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Reducing CA's grid operating costs and renewable curtailment with electric vehicle charge management

6.22.20 – IEPR VGI workshop

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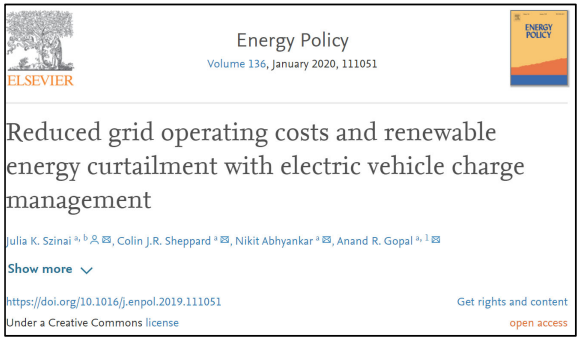
Analyzing wholesale grid impacts of EV charge management in CA

- Study of CA's bulk power system operations in 2025 with 50% RPS
- 4 EV adoption levels (0.95M, 2.1M, 2.5M, 5M) x 3 charging scenarios:

Unmanaged charging

Overnight Time-of-Use (TOU) charging

Smart charging (V1G)



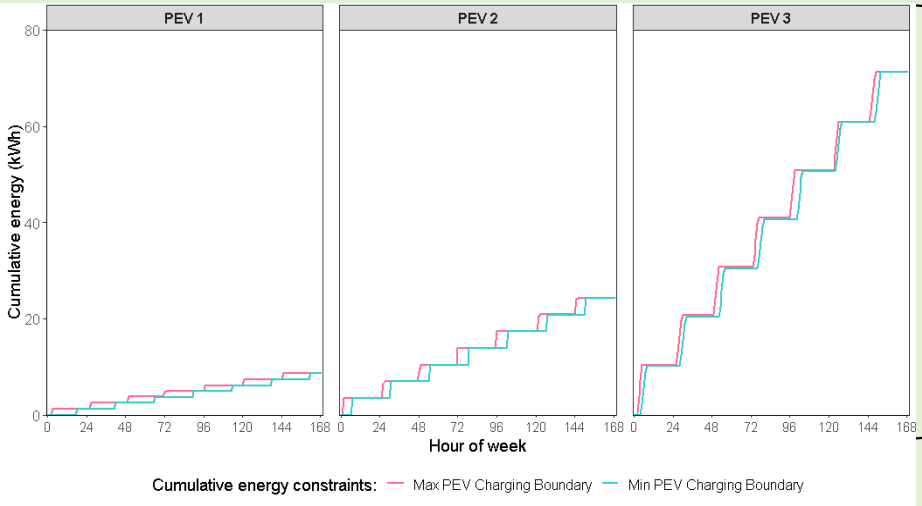
What is the wholesale grid value and renewable impact of managed EV charging?

- Total annual grid operating cost for CA of the wholesale market (generation + emissions)
  - Calculated managed charging value as cost difference compared to unmanaged PEVs
- Renewable curtailment levels with managed vs. unmanaged EVs

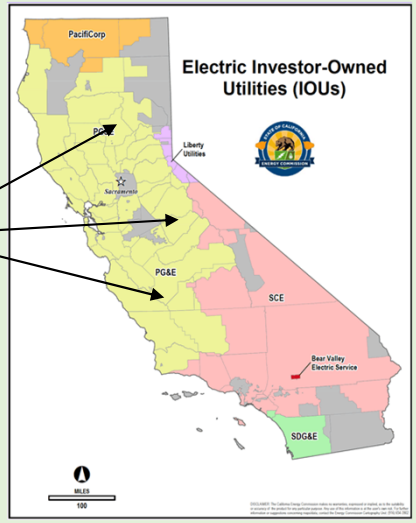
Analysis links high-resolution mobility and grid models to assess impacts

- **BEAM, agent-based mobility model**: Charging given drivers' travel demands and charger availability; smart charging limited to times when EVs are plugged-in if unmanaged
- **PLEXOS, economic dispatch model**: Based on CAISO data; WECC-wide unit commitment and generator dispatch calculates grid operating cost for 2025 with EV loads and CA 50% RPS

1. Mobility model (BEAM) produces EV loads + constraints for managed and unmanaged charging



2. EV charging load aggregated + scaled to CA



3. Grid model (PLEXOS) minimizes total grid operating cost w/ different EV charging scenarios

$$min \sum_{i,t} GenerationCost_{i,t}$$

$$subject\ to\ operational\ constraints$$

Key takeaways of managed charging impacts

Without restricting drivers' mobility, managed charging avoids up to 10% of CA's 2025 grid operating costs compared to unmanaged charging, but value per EV is relatively modest.

Smart charging is most effective at reducing grid costs and renewable curtailment relative to unmanaged EVs.

Overnight TOU charging saves on grid costs by avoiding peaks, but increases curtailment compared to unmanaged EVs.

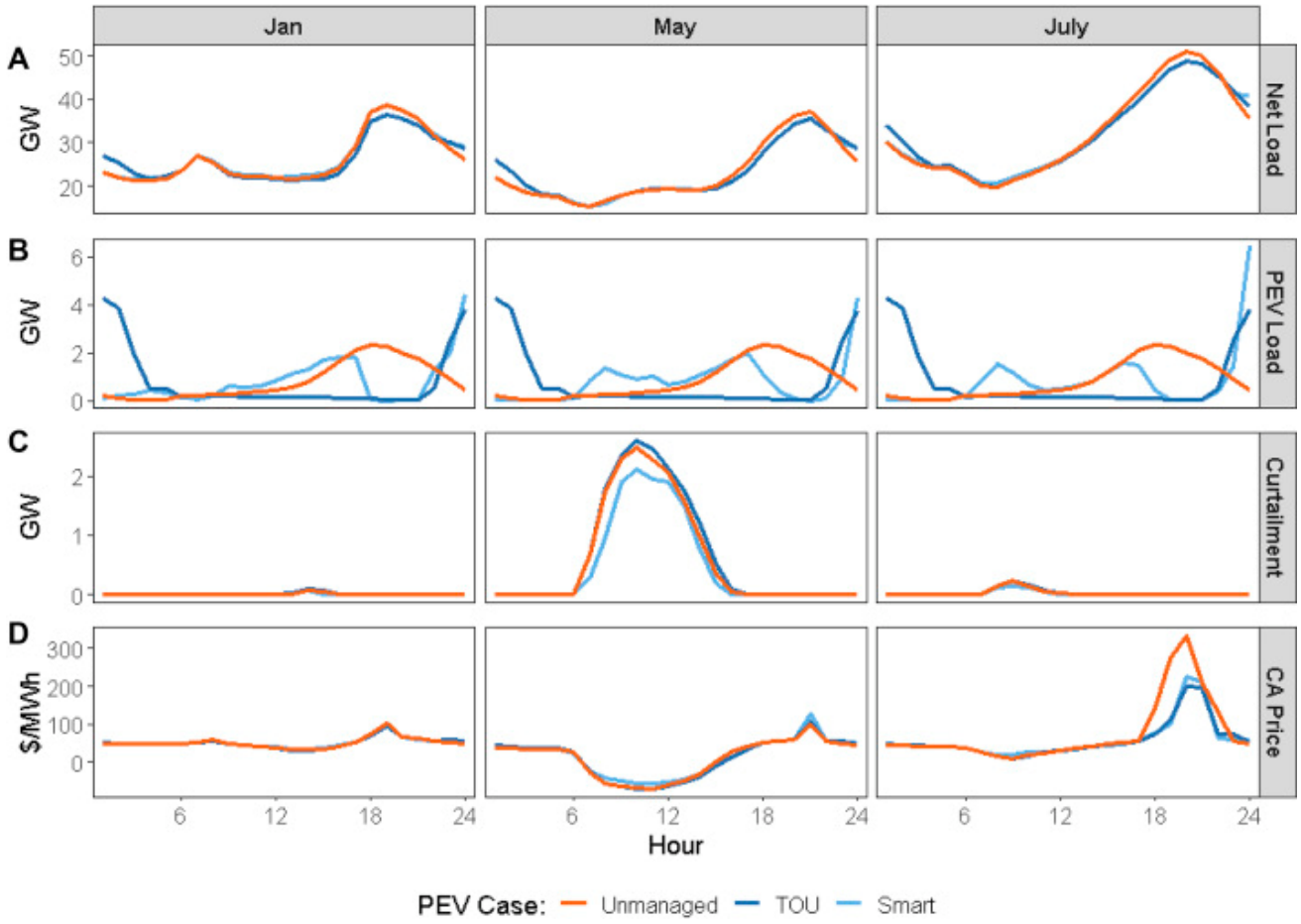
With high EV adoption (5M), both smart and TOU charging defers need for grid capacity expansion.

Residential smart charging provides majority of hourly grid flexibility and benefits.

With 1-5% of total CA load, EV charging strategy affects hourly operations

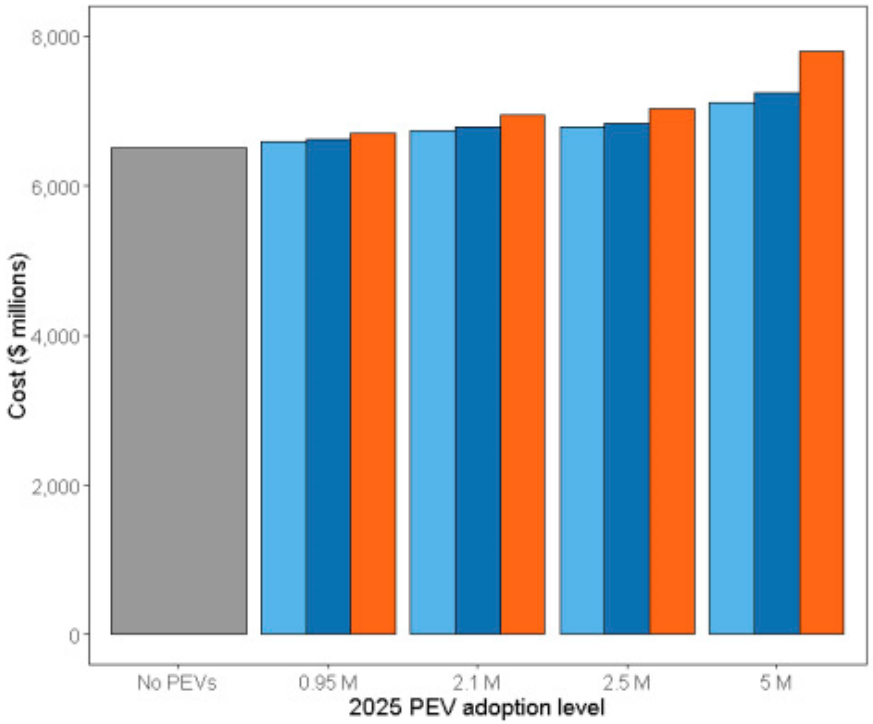
- Net load evening peak decreases with both TOU and smart charging
- Smart charging shifts loads to midday and overnight
- Spring curtailment decreases with smart charging
- Summer peak prices decrease with both smart and TOU charging

A. CA net load. B. PEV load. C. RE curtailment. D. average prices with 2.5 M PEVs.

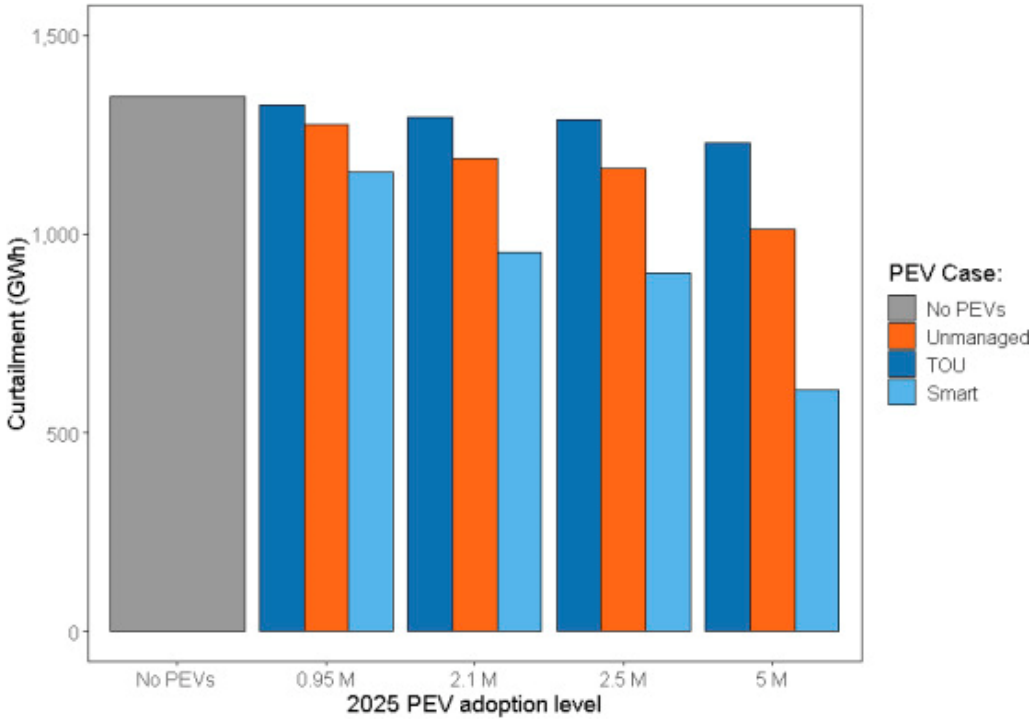


Managed charging lowers annual grid costs and renewable curtailment

A. CA annual wholesale grid operating costs



B. CA annual renewable curtailment



Value provided from operating cost savings compared to unmanaged EVs:

- $120M - 690M/yr; $125 - $140/EV with smart
- $90M - 550M/yr; $95 - $110/EV with TOU

Renewable curtailment levels compared to unmanaged EVs:

- Smart reduces up to 40% of curtailment
- Overnight TOU increases curtailment

Future considerations and uncertainties

- The value and grid impacts of VGI with EV adoption above 5M are likely to be non-linear.
- VGI will likely become more important in reducing curtailment on a grid beyond 50% RPS.
- VGI complements stationary storage and other electrified loads for grid services.
- A shift from personal EVs to light-duty EV fleets (ride-hailing) will affect VGI potential.
- VGI with HDV/MDV may have growing role and impact (including on distribution system).

Thank you!

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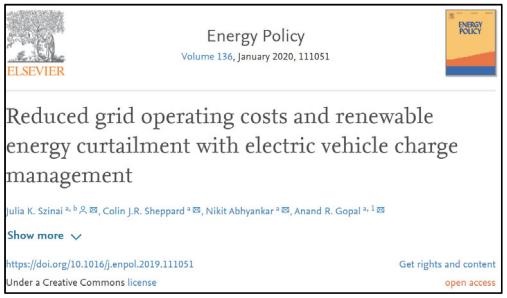
Szinai, Julia K., Sheppard, Colin J. R., Abhyankar, Nikit. & Gopal, Anand. R. Reduced grid operating costs and renewable energy curtailment with electric vehicle charge management. *Energy Policy* **136**, 111051 (2020).

Download our study here:
https://doi.org/10.1016/j.enpol.2019.111051



Gopal, Anand. R, Szinai, Julia. Electric Vehicles and the California Grid. *Next 10* (2018).

Download our study here:
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