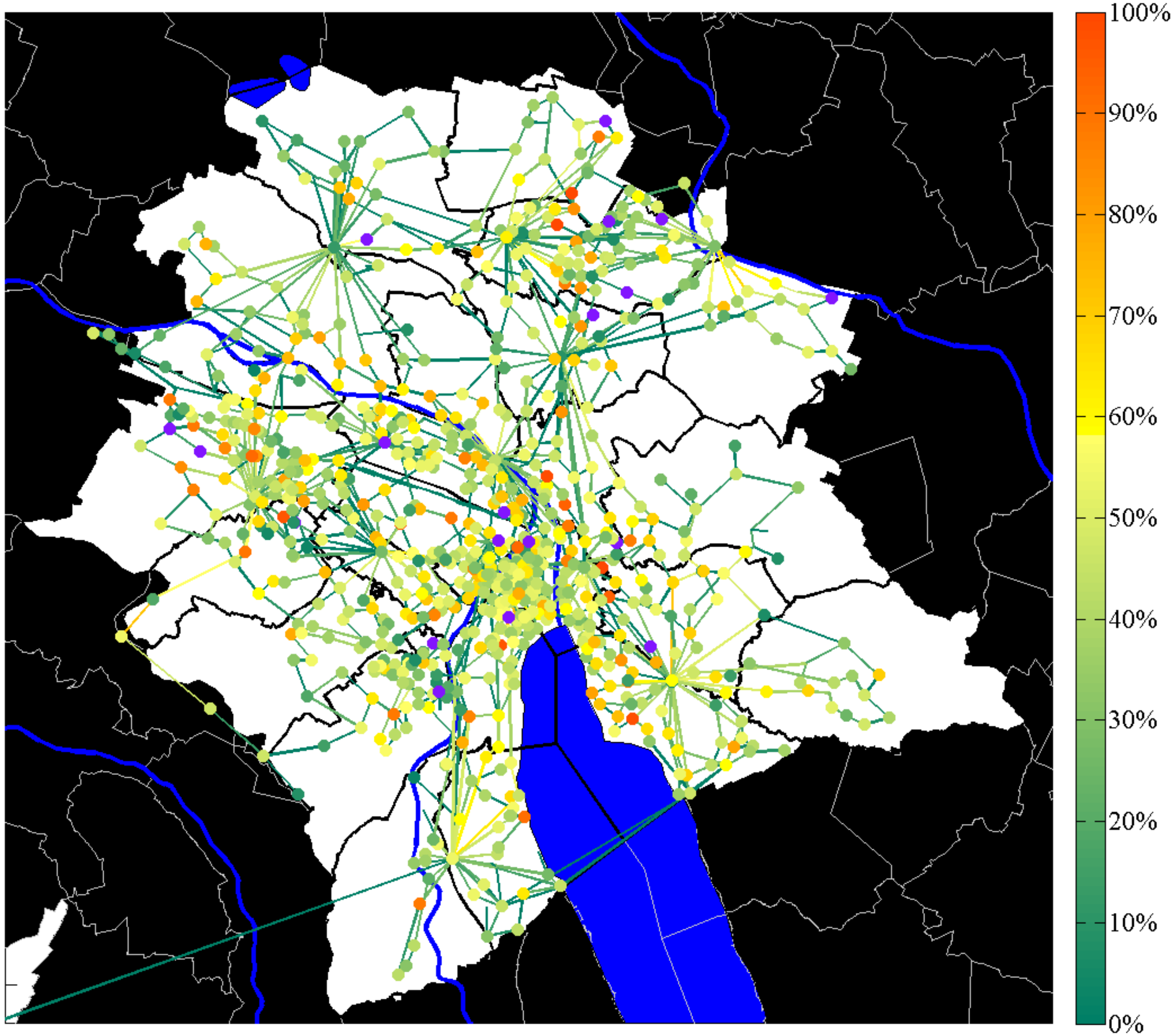


Uncovering Bottlenecks in the Grid

- Mostly used in interdisciplinary context



Electircity Network Resource Utilization (Zurich)

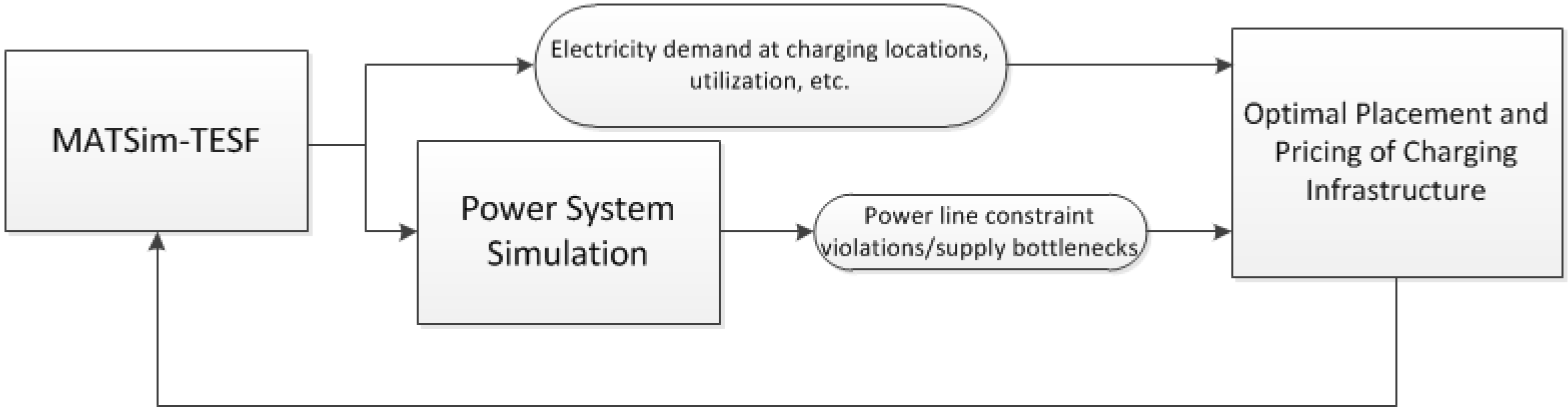


How to introduce public charging stations?

- Charging at private and public parking already modeled
- For charging at fuel stations, we need to model
  - when do people charge (early/late)
  - based on previous/new survey data
  - change route for getting to charging station
- Optimal location of charging infrastructure
  - Not new problem
  - Optimization considering various constraints and objective functions

Optimal Public Charging Location

- Initial deployment of charging infrastructure, e.g. based on separate MATSim run
- Perform electric vehicle simulation for one day with extended behaviour models for public charging infrastucture use (MATSim-TESF)
- Outputs: el. demand, charging infr. demand, grid constraints
- Perform optimal placement of charging infrastructure (repeat until no grid violations)
- Useful for simulating scenarios



What is Missing?

- Real systems develop inclemently
- Influence of charging infrastructure development and EV/PHEV vehicle fleet adoptation on each other
- Charging infrastructure in competition
- EVs and PHEVs in competition for market share
- Interested in impact of policies => various stakeholders

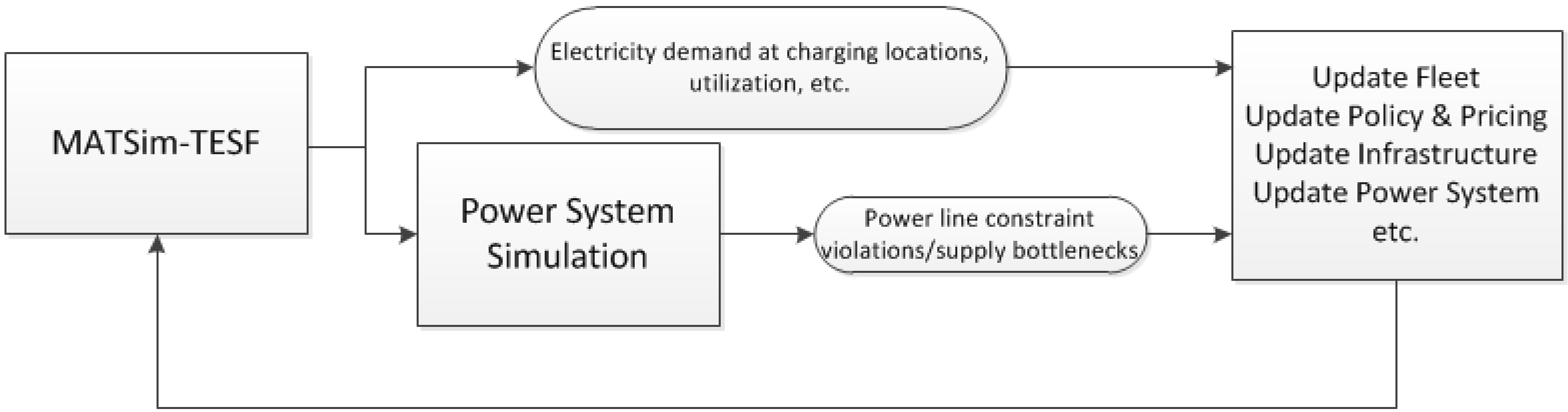
Example other Stakeholders

- Government policy, equip parking with charging infrastructure (e.g. 5% per year)
  - No additional fee for charging
  - Perhaps higher fee for non-Evs parking
  - Promotion of electric vehicles
- Private companies investing in infrastructure are in competition with private home/work and public parking charging infrastructure
  - Help with introduction of EVs
  - Risk of getting wiped out
- Not only model scenarios, which are based on fixed assumptions and then performs optimization
- Allow more degrees of freedom, in order to see how the system could evolve
  - **Possibly uncovering «hidden» implication of policies and interaction of subsystems**

System Evolution

- Allow to perform more changes than only charging infrastructure
  - vehicle fleet
  - policy, pricing
  - charging infrastructure (gov, companyies, individuals)
  - power system infrastructure (PVs, grid updates)

  => not fixed any more

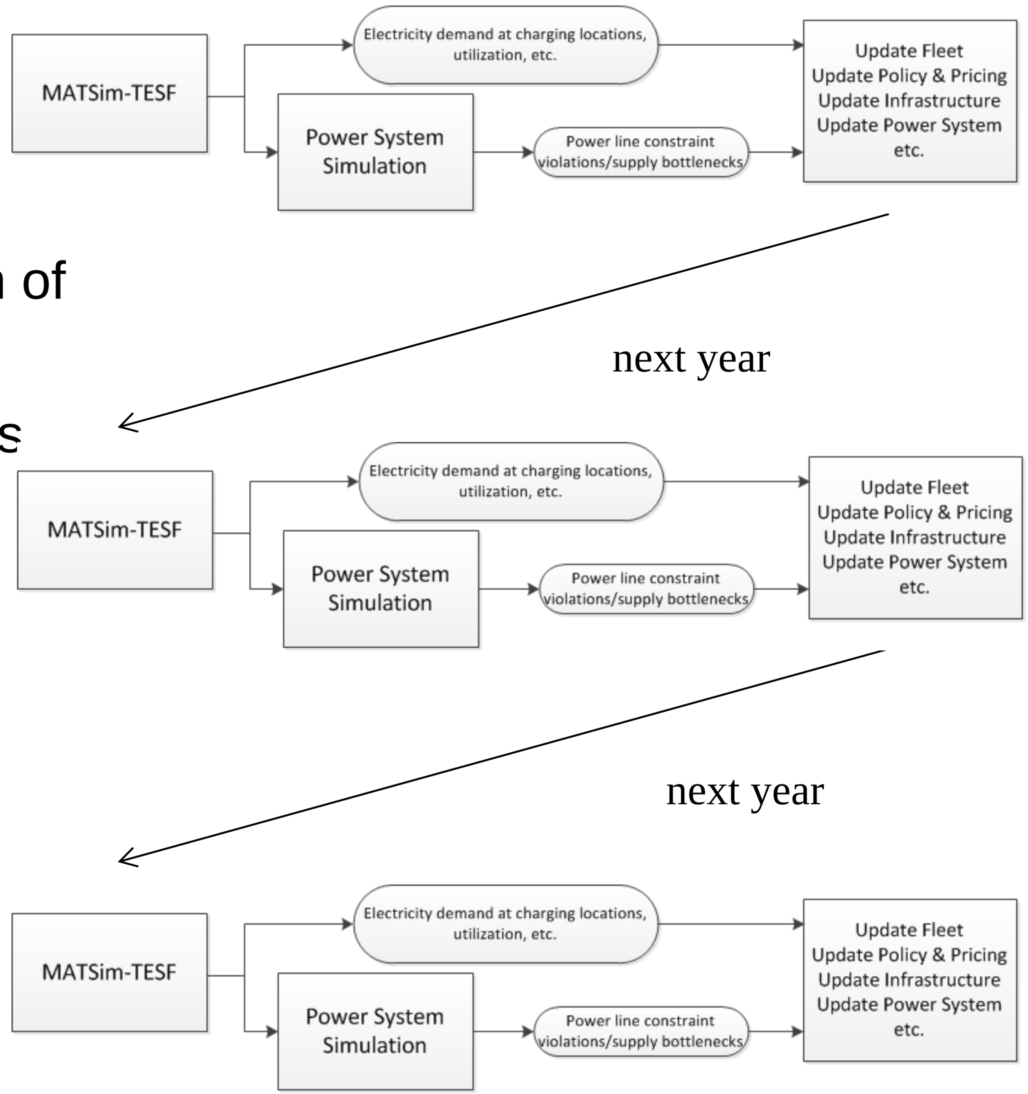


System Evolution (con't)

Output:

Development of utilization of

- charging infrastructure
- pentration of EVs/PHEVs



Conclusions and Future Work

- Move beyond optimizations where most parts of the scenario are fixed (based on assumptions)
- Look at system evolution and interactions of subsystems
  - Uncover «hidden» implication of developments and policies
- Still work in progress: Concepts need to be worked out before implementation into framework

Questions?