Pacific Northwest
NATIONAL LABORATORY

Electric Vehicles at Scale

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Some Perspectives on EV/Grid Integration

- **Energy:**
  - Today: LDV travel 2.2 * 10^12 miles/a. Assume 0.25 kWh/mile => 500 TWh
  - MDV/HDV travel 10^12 miles/a. Assume 1.8 kWh/mile => 1800 TWh
  - Total: 2,300 TWh for all on-road EVs today. (about 60% to current electric generation)
  - Compare to 4,000 TWh total electric generation
- **Power**
  - Assume constant hourly load profile for charging => 260 GW of dispatchable generation
  - If you take wind technology with CF of 33% = 780 GW of Wind capacity
  - Current total capacity 1.1 TW

Take-away:
- When considering electrifying buildings, industry, and maritime/aviation, we need multiple times of the current US electric infrastructure in the next few decades

PNNL previous and current work

- WECC analysis:
- https://www.pnnl.gov/sites/default/files/media/file/EV-AT-SCALE_1_IMPACTS_final.pdf
- https://www.pnnl.gov/news-media/influx-electric-vehicles-accelerates-need-grid-planning

- Distribution planning planning tools

PNNL's Distribution System Analysis Tool

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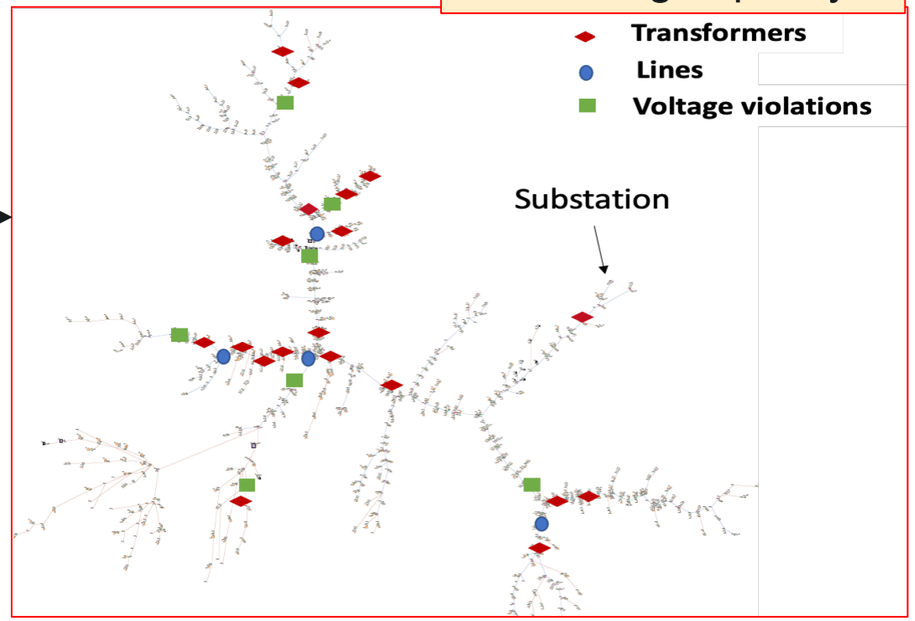
Circuit data

Charging assumptions

Power Flow Modeling

EV hosting capacity



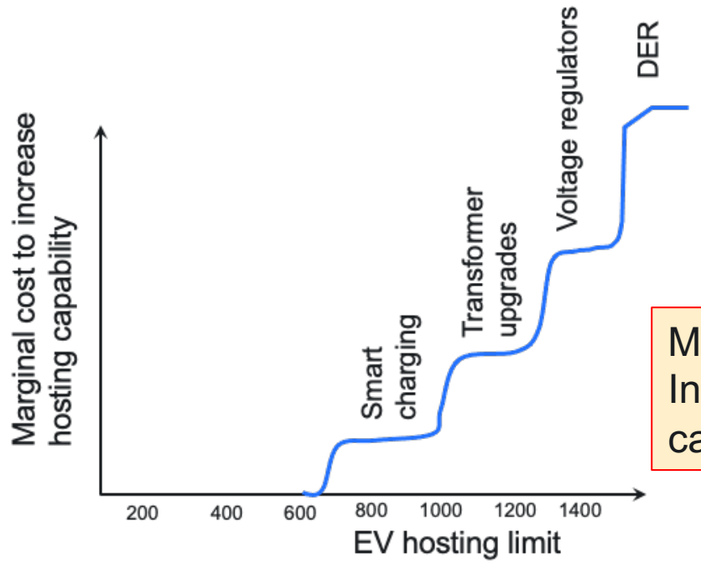
EVs by class
Located in neighborhoods

DMV/DOL Vehicle registration

Census Household Income data

Housing assessment

Market Adoption Modeling



Mitigation strategies In increase hosting capacity

Technical Accomplishments and Progress

New High-Resolution Socio-Economic LDV EV Adoption Model

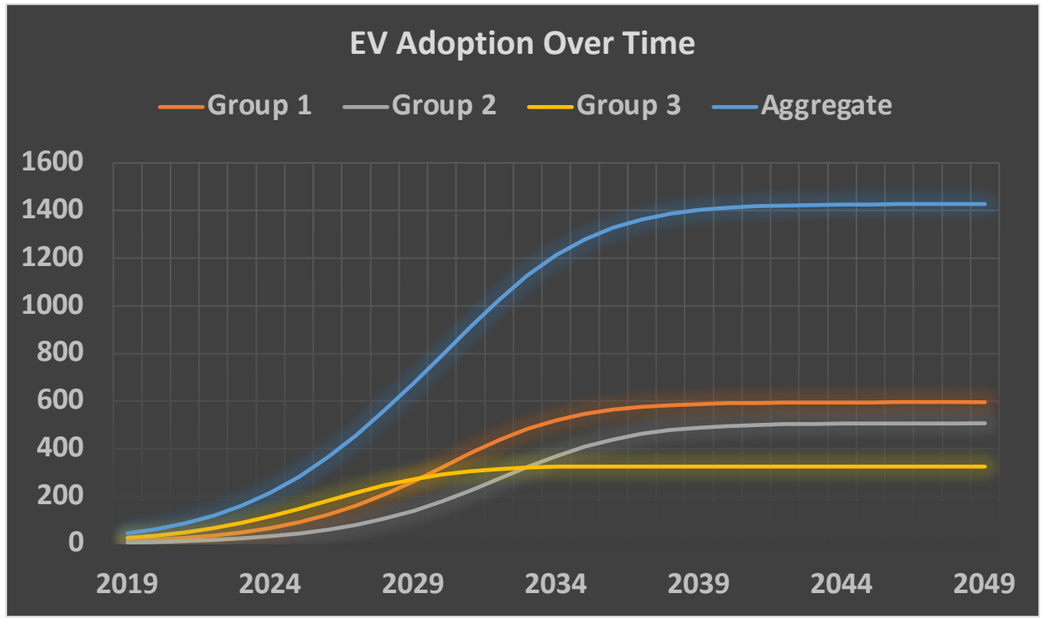
Example: Application to region in West Hollywood, CA

- Existing household vehicle registration was obtained from California Department of Motor Vehicles
- Household income estimated from county tax assessor's data and Census Bureau's income distribution data at the block level; charging accessibility inferences based on housing characteristics also from tax assessor data
- Assumes dedicated market transformation effort by the California Energy Commission and Southern California Edison to obtain 'zero emission vehicle' goals

Key Takeaways

- We can calibrate the model with State, municipal, or utility targets for EV penetration for a given future year

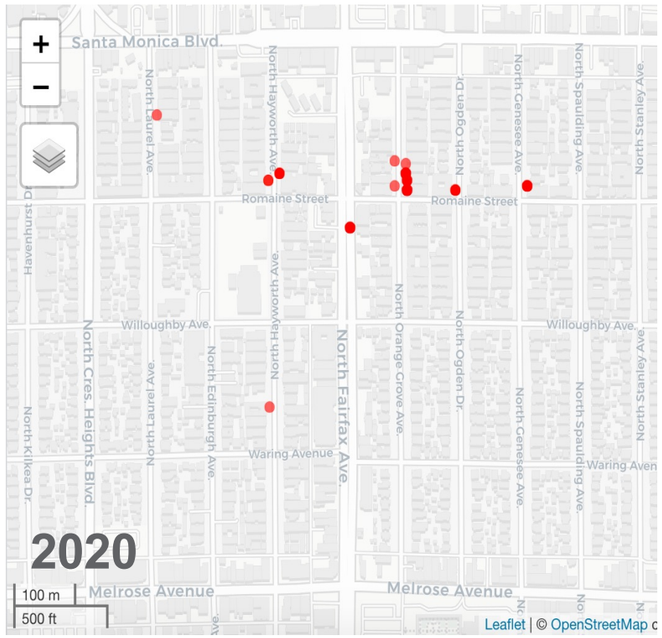
Preliminary results

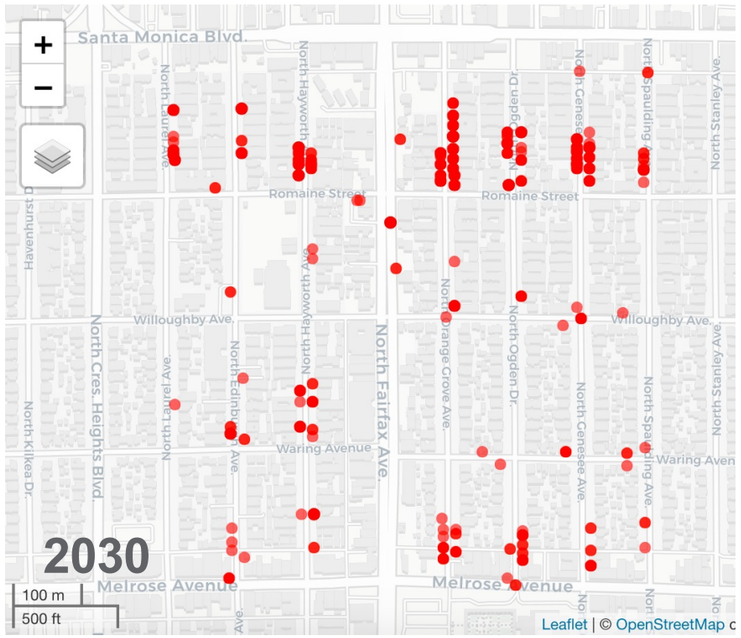


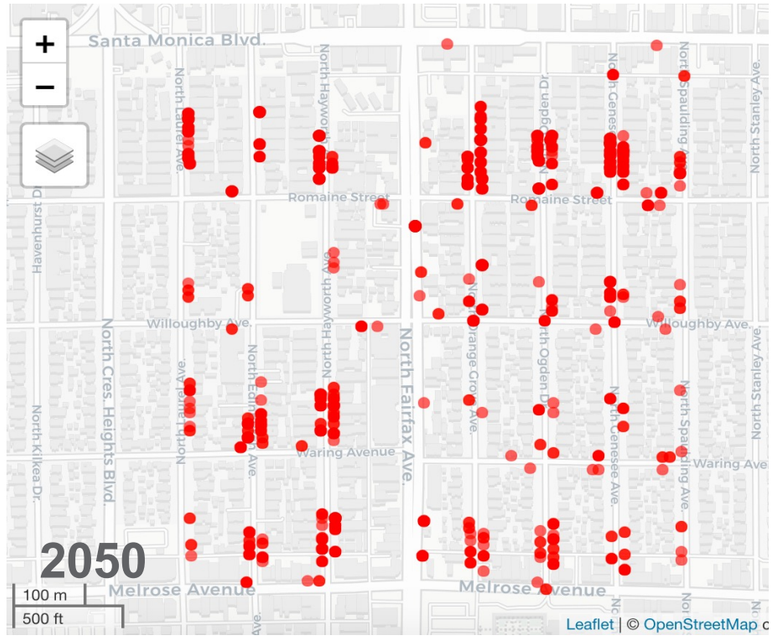
	Group 1	Group 2	Group 3
EV Range	25-300 mi	60-275 mi	PHEV 18-80 mi
Max Adoption	595	507	325

New High-Resolution Socio-Economic LDV EV Adoption Model

Probabilistic Locational Placement into Neighborhoods

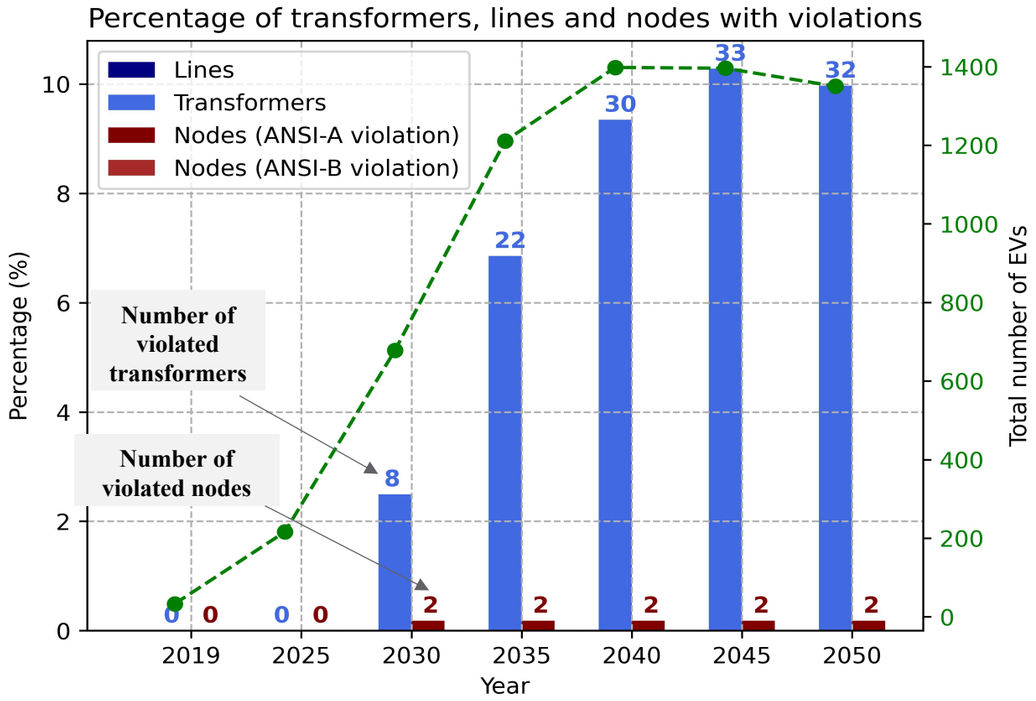






Relevance to Distribution System Engineers

Grid Analysis with GridLAB-D Prototypical Feeder



Impact Metrics	
Transformer thermal violation	180% for service transformers 100% rating exceedance for line,
Line thermal violation	
ANSI A: 5 min voltage violation	$0.95 > V > 1.05$ pu
ANSI B: Instant voltage violation	$0.90 > V > 1.10$ pu

Simulation Details

- Study years: 2025 to 2050 in 5-year increments
- Duration: Summer [June, July, August]. Can be over 1-year
- 500 adoption scenarios randomly drawn for each study year
- A grid component is flagged if its operating limit is violated for more than cumulative 2 hours in more than 5% scenarios
- Develop mitigation scenarios: smart charge management, infrastructure upgrades

Key Takeaways

- ❑ Analysis will identify constrained components in the grid infrastructure
- ❑ Analysis will provide location-specific bottlenecks as a function of time, guiding utility investment decisions
- ❑ Mitigation analysis will include smart charge management and infrastructure upgrade as options