How Emissions-Optimized EV Charging Enables Cleaner Electric Vehicles

Smart timing of EV charging based on marginal emissions rates can reduce associated grid emissions by up to 18% annually and more than 90% on individual days

AUTHORS

Christy Lewis (WattTime), Peter Bronski (Inflection Point Agency), Gavin McCormick (WattTime), Nick Amuchastegui (WattTime)

Executive Summary

The number of electric vehicles (EVs) on U.S. roadways is poised to explode from 1 million in 2018 to nearly 19 million in 2030. In tandem, electric vehicle charging points are also expected to balloon, including nearly 10 million level 2 charging stations distributed across homes, offices, and public locations. Level 2 chargers are especially ripe for optimization—price, emissions, or other—since an EV's charge duration is typically shorter than the overall charge window.

Meanwhile, the nation's electricity grids are evolving. As more renewable energy gets added to traditionally fossil-fueled power grids, real-time emissions rates are increasingly exhibiting large swings from clean to dirty and vice versa from one moment to the next. The growing variation in emissions rates at different times presents an opportunity to make clean EVs even cleaner, by optimizing charging to sync with clean energy and avoid dirty energy.

Effectively implementing this solution requires several prerequisites, from accurate data on which times are cleaner, to software that can seamlessly control the EVs to prioritize charging at these times. WattTime refers to a successfully implemented complete package of all the necessary components of emissions-optimized electricity use (including as used for EV charging in this report's analysis) as Automated Emissions Reduction (AER).

Moreover, we are beginning to see a growing number of periods of surplus renewable energy going to waste. Charging an EV at these exact moments causes literally no incremental pollution at all, because it simply absorbs surplus renewable energy that otherwise would have gone to waste. This opens up the alluring possibility of EVs that could charge on 100% renewable energy, at least at times, even on grids that still have some fossil-fueled generation as part of their mix.

This report's analysis thus answers two key questions: a) How much cleaner can EVs be with correctly implemented emissions-optimized charging? And b) What would be the collective environmental impact of emissions-optimized charging given 2030 EV adoption forecasts and widespread adoption?

We analyzed the additional, incremental emissions reductions that could be achieved with emissions-optimized charging vs. baseline EV charging. We considered average and high mileage scenarios for two of the most common EV charging profiles (i.e., daytime workplace charging, overnight at-home charging). We examined four representative grids that cover a spectrum of fossil fuel and renewable energy generation mixes:

- California Independent System Operator (CAISO) northern California subregion,
- New York Independent System Operator (NYISO) NYC subregion,
- Southwest Power Pool (SPP), and
- Western Area Power Administration Rocky Mountain Region (WACM).

OUR RESULTS FOUND THAT:

Smarter charging reduces ANNUAL emissions up to an additional 18%. While all EVs—even those charged on dirty grids—are cleaner than the average internal combustion engine auto, emissions-optimized charging makes them even cleaner still (by up to 18% vs. baseline charging). Emissions-optimized smart charging reduces EVs' per-mile emissions intensity, equivalent to giving them up to a 10 MPGe "boost."

Smarter charging reduces DAILY emissions up to an additional 90%. Because some days experience more emissions variability than others, emissions-optimized EV charging can achieve significant additional emissions reductions vs. baseline on select days. In addition to helping maximize overall total annual emissions reductions, such daily opportunities can help address regional air quality concerns on alert days and aid renewable energy grid integration during times of excessive curtailment and surplus renewable generation.

Emissions reductions are possible everywhere. We found emissions-reduction opportunities in a variety of U.S. geographies, although the biggest opportunities are in "blended" grids (i.e., fossil and renewable generation) that exhibit large emissions-rate swings. Charging protocols well-matched to the local generation mix (e.g., overnight charging in wind-rich SPP, daytime charging in sun-rich CAISO) maximize emissions reductions.

Adopted at scale, emissions-optimized EV charging could yield very large aggregate, absolute emissions reductions. For example, deployed across California's target of 5 million zero-emissions vehicles (ZEV) by 2030, emissions-optimized EV charging could achieve the emissions-reduction equivalent of taking more than 180,000 gasoline-burning international combustion engine (ICE) cars off the road. These emissions savings are incremental above and beyond emissions savings of baseline EV charging vs. tailpipe emissions from internal combustion engine (ICE) autos. Similarly, with New York's target of 2 million EVs by 2030, smarter charging could yield incremental additional savings equivalent to taking nearly 48,000 ICE cars off the state's roadways.

Thoughtful rate design is critical to align EV charging incentives—and should complement emissions-optimized EV charging. As EV-specific and overall time-of-use (TOU) rates and demand charges become more prevalent nationwide, thoughtful rate design will be helpful to ensure that price signals align with emissions intensity. However, even when prices and emissions rates do align, the vast majority of all rate structures still lack the granularity necessary to take advantage of short-term swings in emissions, which can often account for the lion's share of possible emissions savings. Thus, automated software like emissions-optimized EV charging that also intelligently avoids high-cost rates (such as AER does) are ideal for tapping into this opportunity.

CONCLUSION

Three trends are rapidly converging:

1. Accelerating electric vehicle adoption in the United States,
2. The growth of smart, level 2 EV charging, and
3. Increasingly variable grid emissions rates thanks to renewable energy additions to traditionally fossil-fueled grids.

The timing is right to integrate time-based marginal emissions signals into EV charging protocols. Doing so can help make clean EVs even cleaner, help states and utilities achieve policy goals (e.g., battery energy storage, climate, emissions), respond to consumer motivations and demand for green lifestyle options, and aid further renewable energy grid integration.

FIGURE ES1

Emissions-optimized EV Charging Waterfall

Average Mileage Scenario - SPP Night

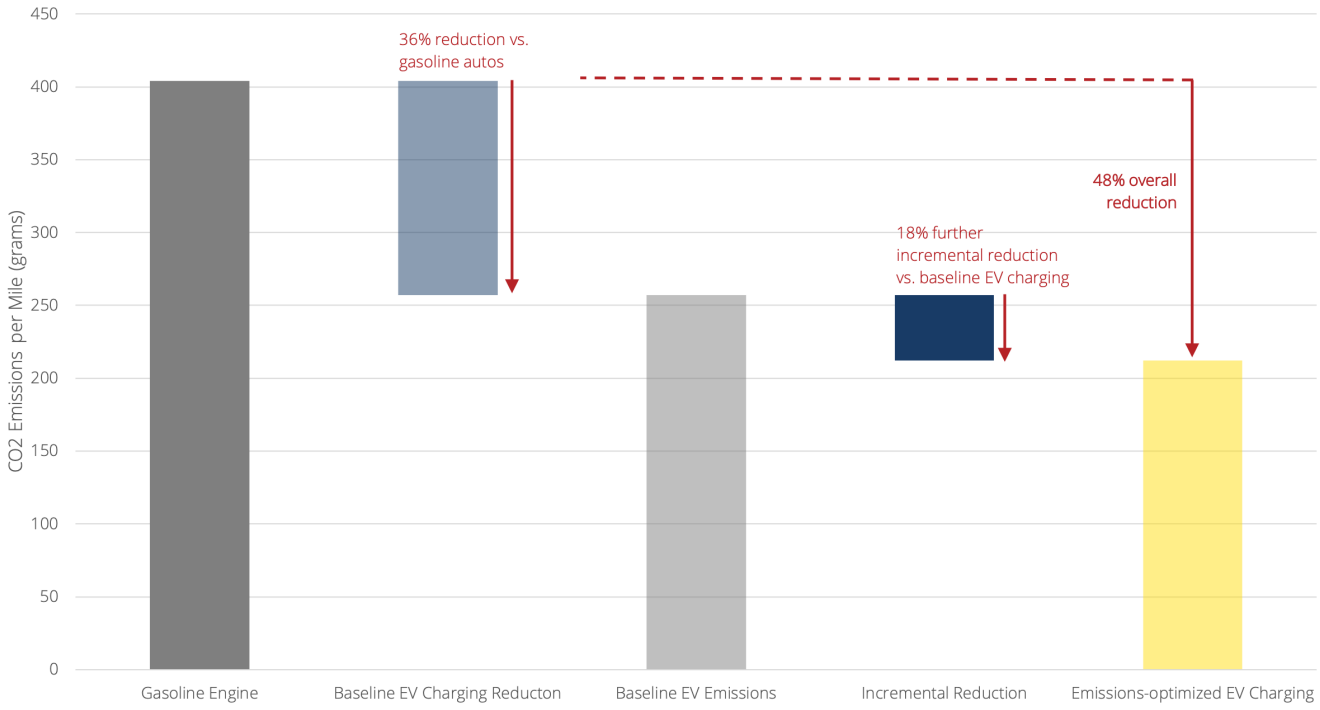


FIGURE ES2

Incremental Additional Emissions Reduction

Average Mileage Scenario - Emissions-optimized vs. Baseline EV Charging

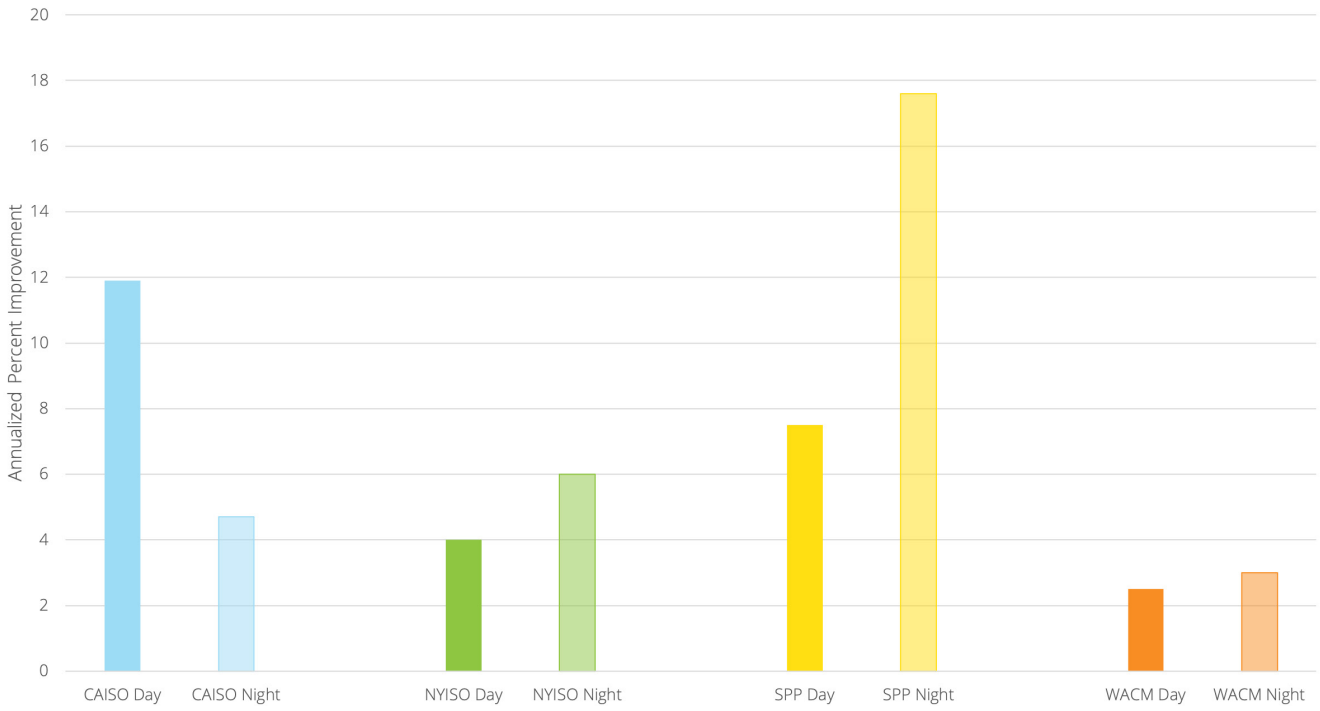
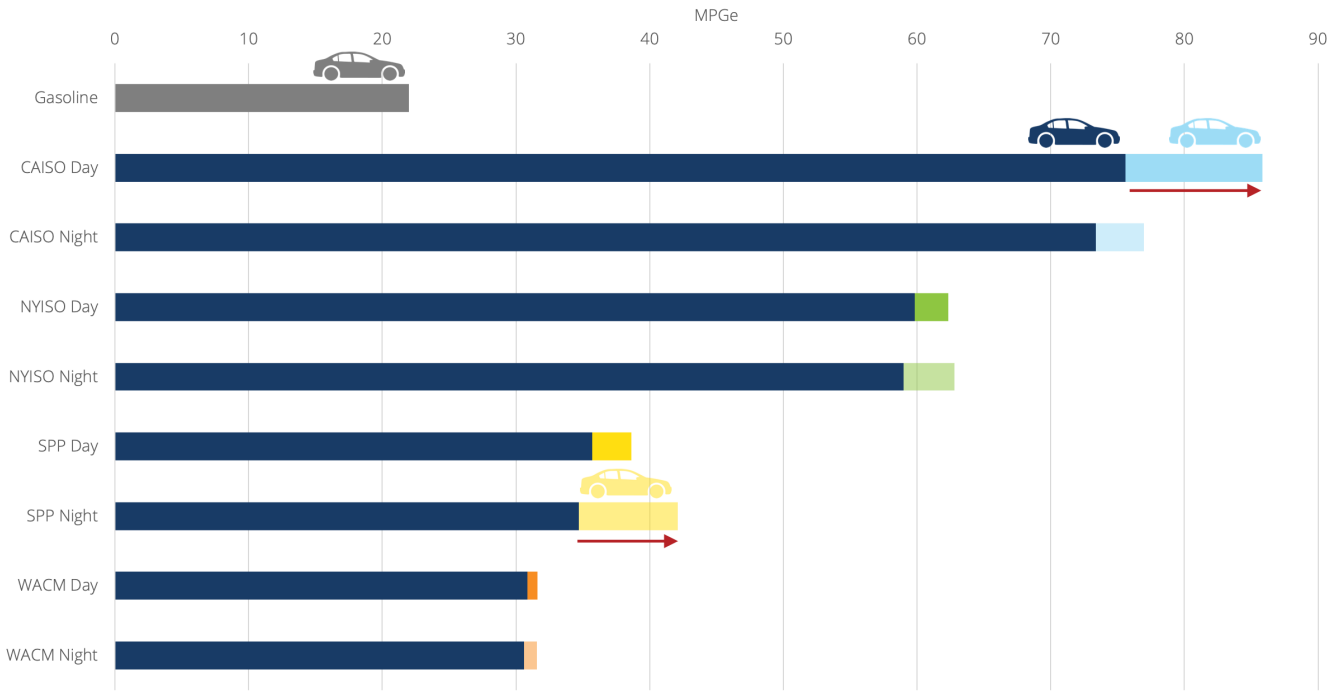


FIGURE ES3

Emissions-optimized MPGe 'Boost' to Baseline EV Charging

Average Mileage Scenario



ABOUT WATTTIME

WattTime is a 501(c)3 nonprofit with a software tech startup DNA, dedicated to giving everyone everywhere the power to choose clean energy. We invented Automated Emissions Reduction (AER), which allows IoT devices—smart thermostats, battery energy storage, electric vehicles, and more—as well as the utilities and people that use them, to effortlessly reduce emissions from energy, when and where they happen. AER works by deploying cutting-edge insights and algorithms, coupled with machine learning, to shift the timing of flexible electricity use to sync with times of cleaner energy and avoid times of dirtier energy. We conduct ongoing research collaborations into the algorithms and analyses that make AER possible, advocate for the spread of AER, and assist organizations in adopting the technology by selling solutions that make it easy for anyone to achieve emissions reductions without compromising cost and user experience. WattTime was founded by PhD students at the University of California, Berkeley, and in 2017 became a subsidiary of Rocky Mountain Institute.

For more information, visit WattTime.org.