# Appendix: State Electric Vehicle Benefits Methodology, Assumptions, and References

Dave Reichmuth

Dave Cooke

Sam Houston

Alyssa Tsuchiya

March 2024

www.ucsusa.org/resources/ state-electric-vehicle-benefits

https://doi.org/10.47923/2024.12615

Union of Concerned Scientists

## Scope

The following statistics apply to battery electric vehicles (EVs) or plug-in hybrid electric vehicles (PHEVs) while operating in electric-only mode. Fuel cell electric vehicles were not included in this analysis.

## EV and gas-powered vehicle emissions

### Power plant emissions

The electricity generation-related emissions values used in our analysis come from the US Environmental Protection Agency's (EPA's) Emissions & Generation Resource Integrated Database (eGRID), which is a comprehensive source of emissions data for every power plant in the United States that provides its generation data to the government (EPA 2023). We used the most up-to-date version of the database available at the time of data analysis: eGRID2021, which contains plant emissions and generation data from calendar year 2021 and was released in January 2023.

The subregions are groups of plants organized by the EPA, based on Power Control Areas and North American Reliability regions. These groupings reflect which power plants serve which households, and they reasonably approximate the grid mix of electricity used by those households within a subregion.

The level of disaggregation of the eGRID subregions allows for more precise calculation of plants' emissions intensities than a national average, as regional variations in grid mix are taken into account. For this reason, eGRID was chosen over other data sources that had the same detailed plant information but fewer subregions. The actual grid mix of a household's electricity is specific to the individual utilities serving each household, but specific grid-mix data are not readily available for most utilities and therefore were not used in the study.

eGRID's methodology treats the subregions as closed systems, calculating the emissions intensity of generation for each one based on the emissions intensities of the plants it contains. This methodology ignores imports and exports of electricity between subregions, which harms the accuracy of the regional emissions estimates. Therefore, the 26 subregions are recommended by eGRID's designers as the level of disaggregation best suited for estimating electricity use–related emissions, as they achieve the best balance between the precision gained by disaggregation and the accuracy lost by omitting imports and exports (Rothschild et al. 2009).

### Transmission loss factors

The eGRID generation emissions rates do not account for transmission and distribution losses between the power plant and the household. To calculate emissions per unit of energy used (rather than energy produced), we increase the emissions rates using grid loss factors as given in eGRID**.**

### Upstream emissions factors

The eGRID subregion emissions rates include only those emissions produced at the plant generating the electricity, and they exclude upstream emissions resulting from the mining and transport of the power plant feedstock. Therefore, we calculated a feedstock emissions rate for each subregion; this rate depends on which fuel types the corresponding power plants use. Each fuel type has a unique upstream emissions rate, which we obtained from a publicly available life cycle emissions model: GREET (2022 release), developed by the Argonne National Laboratory (ANL 2023). The percentage of generation from each fuel type in a subregion was then obtained from eGRID.

For each subregion, the fuel-type emissions rates are multiplied by the share of generation they represent in that subregion; the sum of these products is the subregion's feedstock emissions rate. Most fuel types in GREET correspond directly to a fuel type in eGRID, but there were a few exceptions. A very small share of generation in eGRID subregions corresponds to a fuel type labeled "generic fossil"; for this fuel type, the emissions rate from GREET for natural gas was chosen as a conservative guess, given that its upstream emissions value is higher than those of coal and oil (the other two fossil fuels with known feedstock emissions rates in GREET). An even smaller share of generation in eGRID subregions comes from unknown sources; for this category of fuel type, the feedstock emissions rate is the generation-weighted average of the upstream emissions rates for the other fuel types.

### Conversion of g/kWh to metric tons of $CO_2$e emissions

We multiplied the estimated emissions intensity values (grams of carbon dioxide equivalent per kilowatt-hour, or $gCO_2$e/kWh) and a sales-weighted EV average efficiency of 0.314 kWh/mile, resulting in a $gCO_2$e/mile estimate. For the most efficient EV calculations, an efficiency of 0.24 kWh/mile was used, corresponding to the 2024 Hyundai Ioniq 6 Long Range RWD EV with 18-inch wheels. Annual emissions rate was estimated using an average annual mileage of 11,599 miles per year. Gasoline vehicle emissions are estimated to be 10,708 $gCO_2$e/gallon based on the GREET carbon intensity of gasoline, based on a weighted average of 11 percent California reformulated gasoline and 89 percent non-California gasoline.

## Public health

The data on monetized public health benefits and lost work days avoided were sourced from American Lung Association analysis (ALA 2023), which used the US EPA Co-Benefits Risk Assessment (COBRA) health model, version 4.1. According to the technical documentation, monetized public health benefits "reflect the US population's willingness to pay to reduce risks of premature mortality or certain illnesses," including non-market valuation studies and estimated illness costs and illness-related productivity losses (ALA 2022).

Benefits are cumulative from 2020 to 2050. The analysis assumes 100 percent of all passenger vehicle sales produce zero emissions by 2035, electricity is generated by a grid mix that heavily emphasizes emissions-free renewables, and state zero-emissions vehicle (ZEV) policies are in place (Advanced Clean Cars I and II).

Data were not available for Alaska and Hawaii, as the COBRA model only covers the contiguous United States.

## EV manufacturing jobs

The data on announced EV manufacturing jobs were sourced from the EV Jobs Hub (EVJH), a partnership between the Blue Green Alliance Foundation and Atlas Public Policy (BGA and Atlas 2024). According to the EVJH methodology, "Data is sourced through original research derived from reporting and primary sources and crosschecked with available National Lab and U.S. Department of Energy reports."

Announced job numbers included in the fact sheet are from the date range January 1, 2021, to February 7, 2024. The categories batteries, battery recycling, EV charging, light-duty vehicles, multiple vehicle classes, and parts were included; medium- and heavy-duty vehicles were filtered out.

## Rural travel

Data on rural travel come from the National Household Travel Survey: "The National Household Travel Survey (NHTS) is the source of the nation's information about travel by US residents in all 50 States and the District of Columbia. This inventory of travel behavior includes trips made by all modes of travel (private vehicle, public transportation, pedestrian and cycling) and for all purposes (travel to work, school, recreation, and personal/family trips)" (FHWA, n.d.; FHWA 2019).

"Rural" households were determined using the definition of urban and rural from the US Census Bureau, as delineated in the NHTS dataset. Travel represents a household's total vehicle miles traveled, as represented by the NHTS. Trip length is explicit in the NHTS dataset and weighted using the NHTS trip weights.

Because some states were sampled more heavily than others, and because trips greater than 100 miles are a relatively infrequent occurrence nationwide, data were also aggregated at the Census Division level to ensure a statistically relevant sample. Error bars reflect the sampling error used in the NHTS trip dataset via jackknife method. State average values of rural travel share by trip length were then compared to the Census Division value, and if not statistically different at the 90 percent level, the Census Division trip share was used instead. The values of 20 states were changed to reflect this statistical uncertainty.

## Charging infrastructure

Charging port increases are calculated from data collected by the Alternative Fuels Data Center (AFDC 2024). The calculation is a simple percent change from 2021: (2023 ports - 2021 ports)/2021 ports. The 2021 port counts are an annual snapshot from the "historic data" spreadsheet on the page "Alternative Fueling Station Counts by State." The 2023 counts are based on the real-time data displayed on that webpage as of January 4, 2024 (assumed to be a good approximation of stations deployed as of December 31, 2023).

NEVI Program funding by state is taken from the Department of Transportation Federal Highway Administration's webpage "5-year National Electric Vehicle Infrastructure Funding by State" (FHWA 2022).

## Cost to fuel EVs and gas-powered vehicles

Rate design and costs were obtained via the National Renewable Energy Laboratory Utility Rate Database (NREL 2023), with confirmation using the websites of the electricity service providers. The marginal volumetric rate including adjustments (taxes and fees) was determined for each service provider. Fixed charges (meter charges) were not included. Seasonal rates were averaged based on the proportional length of the season, with the assumption that EV electricity use occurs at a constant rate throughout the year.

Tiered non-TOU (time of use) rates assumed that EV charging was above the average Energy Information Administration (EIA) household consumption or over 100 percent of baseline (if data were available). EV monthly charging was assumed to require 344 kWh/month (11.3 kWh/day). When both tiered and non-tiered TOU/EV rates were available, the non-tiered rates were used. If multiple TOU/EV rates were available, the rate with the lowest nighttime rate was chosen. Rates that required installation of an additional meter were not considered due to the difficulty in quantifying the expense and charges associated with installation and use of a second meter.

For each rate where a per kWh charge (and per kW demand charge, if applicable) was known, the $/gallon equivalent was calculated using (electricity cost) x (EV efficiency) x (1/gasoline efficiency), where the EV efficiency was the sales-weighted US EV efficiency (0.314 kWh/mile) and miles per gallon were 30 mpg.

The price for gasoline in each city was determined using data from GasBuddy (GasBuddy 2024) on the average cost of regular gasoline, using prices from January 18-19, 2024.

## EV sales

EV sales and sales growth rates were based on new-car registration data (Atlas 2023).

### Authors

**Dave Reichmuth** is a senior engineer in the UCS Clean Transportation Program. **Dave Cooke** is a senior vehicles analyst in the program. **Sam Houston** is a senior vehicles analyst in the program. **Alyssa Tsuchiya** is Director of Policy and Government Affairs in the program.

### References

Alternative Fuels Data Center (AFDC). 2024. Alternative Fueling Station Counts by State, accessed January 4. Washington, DC: Department of Energy Vehicle Technologies Office. https://afdc.energy.gov/stations/states

American Automobile Association (AAA ). 2023. *Your Driving Costs*. https://publicaffairsresources.aaa.biz/wp-content/uploads/2023/09/AUTO_YDC-Brochure_r2.pdf

American Lung Association (ALA). 2022. *Updated Evaluation of the National Health Benefits from the Transition to Zero Emission Transportation Technologies*. Chicago. IL. www.lung.org/getmedia/9b396179-40ff-4b3b-9426-9ceea288575d/prior-research-zero-emission-technologies-2022.pdf

American Lung Association (ALA). 2023. *Driving to Clean Air: Health Benefits of Zero-Emission Cars and Electricity*. Chicago, IL. www.lung.org/clean-air/electric-vehicle-report/driving-to-clean-air

Argonne National Laboratory (ANL). 2023. GREET Model: The Greenhouse gases, Regulated Emissions, and Energy use in Technologies Model. Argonne, IL. https://greet.es.anl.gov

Atlas EV Hub (Atlas). 2023. Automakers Dashboard. Washington, DC: Atlas Public Policy. https://www.atlasevhub.com/materials/automakers-dashboard/

Bluegreen Alliance Foundation (BGA) and Atlas Public Policy (Atlas). 2024. EV Jobs Hub, accessed February 6. Minneapolis, MN: Blue Green Alliance Foundation and Washington, DC: Atlas Public Policy. https://evjobs.bgafoundation.org/

Department of Energy (DOE). 2024. Alternative Fuels Data Center, accessed January 4, 2023. Washington, DC. https://afdc.energy.gov/stations/states

Department of Energy (DOE) and Environmental Protection Agency (EPA). 2024. FuelEconomy.gov. Washington, DC. www.fueleconomy.gov/feg/Find.do?action=sbs&id=46957

Environmental Protection Agency (EPA). 2023. Emissions & generation resource integrated database (eGRID), accessed February 8, 2024. Washington, DC. www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

Federal Highway Administration (FHWA). No date. 2017 National Household Travel Survey, accessed November 6, 2020. Washington, DC. http://nhts.ornl.gov

Federal Highway Administration (FHWA). 2019. *2017 NHTS Data User Guide*, revised April 23, 2019. Washington, DC. https://nhts.ornl.gov/assets/2017/doc/NHTS2017_UsersGuide_04232019_1.pdf

Federal Highway Administration (FHWA). 2022. "5-year National Electric Vehicle Infrastructure Funding by State." Washington, DC: Department of Transportation. www.fhwa.dot.gov/bipartisan-infrastructure-law/evs_5year_nevi_funding_by_state.cfm

GasBuddy. 2024. State and/or city gas price averages, accessed January 2024. Boston, MA. www.gasbuddy.com/charts

Inflation Reduction Act, 26 U.S.C. § 25E (2022).

Inflation Reduction Act, 26 U.S.C. § 30C (2022).

Inflation Reduction Act, 26 U.S.C. § 30D (2022).

National Renewable Energy Laboratory (NREL). 2023. Utility rate database, accessed January 2024. https://openei.org/wiki/Utility_Rate_Database

Randall, Tom. 2023. "US Electric Cars Set Record with Almost 300-Mile Average Range." *Bloomberg*, March 9. www.bloomberg.com/news/articles/2023-03-09/average-range-for-us-electric-cars-reached-a-record-291-miles

Reichmuth, Dave, Jessica Dunn, and Don Anair. 2022. *Driving Cleaner: Electric Cars and Pickups Beat Gasoline on Lifetime Global Warming Emissions*. Cambridge, MA: Union of Concerned Scientists. www.ucsusa.org/resources/driving-cleaner

Rothschild, Susy S., Cristina Quiroz, Manish Salhotra, and Art Diem. 2009. "The Value of eGRID and eGRIDweb to GHG Inventories," presented at the EUEC2010 conference, December. www.epa.gov/sites/default/files/2015-12/documents/thevalueofegrid.pdf





https://doi.org/10.47923/2024.12615