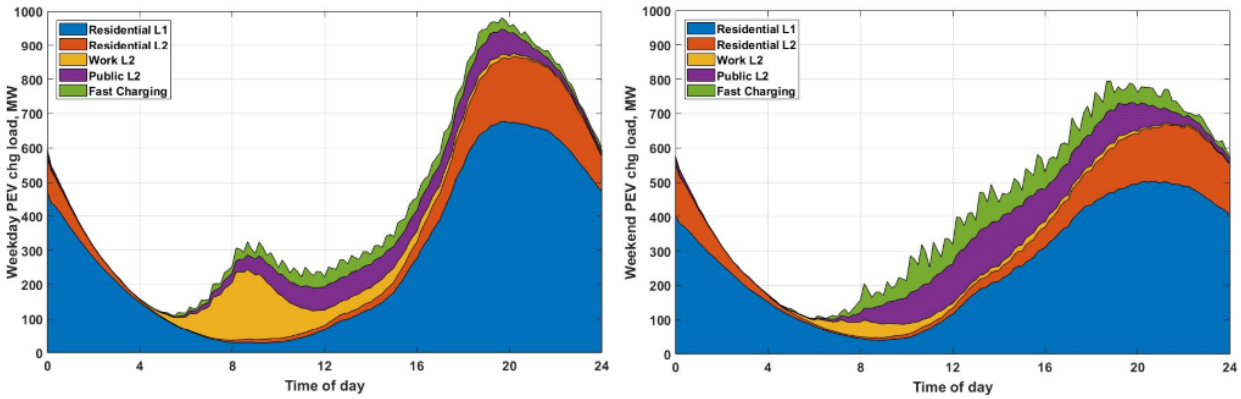
"What is it about VGI that has you focus your time and attention on it? What makes you think it is worth the time, attention, and money (including public funds) that could go into it?"

Transportation electrification is a cornerstone strategy for achieving state policy goals, and progress over the next decade will be critical. However, absent effective integration strategies, TE will create new load and new burdens on the electric system. Figure 1 below shows modeled PEV charging load from 1.3 million PEVs in 2025, adding nearly 1GW at system peak and exacerbating already challenging system ramp requirements. Meeting this new load will require procurement of additional generation or storage resources, and likely require expansions in transmission and distribution system capacity.

Figure 1: Unmanaged charging profile for 1.3 million electric vehicles in 2025



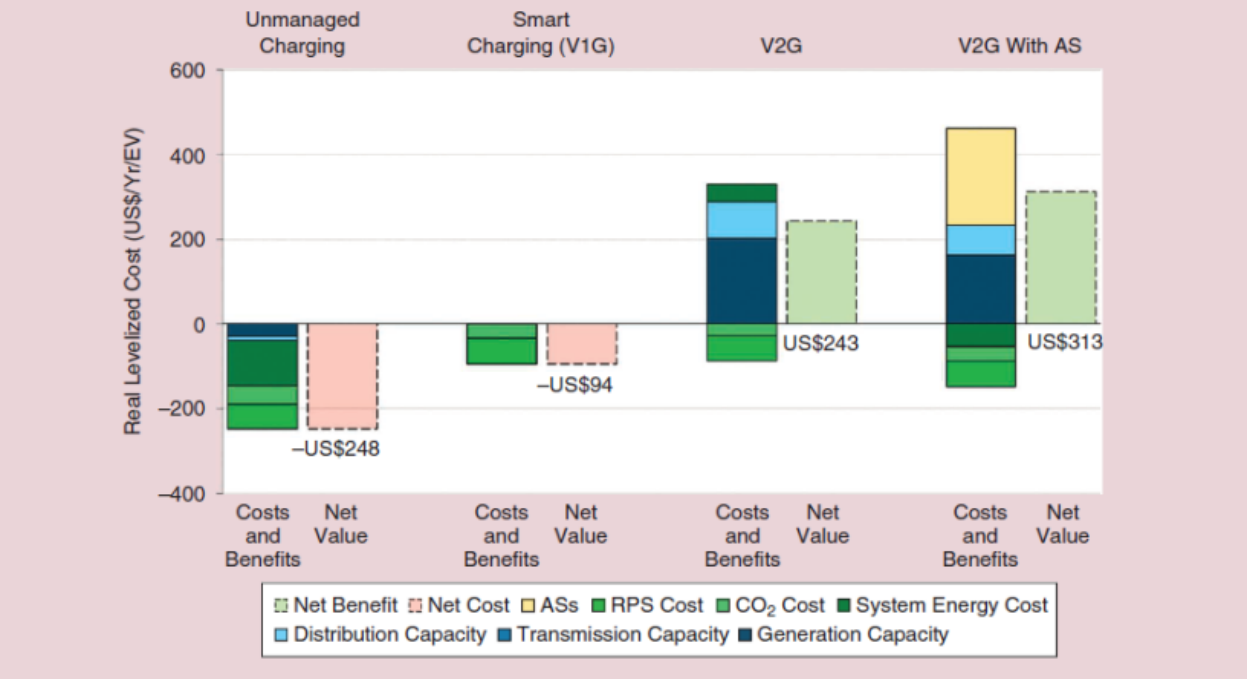
Unmanaged charging may add up to 1GW of peak load just as solar generation decreases. Load profiles undulate over the day across workplace, public destination, and home charging, with smaller intra-hourly surges associated with fast charging.

VGI can reduce the load growth and system burdens depicted in Figure 1—saving ratepayers money—as well generate savings for PEV drivers. Specific VGI benefits include:

1. Accelerating reduction of greenhouse gas and criteria pollutant emissions from the transportation sector;
2. Supporting further decarbonization of the electric sector by reducing curtailment of renewables and providing grid services;
3. Lowering total ownership costs for PEV owners and fleet operators and by managing utility bills and providing additional revenue streams; and
4. Reducing costs to electric ratepayers by limiting congestion on existing infrastructure, mitigating the need for new fossil generation resources, and potentially avoiding costly system capacity expansions.

Several studies of VGI in California call attention to these potential benefits and begin quantifying their magnitude for different use cases. Highlighted below are four CA-specific

studies from the past two years. Donadee et al. 2019[1] apply the E3-developed Solar Plus Storage tool to quantify the benefits of managed charging, V2G, and V2G with participation in ancillary services relative to an unmanaged charging baseline (Figure 2). Shepard et al. 2019[2] estimate system savings of 90-140 $/PEV-Yr for managed charging (60-120 $/PEV-Yr for TOU rates) from avoided system operating costs compared to unmanaged scenarios, and can simultaneously reduce curtailment of renewables by ~12%. Coignard et al. 2019[3] evaluate distribution feeder capacity benefits of managed charging assuming 1 PEV per house in San Francisco, CA, finding an ~55% reduction on average. In an earlier study, Coignard et al. 2018[4] quantified CAISO ramp rate reductions achievable with managed charging and used an estimated cost of stationary storage necessary to monetize these savings.



Despite uncertainty in data, assumptions, and modeling tools, collectively these studies illustrate the benefits and potential value of VGI. By comparing to baselines of unmanaged charging, the studies simultaneously identify risks to ratepayers, system operators, and PEV adopters if TE proceeds without VGI.

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[1] Donadee, J., Shaw, R., Garnett, O., Cutter, E., & Min, L. (2019). Potential benefits of vehicle-to-grid technology in California: high value for capabilities beyond one-way managed charging. *IEEE Electrification Magazine*, *7*(2), 40-45.

[2] Sheppard, Colin, et al. "Grid Impacts of Electric Vehicles and Managed Charging in California: Linking Agent-Based Electric Vehicle Charging with Power System Dispatch Models." *Lawrence Berkeley National Laboratory* (2018). https://eta-publications.lbl.gov/sites/default/files/sheppard_-_grid_impacts.pdf

[3] Coignard, Jonathan, et al. "Will Electric Vehicles Drive Distribution Grid Upgrades?: The Case of California." *IEEE Electrification Magazine* 7.2 (2019): 46-56.

[4] Coignard, Jonathan, et al. "Clean vehicles as an enabler for a clean electricity grid." *Environmental Research Letters* 13.5 (2018): 054031.

My response is below:
Lowering total ownership costs for PEV owners and fleet operators and by providing additional revenue streams. Reports indicate that revenue streams for fleet managers and operators do exists, and can provide long-term avenues for VGI credits, assuming the program and crediting system in place exists.

- A government fleet of PEVs in Southern California providing regulation up and regulation down to the CAISO markets may yield total revenue of $100/month-vehicle.
- An institutional fleet of PHEVs in Boston providing discharging energy to a building at peak times could mitigate demand charges and result in savings of $100/month-vehicle.
- A BEV charging at 6.6 kW in California providing demand response to its utility may provide savings worth approximately $60 /year-vehicle, depending on the time that it is charging.
- I thought this was important to note for the MUD role: "To minimize the risk of stranded investments, future mobility and vehicle ownership patterns should be considered, as some current charging locations (i.e. in apartment buildings, at parking meters along city streets) may not be needed in the future". http://www3.weforum.org/docs/WEF_2018_%20Electric_For_Smarter_Cities.pdf

Reducing costs to electric ratepayers by limiting congestion on existing distribution infrastructure, the need for new fossil generation resources, and costly distribution system upgrades.

- Therefore, regulation in some countries/regions encourages the inclusion of energy storage and local renewable energy (mainly solar PV) for fast-charging sites to reduce the costs and the need for capacity upgrades (*e.g.*, through power purchase agreements for renewable energy for charging providers in some US states). However, the additional high capital costs of storage can limit the effectiveness of this technique to mitigate demand charges. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Innovation_Outlook_EV_smart_charging_2019.pdf

- Utility programs as outlined in the 2016 ZEV Action Plan: "The Power Your Drive Program, administered by San Diego Gas & Electric, authorizes roughly 3,500 charging stations at 350 workplaces and multi-unit dwellings, as well as a vehicle-grid integration rate to incentivize charging that is responsive to dynamic, location-based electricity rates that will help integrate renewable energy and avoid infrastructure and capacity upgrades." https://static.business.ca.gov/wp-content/uploads/2019/12/2018-ZEV-Action-Plan-Priorities-Update.pdf, and "J. Coignard, P. MacDougall, F. Stadtmueller and E. Vrettos, "Will Electric Vehicles Drive Distribution Grid Upgrades?: The Case of California," in *IEEE Electrification Magazine*, vol. 7, no. 2, pp. 46-56, June 2019. https://ieeexplore.ieee.org/document/8732007

Supporting further decarbonization of the electric sector by avoiding curtailment of renewables and providing grid services:

- "EVs can provide a dual benefit of decarbonizing transportation while lowering the capital costs for widespread renewables integration". Jonathan Coignard et al 2018 Environ. Res. Lett. 13 05403 https://iopscience.iop.org/article/10.1088/1748-9326/aabe97/pdf

4. Accelerating reduction of carbon and criteria pollutant emissions from the transportation sector.

- SB 350, SB 676, AB 2127, etc. and related PR Codes (PUCode 740.8, 740.12, 740.3, 740.2)
- CARB Mobile Resource Strategy