Shared Autonomous Electric Mobility:

Opportunities & Challenges

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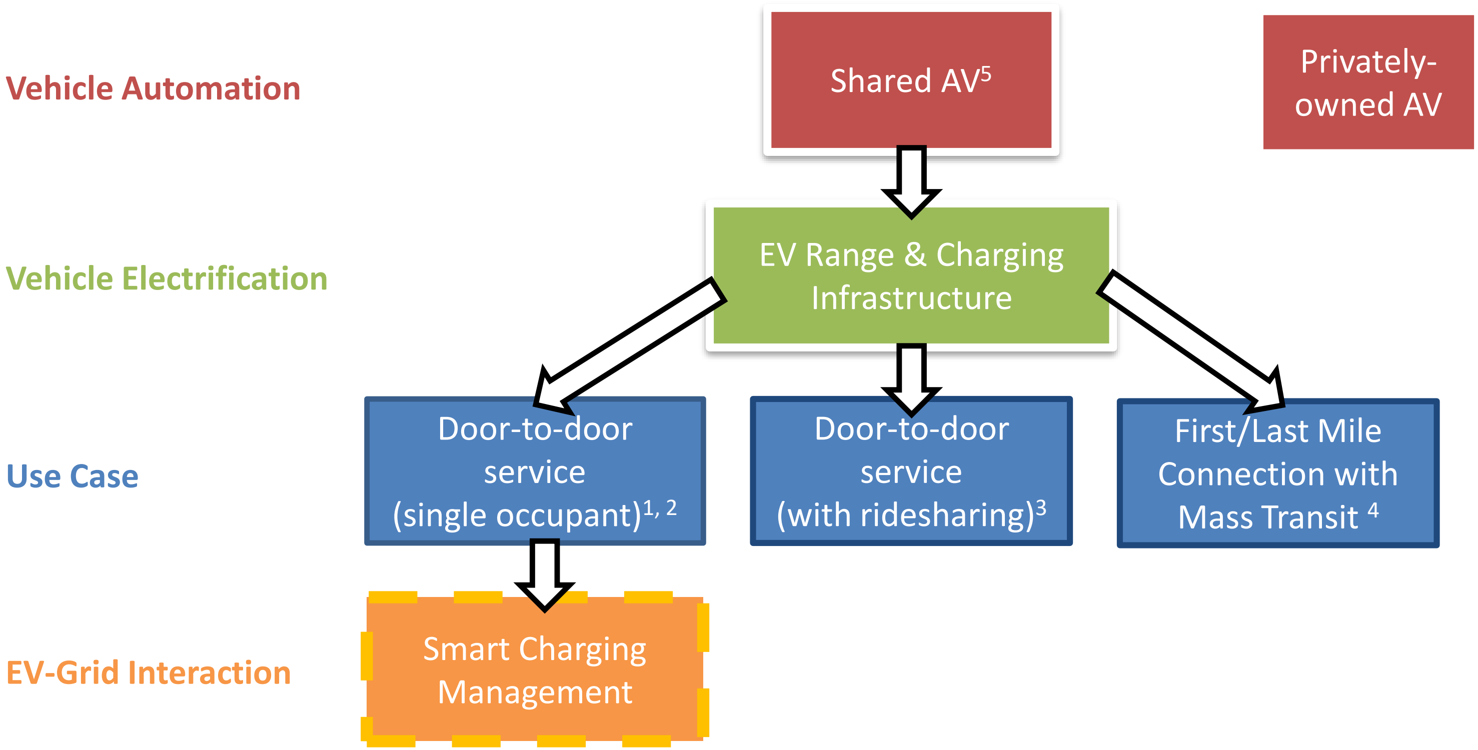
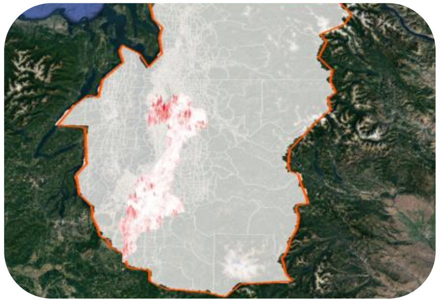
Shared Autonomous Electric Vehicle
Research



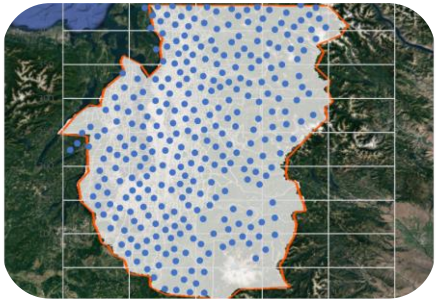
1. Chen, T.D, K. M. Kockelman & J.P. Hanna (2016) "Operations of a Shared, Autonomous, Electric Vehicle Fleet: Implications of Vehicle & Charging Infrastructure Decisions." *Transportation Research Part A: Policy and Practice* 94: 243-254.
2. Chen, T. D. & K.M. Kockelman (2016) "Management of a Shared Autonomous Electric Vehicle Fleet: Implications of Pricing Schemes." *Transportation Research Record* 2572: 37-46.
3. Farhan, J. & T.D. Chen [In Press] "Impact of Ridesharing on Operational Efficiency of Shared Autonomous Electric Vehicle Fleet." *Transportation Research Part C: Emerging Technologies.*
4. Farhan, J., T.D. Chen & Z. Zhang (2018) "Leveraging Shared Autonomous Electric Vehicles for First- and Last-Mile Mobility." Proceedings of the 97th Annual Meeting of the Transportation Research Board, January 2018, Washington, DC.
5. Hanna, J.P., M. Albert, T.D. Chen & P. Stone. (2016) "Minimum Cost Matching for Autonomous Carsharing." *International Federation of Automatic Control Papers On Line* 49-15: 254-259.

SAEV Modeling Framework



Trip Generation

- Use local travel demand model data to generate trips to simulate origin-destination travel demand

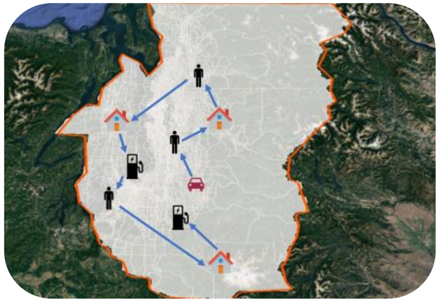


Charging Station Generation

- Charging station site selection to ensure sufficient infrastructure coverage

SAEV Fleet Generation

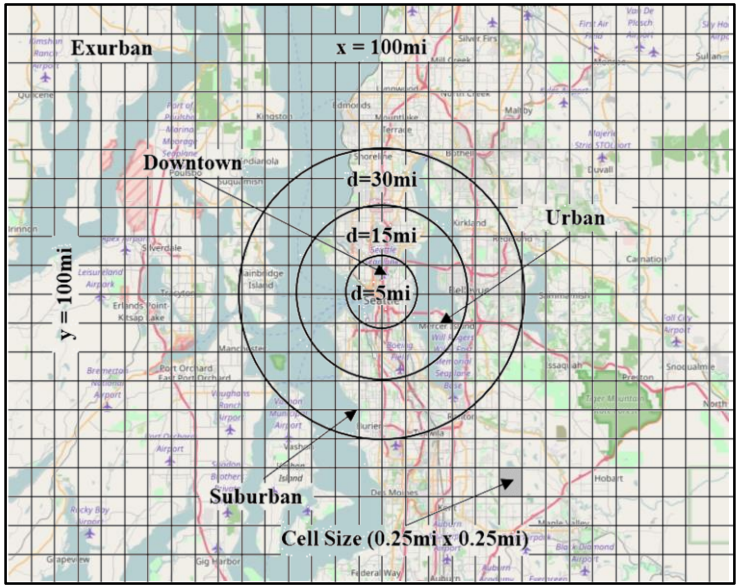
- Determine the necessary fleet size to serve travel demand

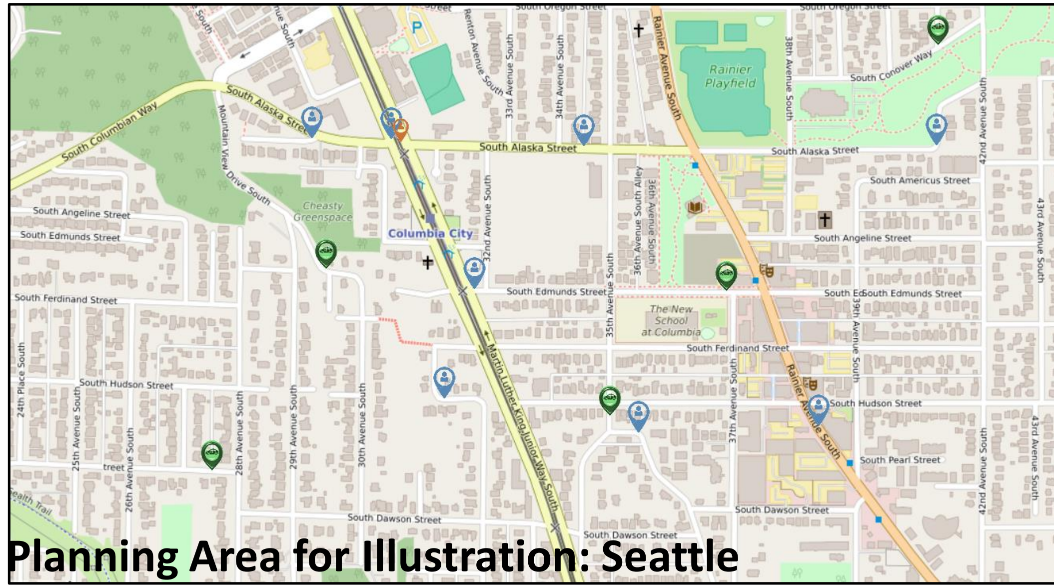


Operation

- Continuous daily operation based on the station and fleet configuration

SAEV Simulation Implementation





Planning Area for Illustration: Seattle

Pixelated Network

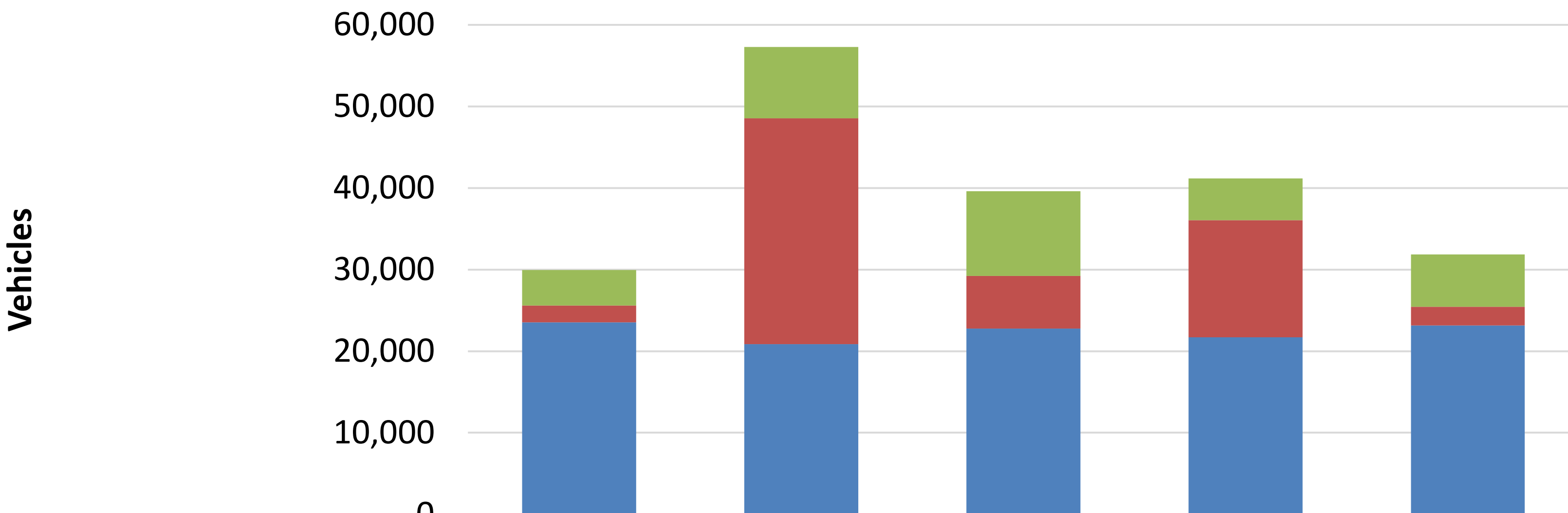
- Discretized network (0.25x0.25 mi cells)
- Restricts vehicle movement to Manhattan grid
- Vehicle moves to adjacent cell in discrete 5 min intervals
- Faster run time due to discretization (of space and time)

Street-level Map

- Map data to construct nodes and links
- Latitude & longitude are transformed to Cartesian coordinates
- Origin & destination positions are mapped to the nearest node using nearest-neighbor search (NNS)
- Slower run time due to continuous real-time operations

Vehicle & Infrastructure Impacts (1)

Fast charging infrastructure & **longer range** vehicles reduce required **fleet size**.

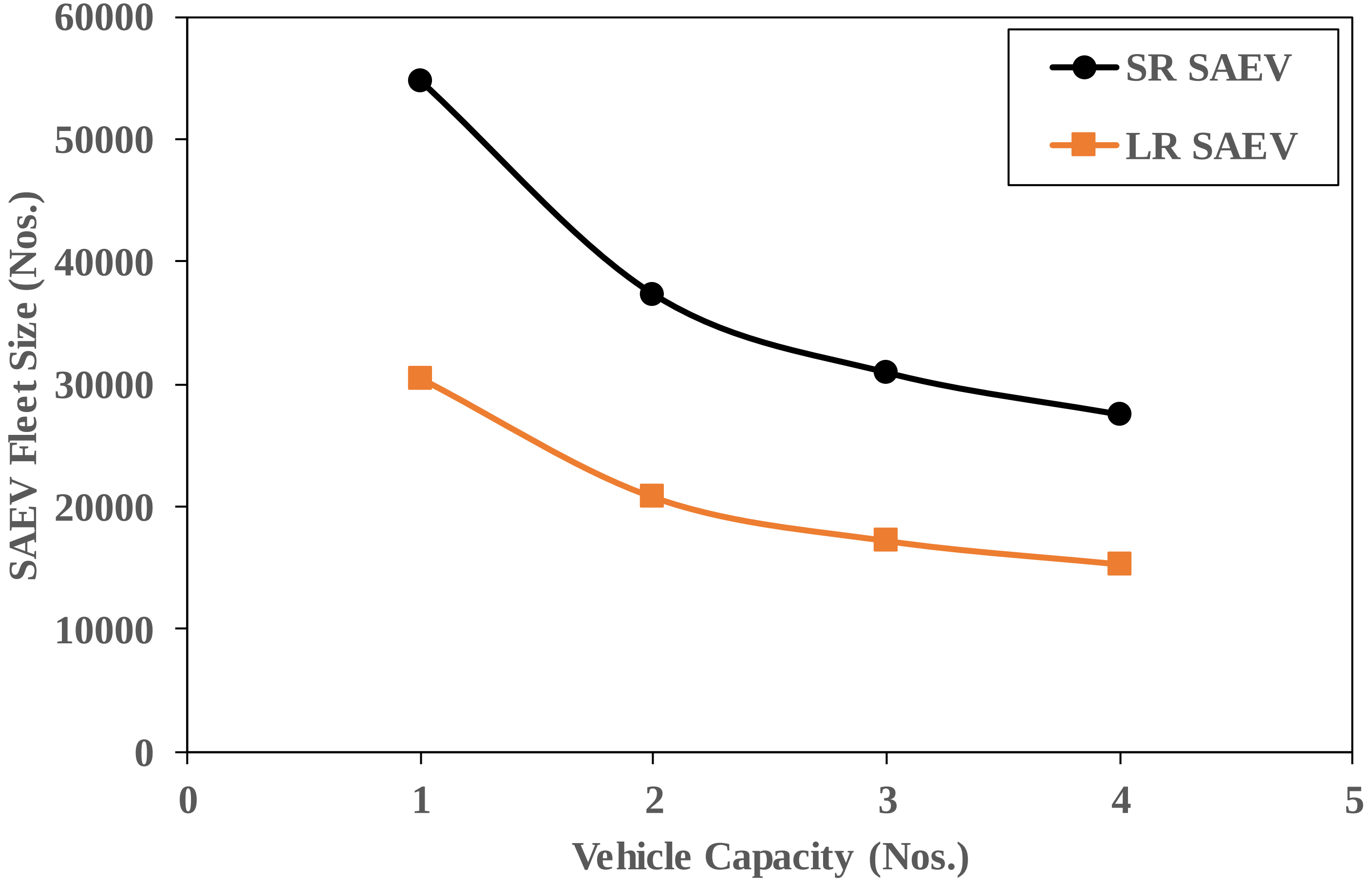


	SAV	SAEV	SAEV Fast Charge	LR SAEV	LR SAEV Fast Charge
Unused/Relocating Vehicles	4339	8741	10359	5145	6408
Charging Vehicles	2085	27668	6459	14340	2288
In Use Vehicles	23515	20869	22774	21693	23162

Fleet Size by Vehicle & Charging Infrastructure Type
(SAEV door-to-door w/o ridesharing)

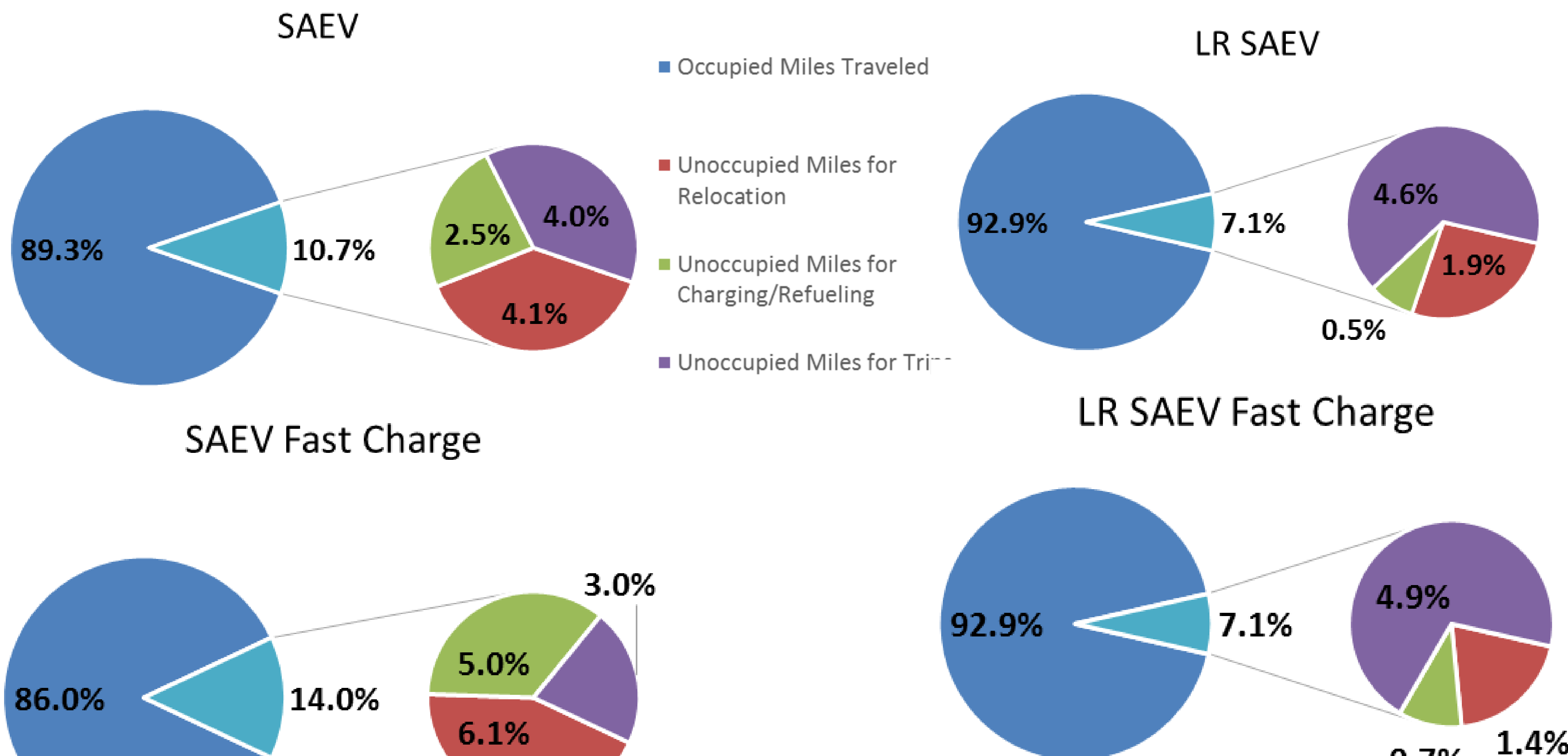
Vehicle & Infrastructure Impacts (2)

With ridesharing, **longer range SAEVs** consistently require smaller **fleet size** no matter the vehicle capacity.



Vehicle & Infrastructure Impacts (3)

Short range SAEVs incur more **zero occupant miles** due to more frequent trips to charging stations (w/o ridesharing).

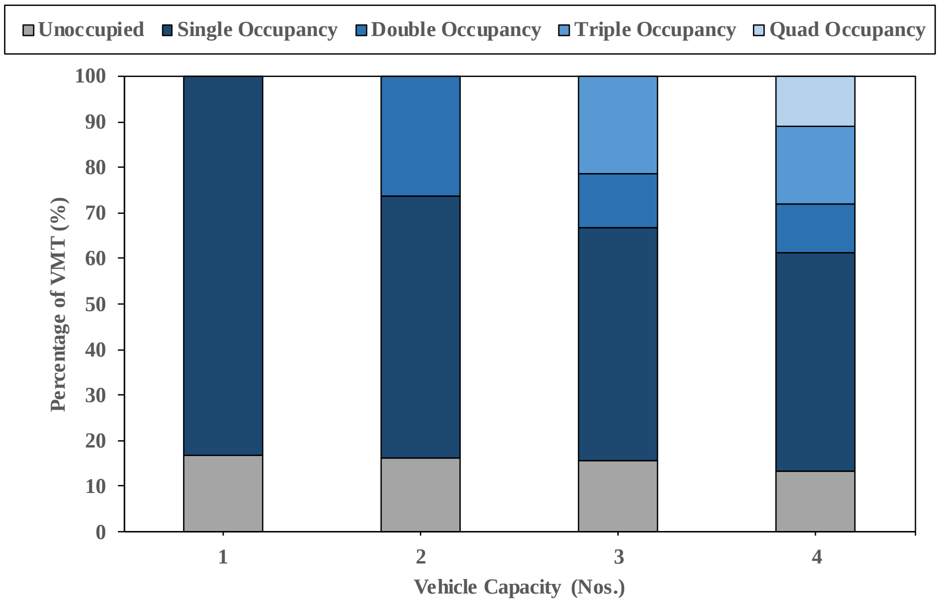


VMT by Vehicle & Charging Infrastructure Type
(SAEV door-to-door w/o ridesharing)

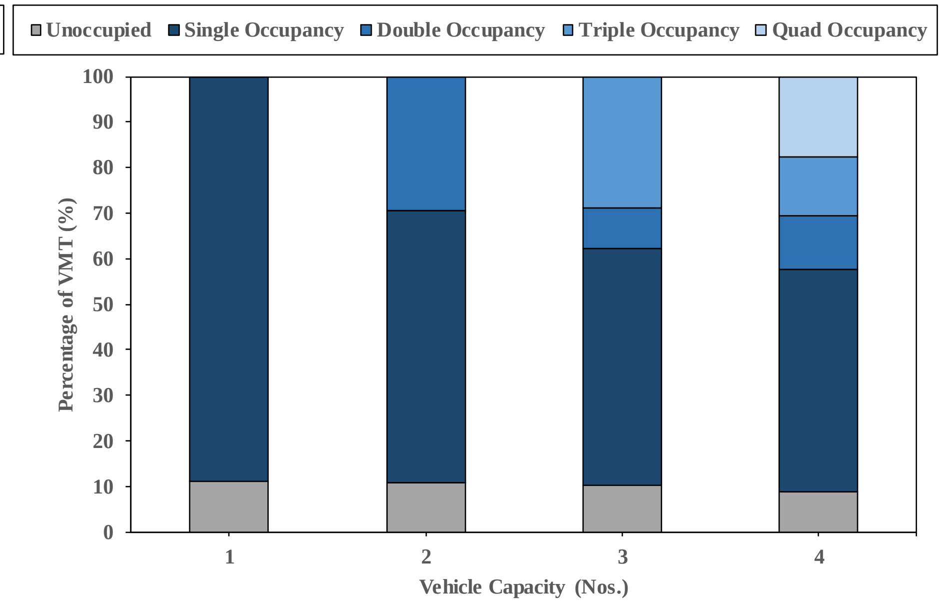
Vehicle & Infrastructure Impacts (4)

For scenarios with ridesharing, **short range** SAEVs' impact on **zero occupant miles** is consistent.

SR SAEV



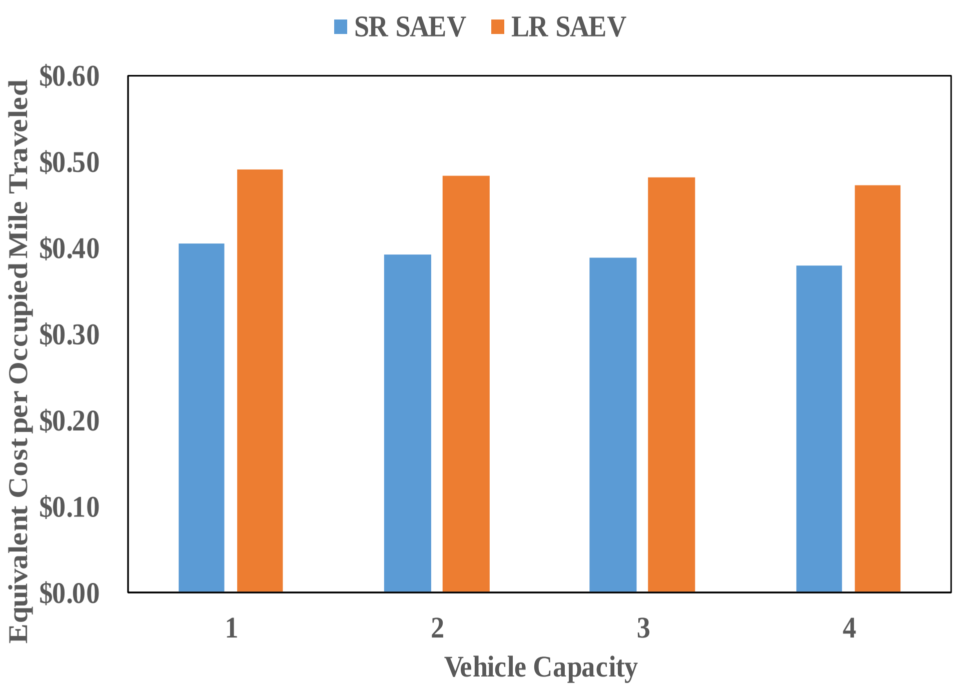
LR SAEV

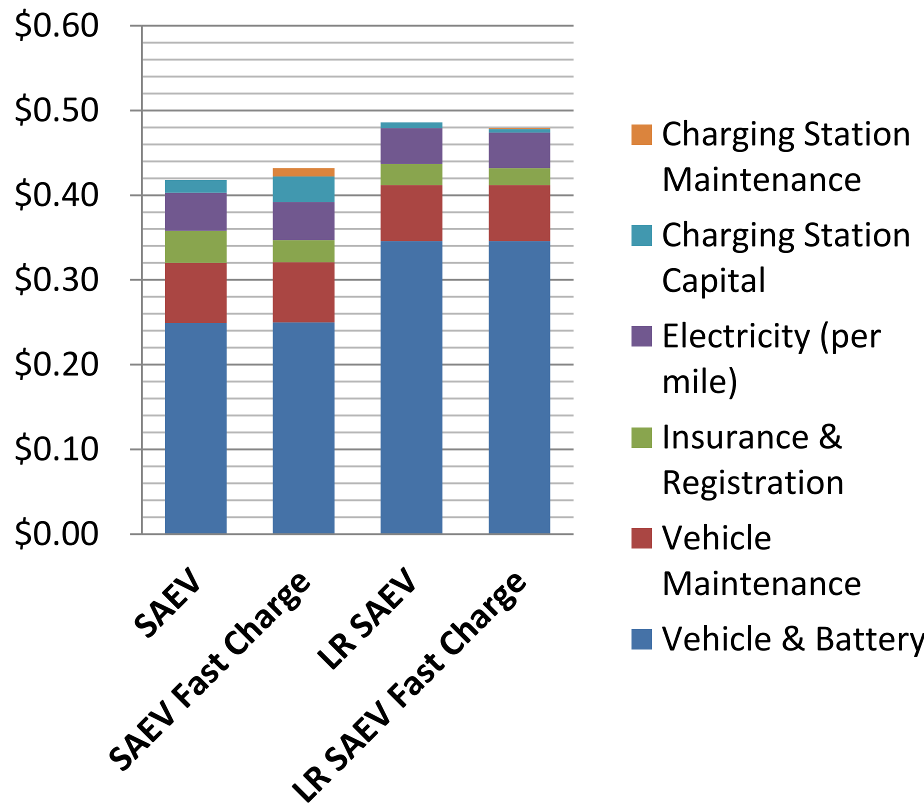


- **"Empty" VMT** comprises 13-16% of total VMT for SR SAEV scenario and 9-11% for LR SAEV scenario.
- Assuming all travelers are willing to participate in ridesharing, about **35% of all vehicle miles traveled** include at **least two passengers**.

Vehicle & Infrastructure Impacts (5)

Short range SAEVs reduce operation costs (per occupied mile traveled) assuming flat rate electricity pricing.



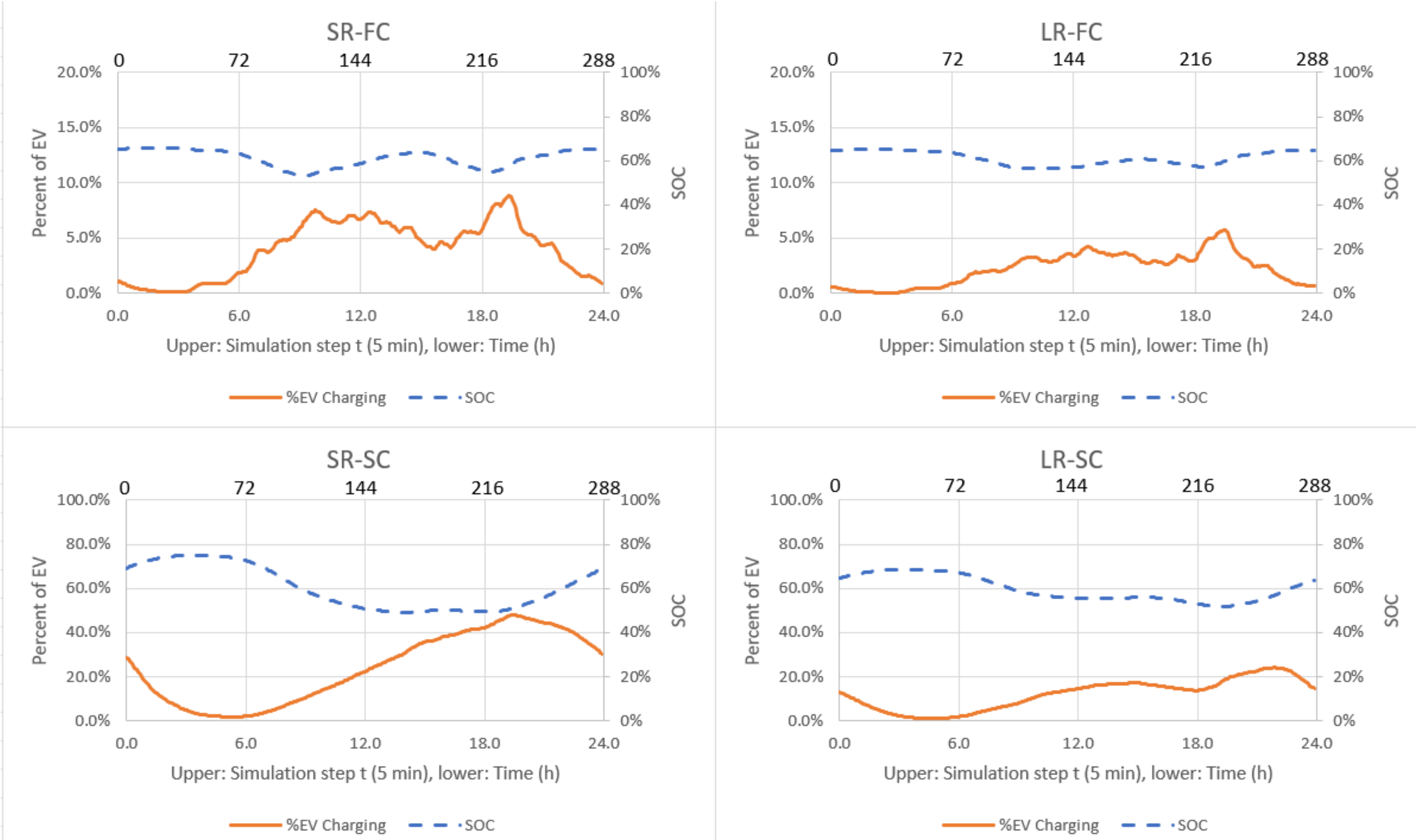


Cost per Occupied Mile Traveled
(With Ridesharing & w/o Ridesharing)

SAEV-Grid Interaction

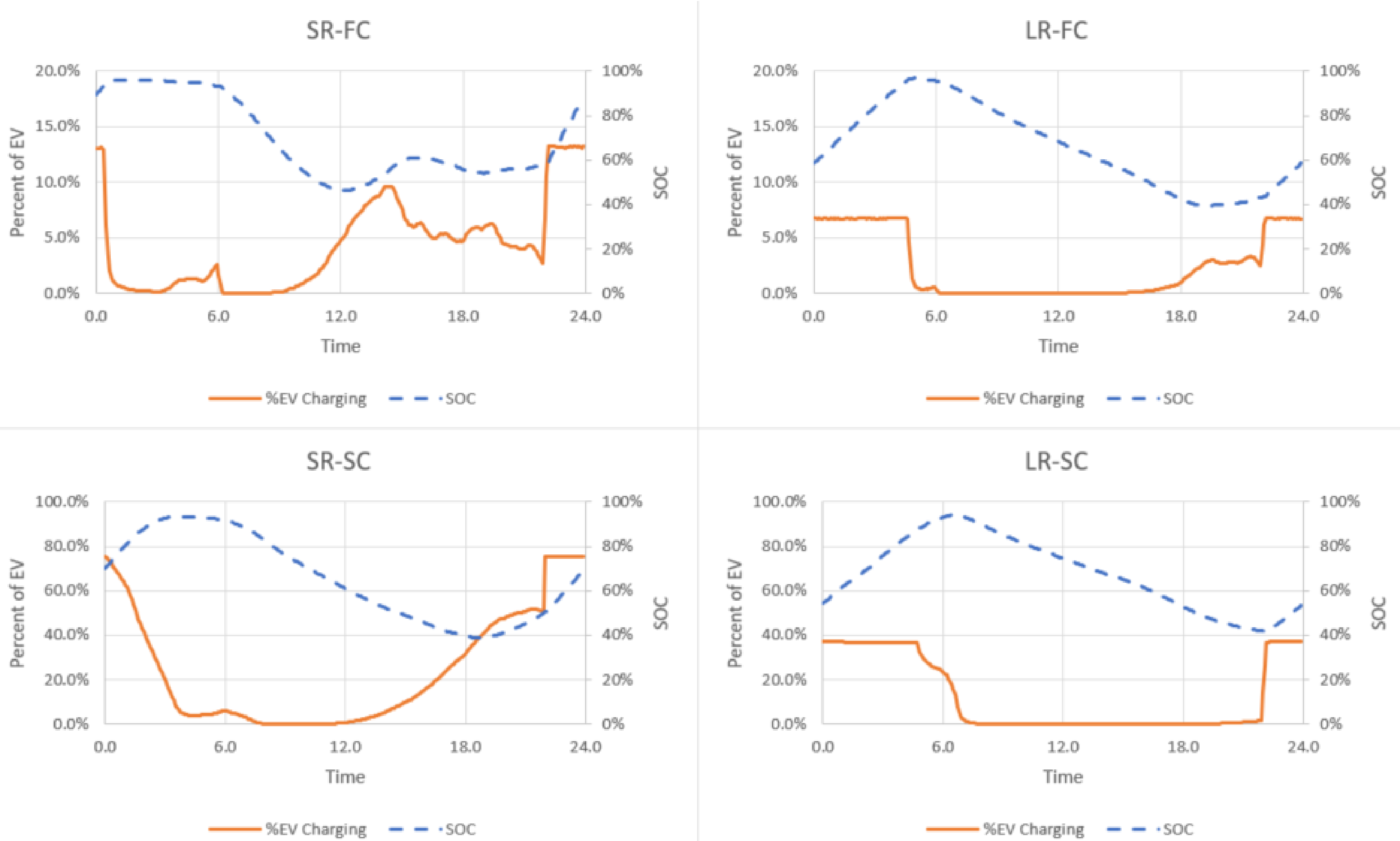
- If SAEVs provide transportation services to 10% of the 2017 transportation demand in the Seattle region, the estimated total electricity consumed by SAEV is 2500 MWh per day.
- At 100% market penetration, this would represent a ~20% increase in regional electricity consumption.

Unmanaged SAEV Charging



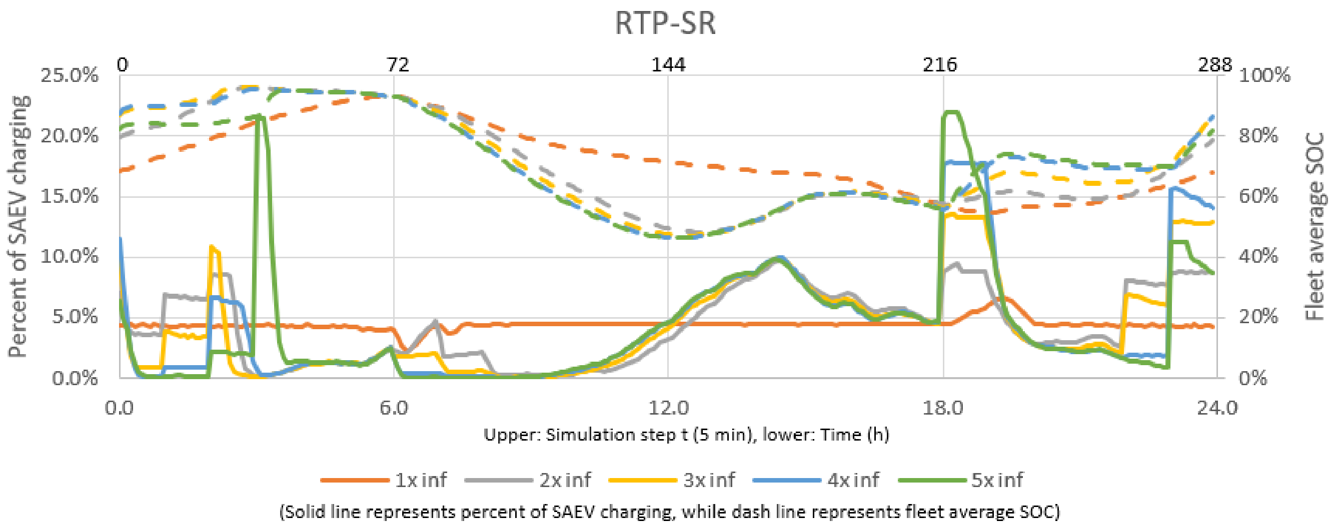
Unmanaged SAEV charging exhibit **peak charging periods** which coincide with **existing peak hours of electricity use**.

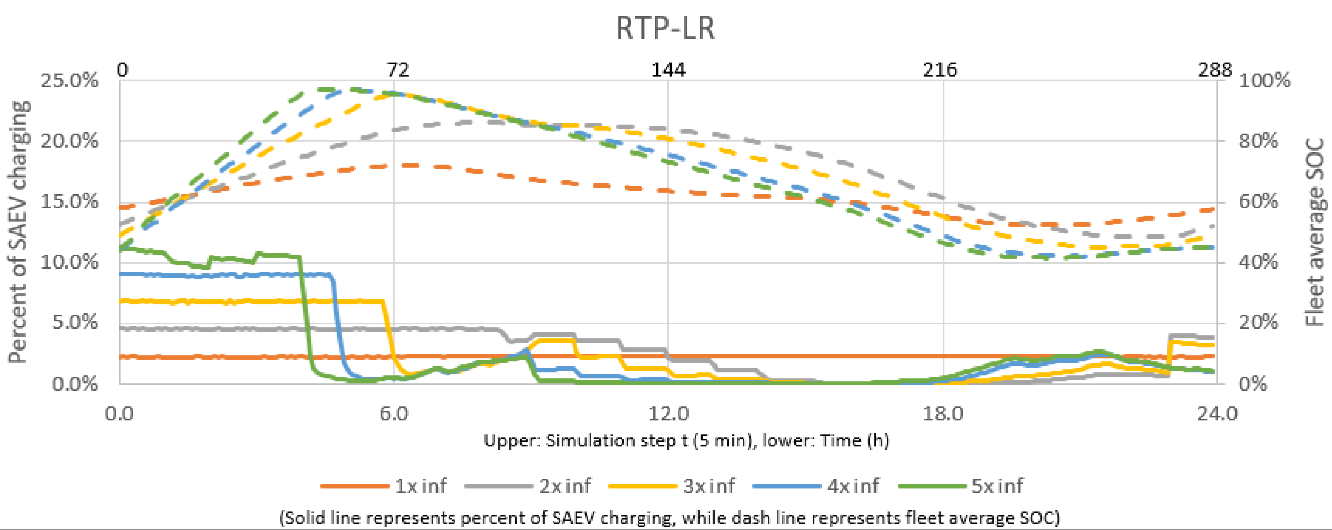
SAEV Smart Charging under TOU Pricing



With increased battery capacity, **LR vehicles** exhibit superior ability to **avoid charging on-peak**. Compared to unmanaged charging, electricity costs can reduce 10% (SR SAEVs) to 34% (LR SAEVs).

SAEV Smart Charging under RTP





Under **real time electricity pricing** scheme, **LR vehicles** are able to decrease electricity cost by 36 to 43% compared to SR vehicles with smart charging.

SAEVs: Key Findings

- Many different ways for SAEVs to impact the future of urban mobility and energy.
- As a mobility service competing with private vehicle ownership:
  - One **single occupant SAEV** can replace **4 to 7 privately owned vehicles with 7-14% zero occupant miles**.
  - One **SAEV with dynamic ridesharing** can **replace 8 to 13 privately owned vehicles with 9-16% zero occupant miles.**
  - **SR SAEVs** require **larger fleet sizes** and induce **greater zero occupant miles** compared to LR SAEVS.
- Interacting with the electric grid:
  - **Unmanaged charging** ("charge as needed") of SAEV fleets will increase evening peak electricity use.
  - **LR SAEVs** are more responsive to **smart charging** compared to SR SAEVs, and are able to decrease electricity costs 30-40% in TOU and RTP pricing scenarios.

Thank you for your time!

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