State Electric Vehicle Benefits

www.ucsusa.org/state-EV-fact-sheets

Appendix: Methodology and assumptions

Union of Concerned Scientists

Scope

Here are the datasets and assumptions used to create the following statistics. These statistics apply to battery electric or plug-in hybrid electric vehicles. Fuel cell electric vehicles were not included in this analysis.

EVs cut global warming emissions. Driving an EV in [STATE] produces [X] metric tons of emissions per year compared with [Y] metric tons from the average new gasoline-powered car.

Power plant emissions

The electricity generation-related emissions values used in our analysis come from the U.S. 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. We used to the most up-to-date version of eGRID available at time of publication— factsheets published in 2021 used eGRID2019, which contains plant emissions and generation data from calendar year 2019, and factsheets published in 2019 used eGRID2016, which contains plant emissions and generation data from calendar year 2016.

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.

Transmission loss factors

The eGRID generation emission 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 (2017 release for factsheets released in 2019 and 2020 release for factsheets released in 2021), developed by the Argonne National Laboratory. 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 CO_2e emissions

We multiplied the estimated emissions intensity values (gCO_2e/kWh) and a sales-weighted EV average efficiency of 0.3385 kWh/mile, resulting in a gCO_2e/mile estimate. Annual emissions rate was estimated using an average annual mileage of 11,440 miles per year. Gasoline vehicle emissions are estimated to be 10958 gCO_2e/gallon based on the GREET carbon intensity of California reformulated and reformulated gasoline, based on a weighted average of 11 percent California gasoline and 89 percent non-California gasoline. This fuel carbon intensity was used with the average 2016 new gasoline vehicle efficiency of 25.6 miles/gallon (EPA 2016) and 11,440 miles/year driving to estimate annual new gasoline vehicle global warming emissions. Our 2021 analysis used updated assumptions for US EV efficiency (0.317 kWh/mi), average new passenger vehicle fuel economy (25.7 mpg), and lifecycle carbon intensity of gasoline (10662 gCO_2e/gallon).

Rural EV drivers save the most on fuel. On average, rural [STATE] drivers could save [$X] by switching from gasoline to electricity.

Annual fuel savings were estimated at the county level for an average driver switching from a passenger car to an electric vehicle (EV). For our 2019 analysis, the driver is assumed to switch from a gas-powered passenger car with a fuel efficiency of 25.2 miles per gallon (average for new passenger cars in 2017) to a battery-electric vehicle with an efficiency of 0.32 kWh/mile. For our 2021 analysis, the driver is assumed to switch from a gas-powered light-duty passenger vehicles with a fuel efficiency of 24.9 miles per gallon (average for new passenger cars in 2019) to a battery-electric vehicle with an efficiency of 0.317 kWh/mile.

Note that there are differing definitions of what constitutes a rural area. In this analysis, rural drivers are defined to be those who live in counties within the two lowest population density groups (one group up to 99 persons per square mile, and the second group from 100 to 499 persons per square mile).

Annual fuel savings were first estimated for each county within the two lowest population density groups. These savings were then averaged over the two groups to obtain an overall annual fuel savings estimate for rural drivers in the state.

Annual vehicle miles driven (VMT) for each county was determined by identifying which population density group the county is located in. The annual VMT was determined by mapping the county into one of the 72 'baskets' for 8 typical population density areas in 9 census divisions (see assumptions used in our 2019 and 2021 analyses in Table 1 and Table 2, respectively).

For our 2019 analysis, gasoline prices are 2018 state averages. EV drivers were assumed to charge their vehicles at home so electricity prices are 2017 residential retail rates in the state. For our 2021 analysis, gasoline prices are 6/25/2021 state averages, assumed to be representative of the fluctuating but generally high gasoline prices. Electricity prices are 2019 residential retail rates in the state. It should be noted that many areas have time-of-use (TOU) rates, which are usually lower than the state average, so the estimates presented here are conservative, and fuel savings could be higher.

Since gasoline and electricity prices were assumed to be state-level averages, and since constant fuel economies and EV efficiencies are assumed, the only factor that determines the difference between fuel savings in different counties is the VMT. Therefore, if all other factors remain constant, annual fuel savings for each driver increases proportionally with annual VMT.

Table 1 – Annual miles driven by an average driver in 8 typical population density areas for each of the 9 census divisions (2019)

Persons per square mile	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific
0-99	13634	13251	14347	15934	14569	15337	14394	13847	11666
100-499	14491	12816	14224	15324	13189	13389	12574	11498	12144
500-999	11924	11424	12830	15862	13016	13258	12954	11119	10133
1,000-1,999	11506	11385	11362	11741	12168	11764	13373	11358	11223
2,000-3,999	10737	11260	11804	10739	10576	14065	12378	9621	10494
4,000-9,999	10014	10586	10593	11729	11165	10014	11464	10765	10006
10,000-24,999	6735	7840	9203	7978	10103	1735	12615	10905	10273
25,000-999,999	3441	4721	6676	6916	8758	.	13062	24988	8002

Table 2 – Annual miles driven by an average driver in 8 typical population density areas for each of the 9 census divisions (2021)

Persons per square mile	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific
0-99	12380	13538	14285	16232	14480	15051	14501	12477	11658
100-499	14078	12732	13587	16040	12774	13511	12755	13371	11000
500-999	11857	10759	12971	11857	13236	12964	13008	11302	11660
1,000-1,999	11879	11517	12016	12271	12134	11872	13289	11785	11090
2,000-3,999	10209	11650	11773	11217	10641	13939	11763	10067	10372
4,000-9,999	11061	9864	10001	10779	10846	9006	11721	10600	10353
10,000-24,999	6160	8652	7464	9361	10795	-	11500	8661	9404
25,000-999,999	3295	4323	6863	3650	7461	-	8552	9124	7068

Note: Obtained from the NHTS variable HTPPOPDN - Category of population density (persons per square mile) in the census tract of the household's home location. The annual average VMTs listed are subject to periodic updates by the National Housing Travel Survey.

City drivers save money too. Charging an EV at home in [CITY] is like paying $[X] per gallon of gasoline.

Rate design and costs were obtained via the U.S. Department of Energy's Utility Rate Database with confirmation using the websites of the electric 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 electric use occurs at a constant rate throughout the year.

Demand charges were added if they were applied at all hours, assuming 30A, 240V (7.2 kW) charging with 1.6 hours of charging required per day (12,700 miles per year, 0.325 kWh per mile). If demand charges were applied only on peak hours, then no demand charges were added; it is assumed that charging would be avoided during peak periods.

Tiered non-TOU rates assumed that EV charging was above the average 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.

Rates for deregulated markets were estimated by selecting representative rate plans with a 12-month contract period. Because the rate structures in deregulated markets can vary significantly between electricity providers, rates available in these markets may result in lower electricity costs than those presented here.

For each rate where a per kWh charge (and per KW demand charge, if applicable) was known, the $/GGE equivalent was calculated using (electricity cost) x (EV efficiency) x (1/gasoline efficiency), where the EV efficiency was the sales-weighted US EV efficiency (0.325 kWh/mi) and miles per gallon were 25.6, the average new vehicle efficiency for all MY2016 vehicles. Our 2021 analysis used updated assumptions for US EV efficiency (0.317 kWh/mi) and average new passenger vehicle fuel economy (25.7 mpg).

Note that the GGE rate for Newark was based on an average for NJ GGE rates, since data for Newark was unavailable.

The price for gasoline in each city was determined using data from GasBuddy (www.gasbuddy.com/Charts) on the average cost of regular gasoline, using prices on October 24, 2017 for cities with data from 2017 (see Table 2 below); prices on October 1, 2019 for Des Moines, IA; prices on October 10, 2019 for Anchorage, AK; prices on July 6, 2021 for Manchester, NH and Charleston, WV.

Table 2 – Utilities, rate type and cost of gallon of gas equivalent cited for each city.

City	State	GGE	Electric Utility	Rate type	Year
Anchorage	AK	$ 1.58	Municipal Light & Power	Standard	2019
Tucson	AZ	$ 0.49	Tucson Electric Power	EV	2017
Sacramento	CA	$ 0.60	Sacramento Municipal Utility District	EV	2017
Colorado Springs	CO	$ 0.59	Colorado Springs Utilities	TOU	2017
Bridgeport	CT	$ 1.41	United Illuminating Company	TOU	2017
Washington, D.C.	DC	$ 0.85	Pepco	TOU	2017
Wilmington	DE	$ 0.41	Delmarva Power	TOU	2017
Miami	FL	$ 0.52	Florida Power & Light Company	TOU	2017
Atlanta	GA	$ 0.32	Georgia Power	EV	2017
Honolulu	HI	$ 1.80	Hawaiian Electric Company	TOU	2017
Des Moines	IA	$ 0.70	MidAmerican Energy Company	TOU	2019
Chicago	IL	$ 0.70	ComEd	Standard	2017
Indianapolis	IN	$ 0.30	Indianapolis Power & Light Company	EV	2017
Wichita	KS	$ 0.50	Westar Energy	TOU	2017
Louisville	KY	$ 0.61	Louisville Gas and Electric	TOU	2017
New Orleans	LA	$ 0.57	Entergy New Orleans	Standard	2017
Boston	MA	$ 1.30	Eversource	TOU	2017
Baltimore	MD	$ 0.81	Baltimore Gas & Electric Company	TOU	2017
Portland	ME	$ 0.99	Central Maine Power	TOU	2017
Detroit	MI	$ 0.85	DTE Energy Company	TOU	2017
Minneapolis	MN	$ 0.25	Xcel Energy	TOU	2017
Kansas City	MO	$ 0.82	Kansas City Power & Light (Kansas)	Standard	2017
Raleigh	NC	$ 0.41	Piedmont Electric Membership Corporation	TOU	2017
Omaha	NE	$ 0.76	Omaha Public Power District	Standard	2017
Manchester	NH	$ 0.93	Eversource	TOU	2021
Newark	NJ	$ 1.37	PSE&G	Standard	2019

City	State	GGE	Electric Utility	Rate type	Year
Albuquerque	NM	$ 0.56	Public Service Company of New Mexico	TOU	2017
Las Vegas	NV	$ 0.41	NV Energy	TOU	2017
New York	NY	$ 0.36	ConEdison	TOU	2017
Cleveland	OH	$ 0.43	Cleveland Public Power	Standard	2017
Oklahoma City	OK	$ 0.54	Oklahoma Gas & Electric Co.	TOU	2017
Portland	OR	$ 0.72	Portland General Electric	TOU	2017
Philadelphia	PA	$ 0.58	PECO Energy Company	Standard	2017
Providence	RI	$ 1.32	National Grid	Standard	2017
Greenville	SC	$ 0.49	Duke Energy	TOU	2017
Sioux Falls	SD	$ 0.50	Xcel Energy South Dakota	TOU	2017
Memphis	TN	$ 0.63	Memphis Light, Gas and Water Division	TOU	2017
Dallas	TX	$ 0.57	Reliant	Standard	2017
Salt Lake City	UT	$ 0.59	Rocky Mountain Power	EV	2017
Virginia Beach	VA	$ 0.50	Dominion Virginia Power	EV	2017
Burlington	VT	$ 0.90	Burlington Electric Department	TOU	2017
Spokane	WA	$ 0.78	Avista Corporation	Standard	2017
Milwaukee	WI	$ 0.75	WE Energies	TOU	2017
Charleston	WV	$ 1.00	Appalachian Power	Standard	2021

Interest in EVs is quickly growing. EV sales grew [X] percent in [STATE] from [Y] to 2018, reaching [Z] sold by the end of 2018.

EV sales and sales growth rates based on new car registration data from IHS Markit (non-public dataset).

REFERENCES

Alaska Power & Telephone. 2019. AMP-UP EV Program. Port Townsend, WA. Online at https://www.aptalaska.com/amp-up/, accessed November 5, 2019.

American Automobile Association (AAA). 2017. *Your driving costs: How much are you paying to drive?* Heathrow, FL. Online at *https://exchange.aaa.com/wp-content/uploads/2017/08/17-0013_Your-Driving-Costs-Brochure-2017-FNL-CX-1.pdf*, accessed March 13, 2019.

Appalachian Power. 2021. EV charging station rules. Charleston, WV. Online at *https://takechargewv.com/ev-charging-station-rules*, accessed August 3, 2021.

Argonne National Laboratory (ANL). 2017. GREET model: The greenhouse gases, regulated emissions, and energy use in transportation model. Argonne, IL. Online at *https://greet.es.anl.gov*, accessed March 13, 2019.

Argonne National Laboratory (ANL). 2020. GREET model: The greenhouse gases, regulated emissions, and energy use in transportation model. Argonne, IL. Online at *https://greet.es.anl.gov*, accessed August 3, 2021.

Berckmans, G., M. Messagie, J. Smekens, N. Omar, L. Vanhaverbeke, and J. Van Mierlo. 2017. Cost projection for state-of-the-art lithium-ion batteries for electric vehicles up to 2030. Brussels: MOBI Research Group, Vrije Universiteit Brussel. Online at *www.mdpi.com/1996-1073/10/9/1314/pdf*, accessed March 14, 2019.

Cass County Electric Cooperative (CCEC). 2019. Electric Vehicles. Fargo, ND. Online at *https://www.kwh.com/content/electric-vehicles*, accessed November 5, 2019.

District of Columbia Office of Tax and Revenue (OTR). 2014. Alternative Fuel Vehicle Infrastructure and Conversion Credits FAQs. Washington, DC. Online at *https://otr.cfo.dc.gov/publication/alternative-fuel-vehicle-infrastructure-and-conversion-credits-faqs*, accessed November 5, 2019.

Entergy eTech. 2019. Electric Vehicles - Entergy's eTech program. New Orleans, LA. Online at https://entergyetech.com/electric-vehicles/, accessed November 5, 2019.

Environmental Protection Agency (EPA). 2016. Emissions & generation resource integrated database (eGRID). Washington, DC. Online at *www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid*, accessed March 14, 2019.

Environmental Protection Agency (EPA). 2017. Health and environmental effects of particulate matter (PM). Washington, DC. Online at *www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm*, accessed March 13, 2019.

Environmental Protection Agency (EPA). 2018. Inventory of U.S. greenhouse gas emissions and sinks. Washington, DC. Online at *www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks* , accessed March 14, 2019.

Environmental Protection Agency (EPA). 2021. Emissions & generation resource integrated database (eGRID). Washington, DC. Online at *www.epa.gov/egrid*, accessed August 3, 2021.

GasBuddy. 2019. Gas price charts. Boston, MA. Online at *www.gasbuddy.com/Charts*, accessed November 5, 2019.

GasBuddy. 2021. State gas price averages. Boston, MA. Online at *https://web.archive.org/web/20210706211553/https://gasprices.aaa.com/state-gas-price-averages/*, accessed July 6, 2021.

Gatti, D. 2018. Rural drivers can save the most from clean vehicles. Cambridge, MA: Union of Concerned Scientists. Blog post, December 13. Online at *https://blog.ucsusa.org/daniel-gatti/clean-vehicles-save-rural-drivers-money*, accessed March 13, 2019.

Hickenlooper, J., Otter, C.L., Bullock, S., Mead, M., Herbert, G.R., and S. Martinez. 2017. Governors of Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming Sign MOU to Plan Regional Electric Vehicle Corridor for the West. Press release, October 4. Online at *https://deq.mt.gov/Portals/112/Energy/Documents/FINAL_EV_Corridor_%20Press_Release100317.pdf?ver=2017-10-10-085946-897*, accessed November 5, 2019.

Nealer, R., D. Reichmuth, and D. Anair. 2015. *Cleaner cars from cradle to grave: How electric cars beat gasoline cars on lifetime global warming emissions*. Cambridge, MA: Union of Concerned Scientists. Online at *www.ucsusa.org/clean-vehicles/electric-vehicles/life-cycle-ev-emissions*, accessed March 28, 2019.

New Hampshire Electric Co-op (NHEC). 2021. Plug-in to your Future-Drive Electric! Plymouth, NH. Online at *https://www.nhec.com/drive-electric/*, accessed July 6, 2021.

Plug In America (PIA). 2019. State incentives. Online at *https://pluginamerica.org/why-go-plug-in/state-federal-incentives*, accessed March 14, 2019.

Reichmuth, D. 2017. *Going from pump to plug: Adding up the savings from electric vehicles*. Cambridge, MA: Union of Concerned Scientists. Online at *www.ucsusa.org/clean-vehicles/electric-vehicles/ev-fuel-savings*, accessed March 13, 2019.

Reichmuth, D. 2018. New data show electric vehicles continue to get cleaner. Cambridge, MA: Union of Concerned Scientists. Blog post, March 8. Online at *https://blog.ucsusa.org/dave-reichmuth/new-data-show-electric-vehicles-continue-to-get-cleaner*, accessed March 13, 2019.

Reichmuth, D. 2021. Plug in or gas up? Why driving on electricity is better from gasoline. Cambridge, MA: Union of Concerned Scientists. Blog post, June 7. Online at *https://blog.ucsusa.org/dave-reichmuth/plug-in-or-gas-up-why-driving-on-electricity-is-better-than-gasoline/*, accessed July 6, 2021.

State of Vermont Agency of Transportation (VTrans). 2019. Electric Vehicle Incentive Program. Montpelier, VT. Online at *https://vtrans.vermont.gov/planning/projects-programs/electric-vehicles*, accessed November 5, 2019.

Union of Concerned Scientists (UCS). 2016. Infographic: California drivers demand electric cars. Cambridge, MA. Online at *www.ucsusa.org/clean-vehicles/electric-vehicles/california-electric-cars*, accessed March 14, 2019.

Union of Concerned Scientists (UCS). 2019. State Electric Vehicle Benefits, Appendix: Methodology and assumptions. Cambridge, MA. Online at *www.ucsusa.org/state-EV-fact-sheets*, accessed November 5, 2019.

Union of Concerned Scientists (UCS). 2021. State Electric Vehicle Benefits, Appendix: Methodology and assumptions. Cambridge, MA. Online at *www.ucsusa.org/state-EV-fact-sheets*, accessed August 3, 2021.

Union of Concerned Scientists (UCS) and Consumer Reports Advocacy (CR). 2019. Electric vehicle survey findings and methodology. Cambridge, MA and Yonkers, NY. Online at *www.ucsusa.org/resources/surveying-consumers-electric-vehicles*, accessed August 3, 2021.