Optimization of Electric Vehicle System Models for Improved Decision Making

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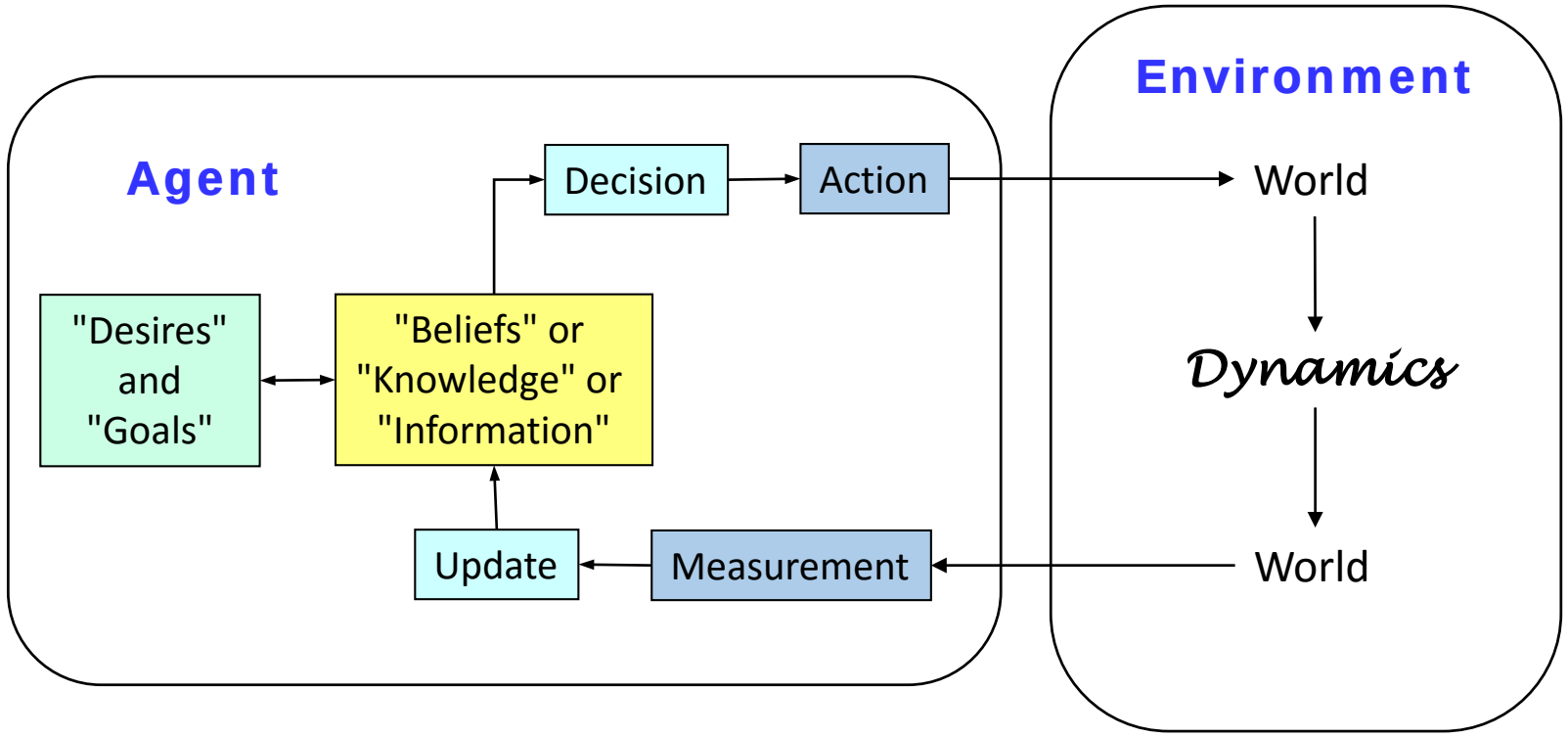
Introduction

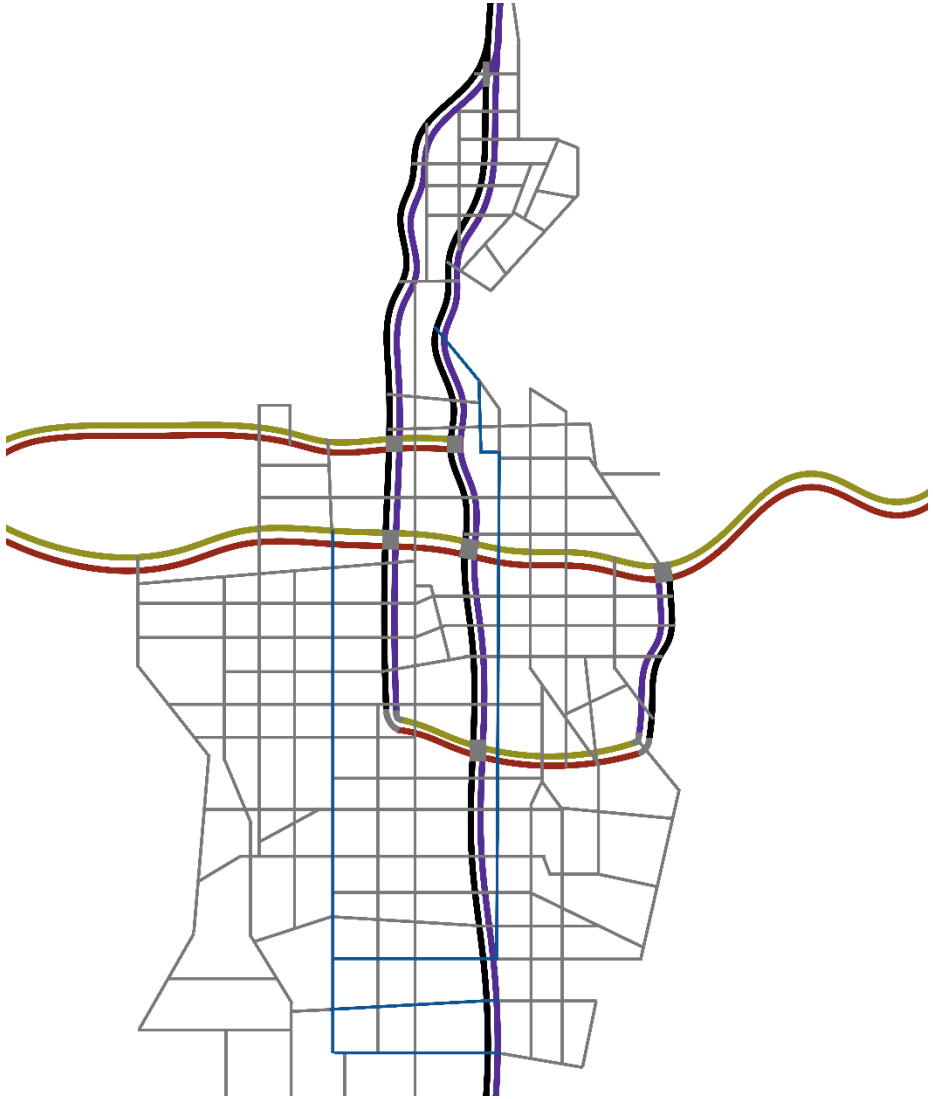
- The Infrastructure to support the Electric Vehicle System is highly non-linear and multi-dimensional
  - Multiple stakeholders, Power Companies, Vehicle OEMs, Government Officials, …
  - 1000s of agents, Unknown Behavioral Response, Traffic Impacts, …
  - Physical Constraints, Power Supply/Demand, Spatial-Temporal interactions, …
  - Evolving Technology, Obsolescence, Utilization, …
  - Adoption concerns, Range Anxiety, Safety, …
  - Implementation/Maintenance Cost, etc.
- Approach is to model the system with Agent Based Modeling and develop a framework to answer key questions
  - Start with exploratory and validation efforts
  - Continue with optimization of the EV system for multiple scenarios

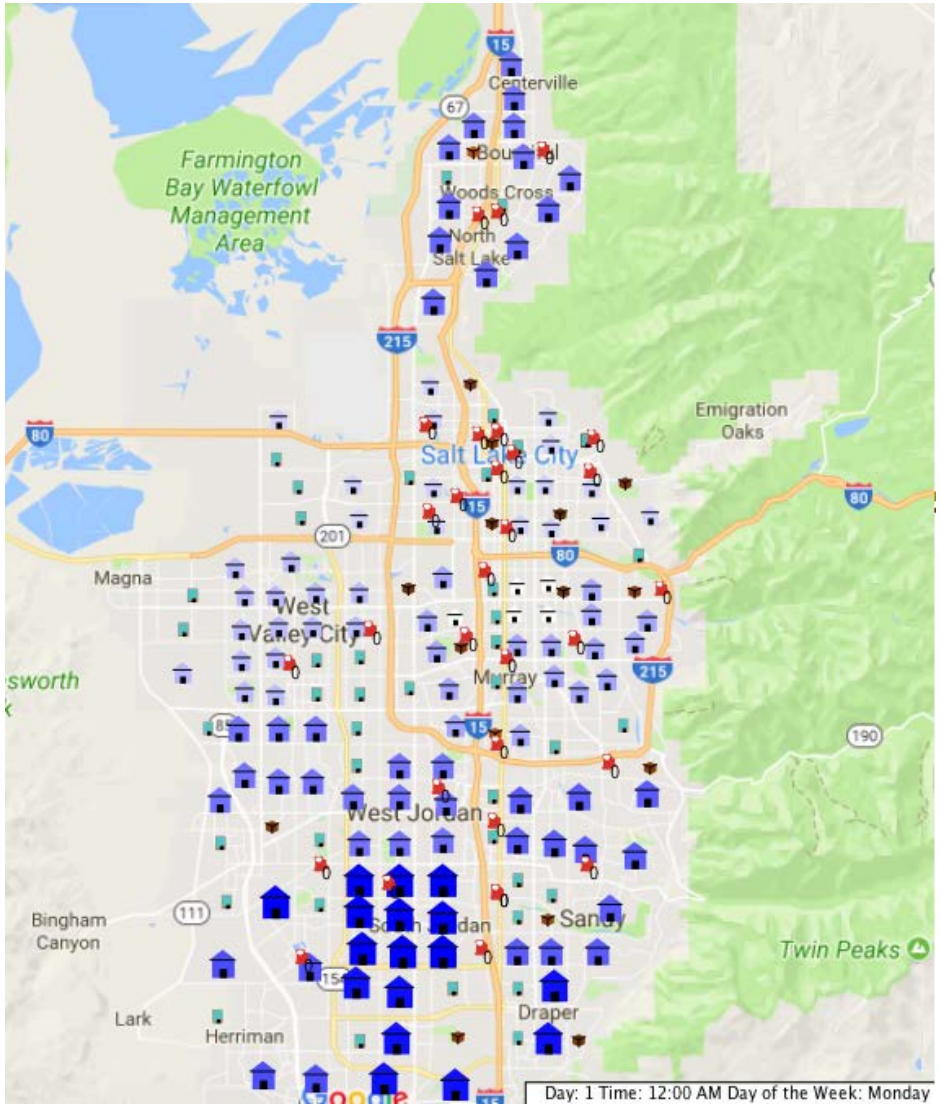
A Simple Agent-Based Modeling (ABM) Mechanism



Observe **"emergent behaviors"** from agent-environment interactions

Environment - Salt Lake County

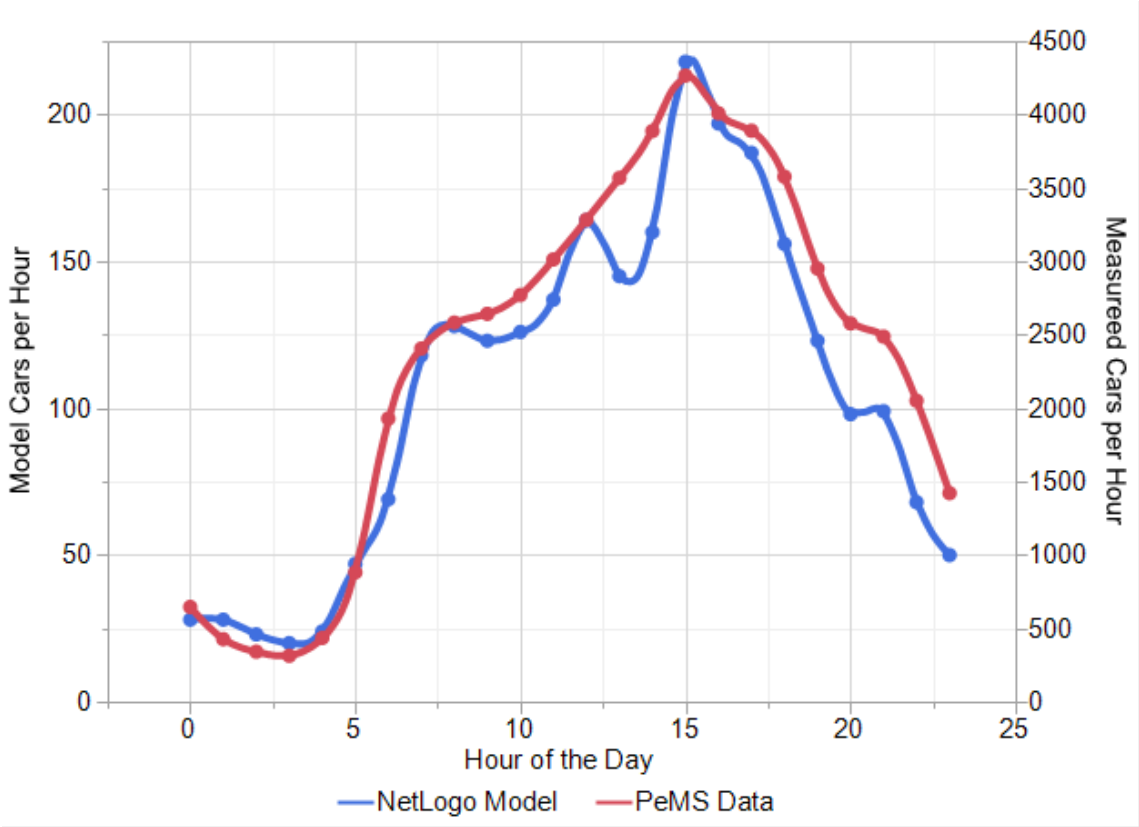


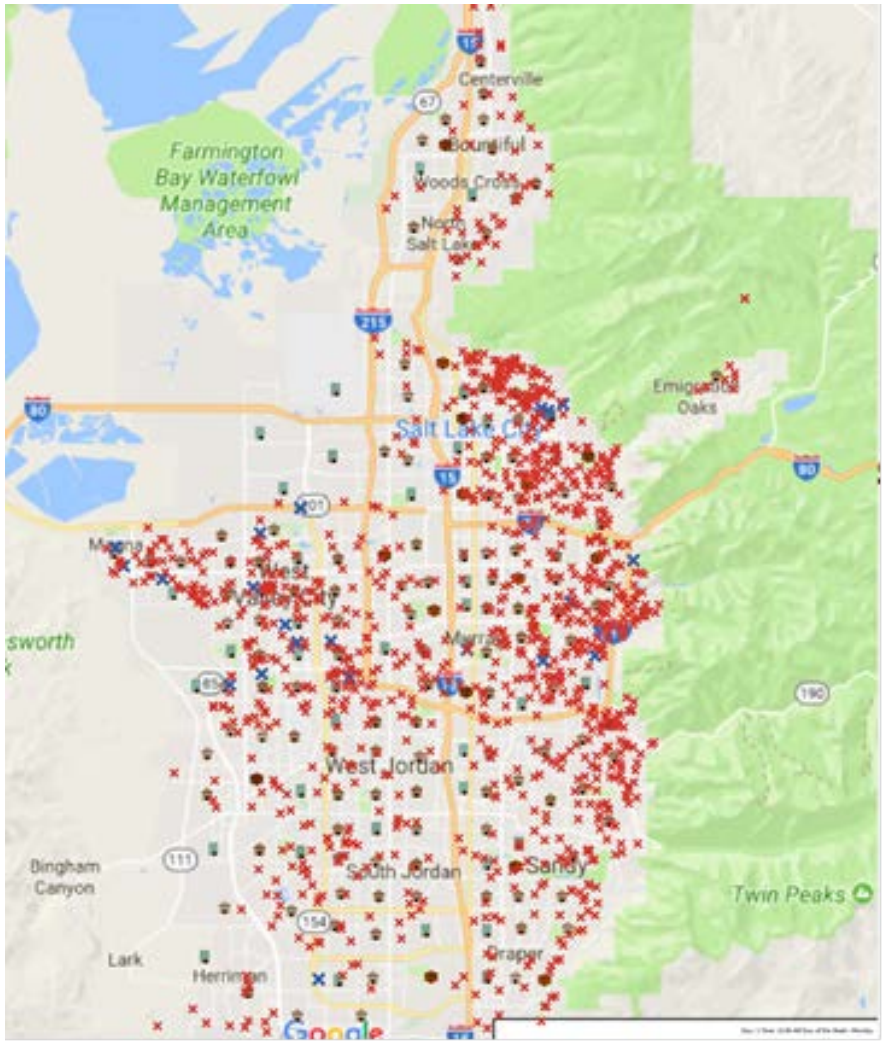


Agents/Personas

- Each agent in our system takes on a persona
- Each persona has a defined
  - Home location
  - Work location
  - Type of EV
  - Work Schedule
  - Recreation Schedule
  - Family Responsibilities (e.g. children at school)
  - Driving/Charging Style and Behavior
- These are randomly assigned at the initialization phase to N individuals

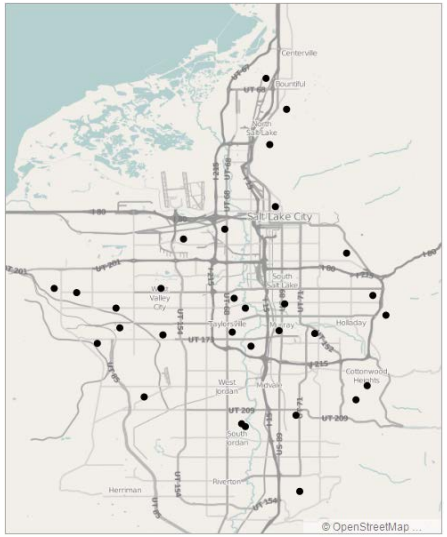
Model Validation



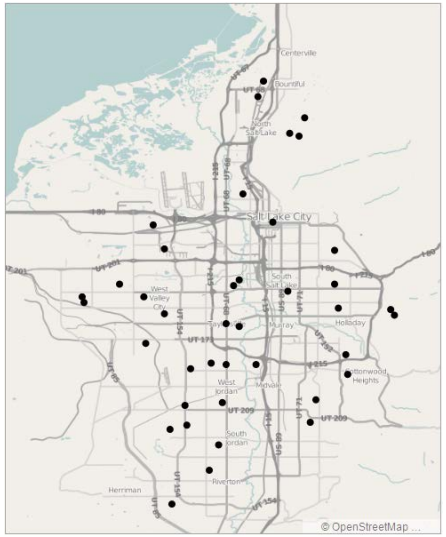


10 Charger Locations

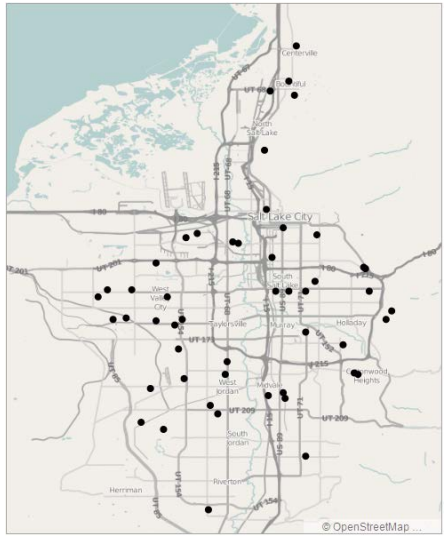
20 Charger Locations



30 Charger Locations

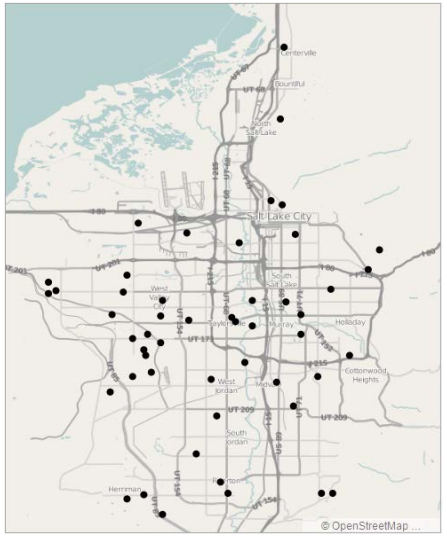


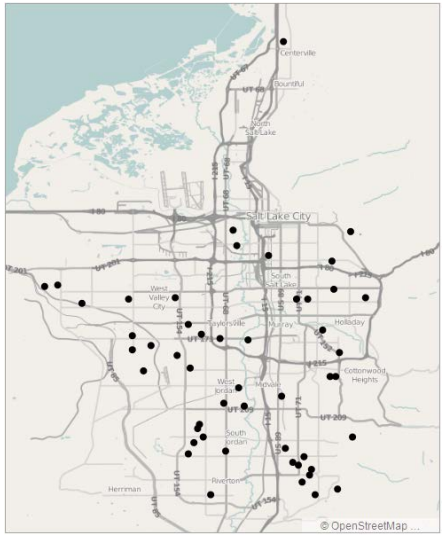
40 Charger Locations

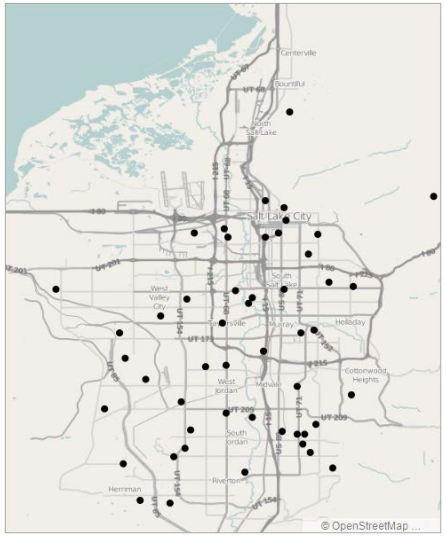


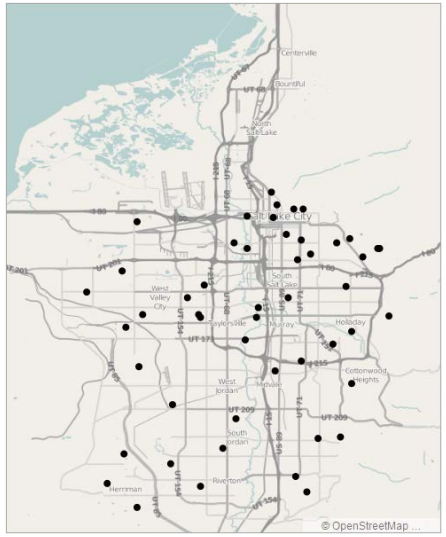
50 Charger Locations

50 Charger Locations









Electrified Roadways

- A similar ABM can be used but instead of locations for chargers we defined sections or patches of road to be WPT
- As the agents move across these “patches” their battery is charged a small amount
- Similar questions can be asked
  - How many sections of WPT chargers are required for different scenarios?
  - Where should they be located?
  - How will drivers respond?

Which Infrastructure is "Better"?

VS

Setup | Go | Go Once | r-seed | experiment-st...

On Off run-experiments | On Off r-seed?

Reset Output | number-of-cars 250 | On Off od-data?

On Off additional-charge-stations? | percent-evs 100

Day	Time	AM/PM	Day of the Week	start-day
1	12:00	AM	Monday	Monday

Drained EVs	Cars at Home	Charging Cars	Waiting EVs
1	1	1	1

Cars on the Road

10
Cars
0
0 Time (min) 1440

Cars Waiting

10
Cars
0
0 Time (min) 1440

Max Wait Time (min)	Avg Wait Time (min)	Avg Path Deviation (mi)
N/A	N/A	N/A

Scores | Locate New Stations | num-new-stations | new-station-color

Store Scores | Restore Scores

On Off pollution-tracker | On Off view-pollution? | On Off slow-to-charge

model-speed 0 | movement-speed 0 | charge-speed 0

On Off record-interfa... | On Off output-flow? | On Off traffic?

Display Setting

Show/Hide Map

Zoom In | Zoom Out

Drained Loc | Details?

Charge Loc | Details?

home-prob	work-prob
0	0

On Off residential-data?

home-charge-level: 1

On Off commercial-data?

work-charge-level: 1

On Off public-data?

On Off existing-stations?

On Off auto-create?

number-of-stations: 0

Add/Remove Stations

charge-station-level: 3

charge-station-capacity: 0

On Off electrify-roadways?

Conclusion

- ABM shows usefulness in modeling an EV system where 1000s of agents must interact to obtain the collective emergent behavior
- Modeling EV infrastructures with charger locations has shown to offer methods to explore and optimize these systems and inform decision makers about potential policies
- Analyzing electrified roadway systems can use similar models and will help explore how WPT will impact responses such as adoption rates, costs to various stakeholders, and driver behavior

THANK YOU!