Impact of workplace and other convenient vehicle charging

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We use market analysis and simulation of the US light duty vehicle fleet to examine the potential impact of conveniently located away from home charging infrastructure on the goals of (1) reducing long-term reliance on petroleum and (2) increasing future electric vehicle (EV) sales. This infrastructure is most commonly implemented as workplace charging (WPC).

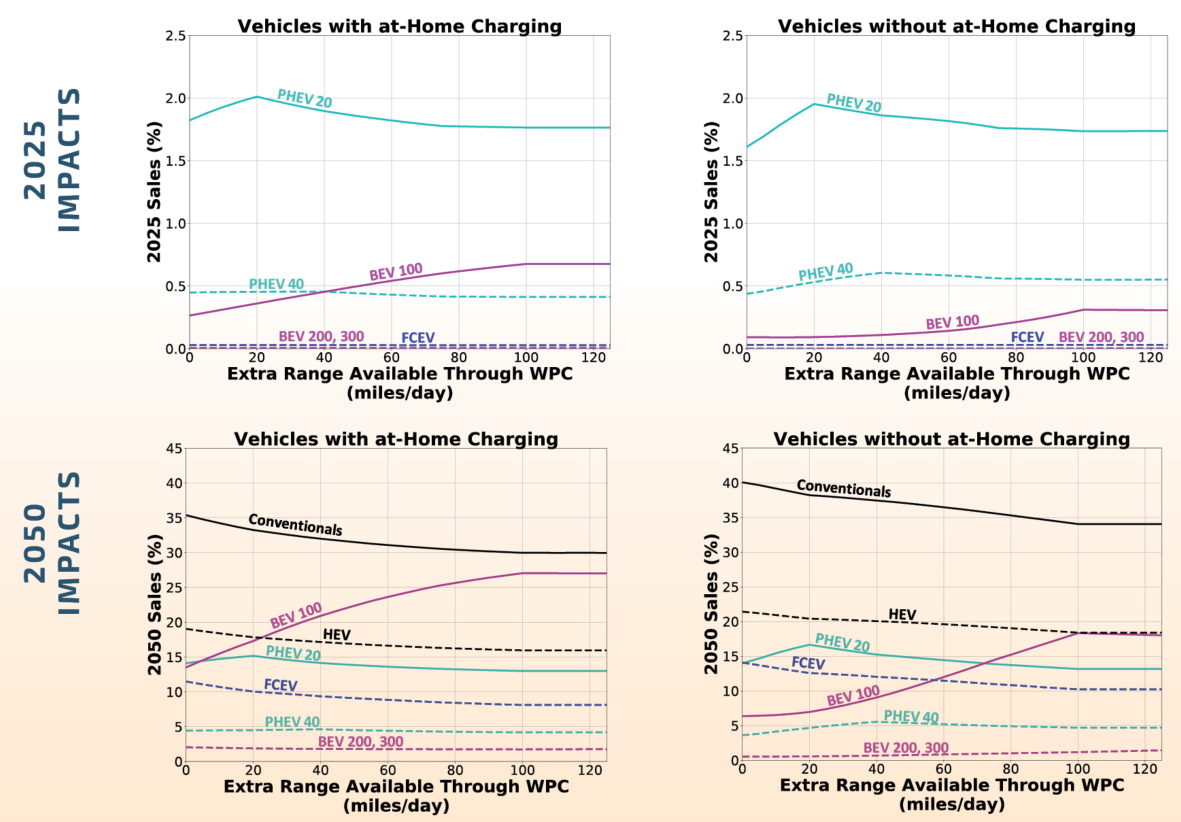
Our market analysis simulation tool is the ParaChoice model, which captures the dynamic feedback between consumer choice and the energy, fuel, and infrastructure which influences that choice. At each simulation time step, representative consumers for different demographic sets choose between different vehicle powertrains, driving the evolution of the fleet through new vehicle sales. Fuel use, prices, and infrastructure evolve in response influencing the next time step's sales.

THIS ANALYSIS AVOIDS SOME OF THE PITFALLS OF FORMER AWAY FROM HOME CHARGING ANALYSES, SPECIFICALLY:

- EV ownership evolves as consumers choose if an EV is appropriate for them. This varies based on consumers' annual mileage, ability to install at home charging, WPC options, and other demographics.
- Consumers choose between different EV ranges and types. Vehicles considered are all-electrics (BEVs) with 100, 200, and 300 mile ranges, and plug-in hybrids (PHEVs) with 20 and 40 mile electric ranges.
- Causation is captured. Unlike in data analyses where cause and effect are necessarily convoluted, scenarios with WPC can be compared directly to scenarios without.
- Sales, petroleum use, and GHG emissions are analyzed for the near-term and projected into the future, providing insight on long-term impacts of WPC.
- Uncertainties are quantified through Monte Carlo analysis.

Sales Impact

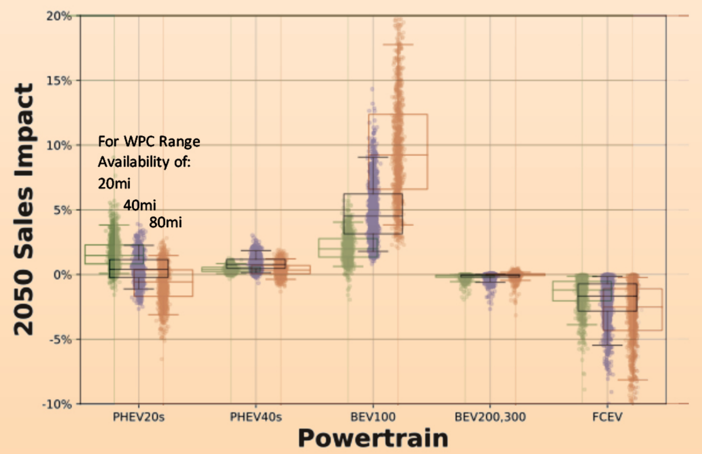
With at-home charging / Without at-home charging



- All-electric vehicles with 100 mile range (BEV100s) see greatest net sales increase for all workplace charging (WPC) range offerings, both short-term and long-term
- Higher range BEVs gain little from WPC
- Plug-in hybrid (PHEV) sales increase in homes without at-home charging access for < 40 mi/day WPC range
- Conventional, hybrid (HEV), and fuel cell (FCEV) sales decrease

Uncertainties explored through Monte Carlo analysis of technology and energy futures, consumer behavior and modeling assumptions

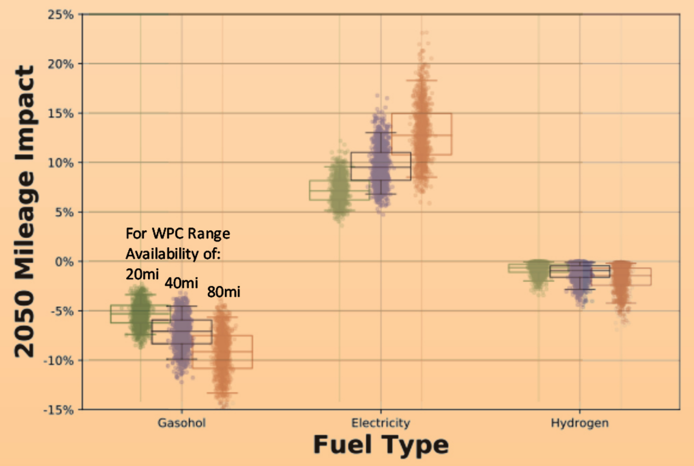
- Potential future sales impact on BEV100s from WPC is large, but subject to a wide range of uncertainty
- Longer range BEV and FCEV sales decrease as less expensive BEV100s are enabled by WPC
- Depending on the electric range made available by WPC, low range PHEV sales might be negatively impacted as consumers seek vehicles better able to use the electric range



Mileage Impact

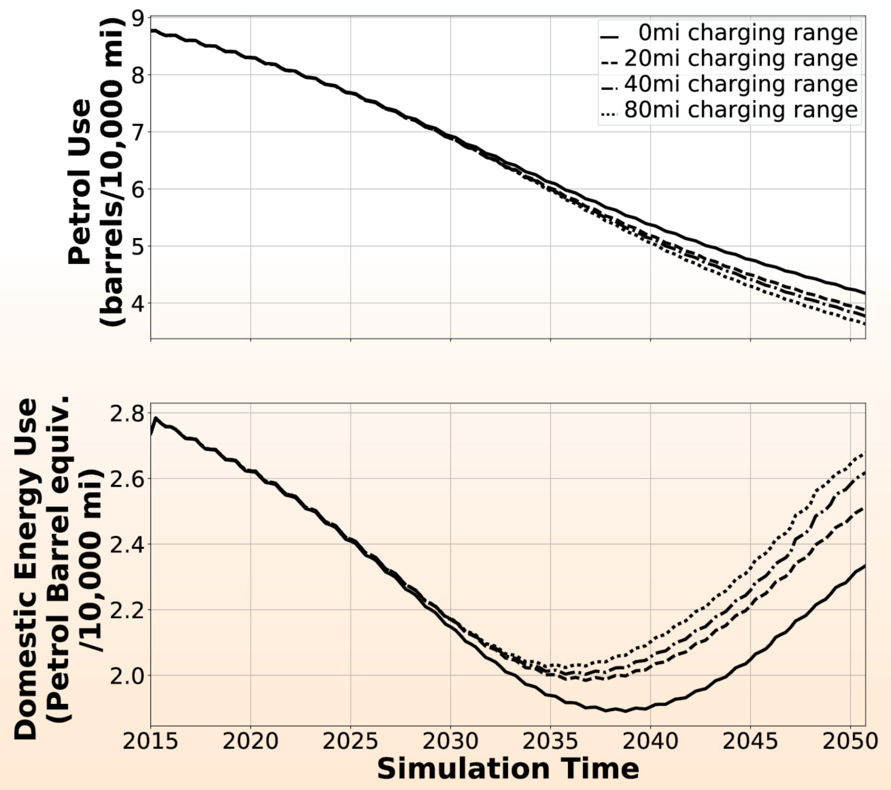
LDV fleet composition and sales projections are used to compute LDV mileage by fuel type

- 20 mi/day of WPC availability for 100% of the population may reduce 2050 fleet-wide gasohol usage per mile by >5%
- Increasing WPC availability to 40 mi/day will likely only lead to an additional 2% reduction



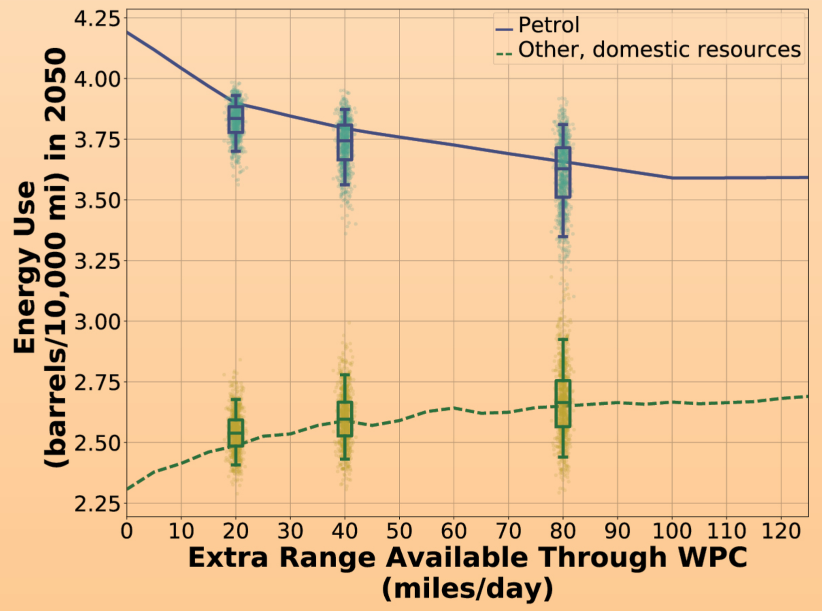
Energy Impact

Energy Use by LDVs



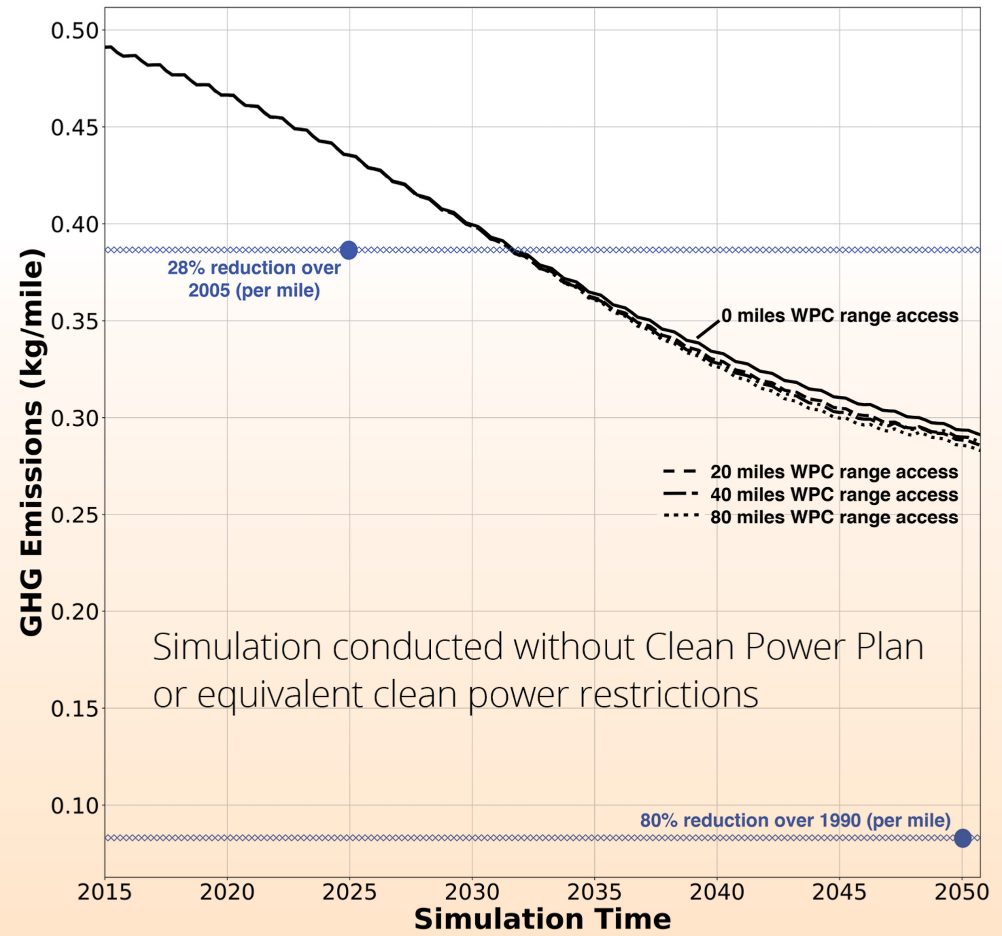
Domestic Energy is non-petrol domestic energy. (Natural gas, biomass, nuclear etc.)

- Petrol use decreases in all scenarios due to increasing efficiency of all vehicles and increasing electrification of the fleet with time
- In scenarios with increased ranges of workplace charging (WPC), additional reductions in petrol use may be realized due to increased adoption of electric vehicles and utilization of batteries
- The largest reduction in petrol use comes from the addition of the first 20 miles of range made available through WPC
- Non-petrol domestic energy use is dominated by electricity use. Electricity is used by LDVs
  - Indirectly during gasoline production
  - OR Directly for charging electric vehicles
- The decrease in non-petrol domestic energy use in early years is due to petrol use reduction
- The uptick in non-petrol domestic energy use in later years is due to electricity use increase

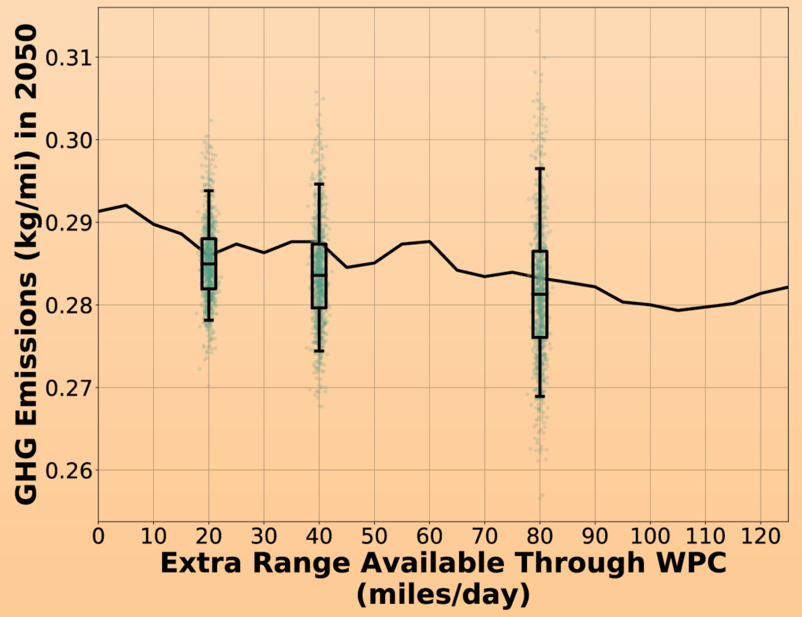


Greenhouse Gas Impact

GHG Emissions from LDVs

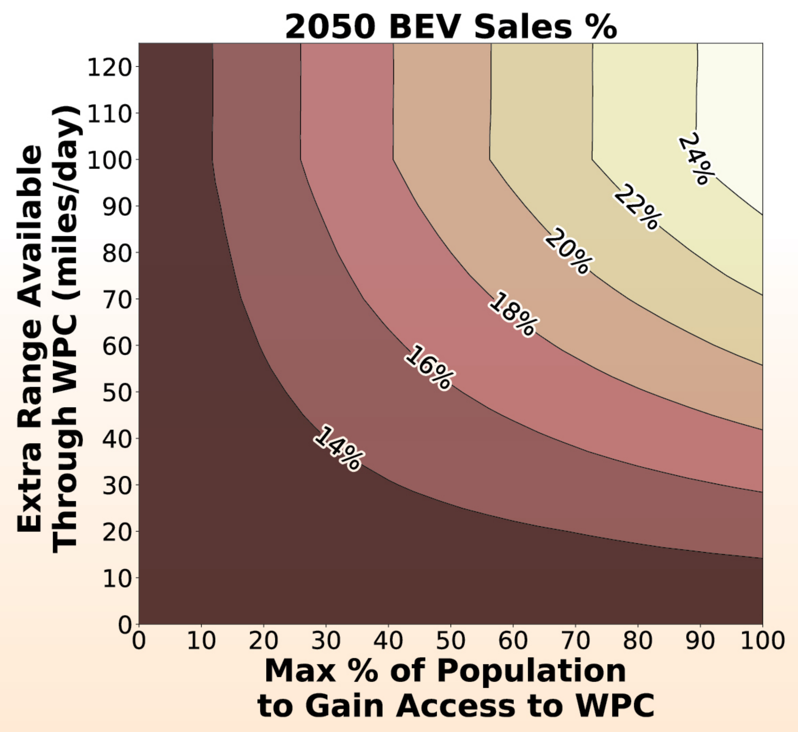


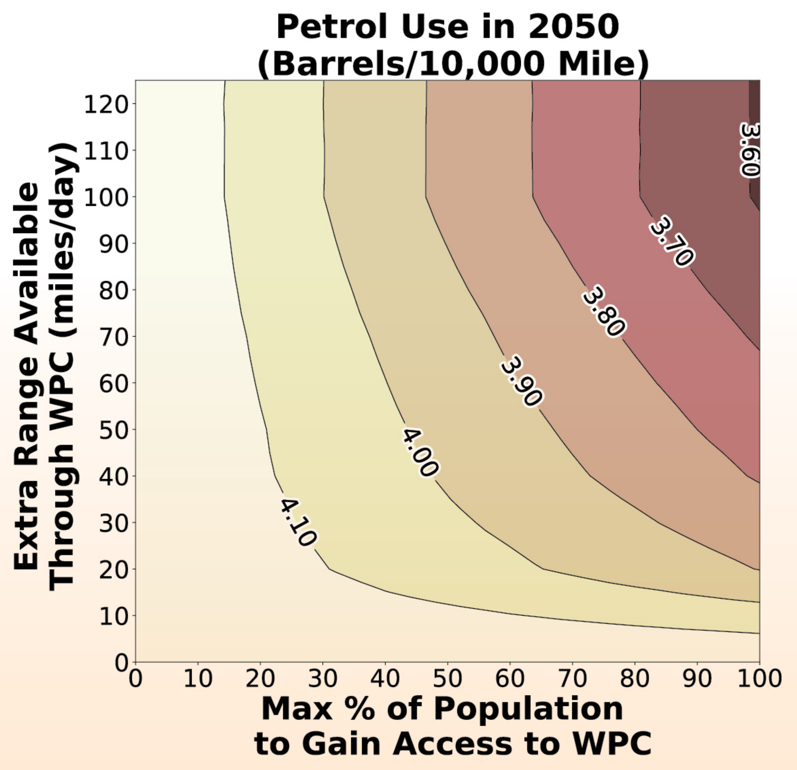
- GHG emissions per vehicle mile traveled decrease ~40% in all scenarios due to increasing efficiency of all vehicles and electrification of the fleet
- Without implementation of incentives or directives to shift the nation to cleaner power or to encourage electric vehicle drivers to charge off-peak, impacts of workplace charging will likely be small
- Workplace charging alone cannot drive the LDV sector to meet Paris climate convention targets or those required to maintain 2° C climate change (blue dots)



Miles vs Access

Reduction to impact if only a fraction of the population has access to WPC





- If <10% of the population has access to workplace charging (WPC), then the impact on 2050 BEV sales will likely be < 2%
- If the range made available to individuals through WPC is at least 20 miles/day, petrol use reduction becomes much more sensitive to the fraction of the population with access than any additional range made available
- BEV sales benefit more in response to increases in range availability through WPC than does petroleum use reduction.

Conclusion

(a) If workplace or other convenient charging is rolled out to 100% of the population, the projected consequence to BEV sales and petroleum use might be significant. In particular:

i. Access to a full workday of level 1 charging (up to 40 miles/day) will likely spur a 40% increase to BEV sales and a 9% reduction to petroleum use per mile of driving (fleet-average) by 2050

ii. Access to a half workday of level 2 charging (up to 80 miles/day) will likely spur an 80% increase to BEV sales and a 12% reduction to petroleum use per mile of driving (fleet-average) by 2050

(b) Greenhouse gas emissions impacts will be modest, 0.1 kg/mile CO_2-equivalent reduction in GHG emissions by 2050, if there is no incentive or directive on electricity generation or charging off-peak

(c) Petrol use reduction is much more sensitive to the fraction of the population with access than any additional range made available through public charging, once access to workplace charging range extension reaches ~20 miles/day

(d) Assuming that a charger only guaranteed for a half workday could be shared by 2 vehicles, and that one guaranteed for a full workday cannot be shared, four level 1 chargers induces roughly the same 2050 BEV sales impact as one level 2 charger. However, the petrol reduction impact of four level 1 chargers is generally superior

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