Calculations for Electric Cars

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I've calculated some costs and greenhouse gas emissions associated with driving gas-powered or electric-powered cars, based on current prices and technology.

Cost Comparison Gasoline vs. Electricity

Modern cars can easily go 200,000 m>i in a lifetime, so let's base calculations on that. As the table below shows, typical electric vehicle (EV) energy uses are .25 kWh or .30 kWh to go a mile. "kWh" means "kilowatt hour", a standard unit of energy used in measuring the amount of electricity used.

Energy Usage Selected EVs		
kWh/mi	Car	Year
.26	Tesla Model 3 Long Range AWD Automatic	2022
.25	Hyundai Ioniq Electric Automatic	2021
.28	Hyundai Kona Electric Automatic	2022
.28	Chevrolet Bolt EV Automatic	2022
.29	Kia EV6 RWD	2022
.30	Hyundai Ioniq 5 RWD	2022
.30	Kia Niro Electric Automatic	2022
.30	Nissan Leaf (40 kW-hr battery) Automatic	2022
.31	Nissan Leaf (62 kW-hr battery) Automatic	2022
.31	MINI Cooper SE Hardtop 2 door Automatic	2021
.33	Ford Mustang Mach-E RWD Automatic	2022
Energy Usage Selected Plug-in Hybrid EVs (PHEVs)		
.25	Toyota Prius Prime 1.8 L, 4 cyl, Automatic	2022
.28	Hyundai Ioniq Plug-in Hybrid 1.6L, 4 cyl, automatic	2022
.32	Ford Escape FWD PHEV 2.5L, 4 cyl, automatic	2022

https://www.fueleconomy.gov/feg/alternatives.shtml

How much gas does a car use? Looking at recent best-selling cars and small SUVs (table below), 30 MPG is reasonable; including larger SUVs, an average of 25 MPG might be more appropriate:

		5 Most Popular Cars, 2021		
MPG	**Mid MPG**	**Make**	**Model**	**Type**
25-32	28.5	Toyota	RAV4	SUV
29-30	29.5	Honda	CR-V	SUV
28-30	29	Toyota	Camry	Mid-size sedan
31-33	32	Nissan	Rogue	SUV
29-36	32.5	Honda	Civic	Sedan

https://www.caranddriver.com/news/g36005989/best-selling-cars-2021/

To get the lifetime cost of powering a car, let's assume gas is $4/gal. Current average residential electricity rate is about 14 cents/kWh in the US and about 12 cents/kWh in Virginia. To calculate the total cost, use the following formula:

(miles driven) x (fuel/mile) x (cost/fuel) = cost.

Cost to Drive 200,000 miles					
	Gasoline – fuel use &cost		Electric– energy use & cost		Total Cost
Description	Gal/mi	$/gal	kWh/mi	$/kWh	$
Gas – worse MPG	1/25	4			32,000
Gas – better MPG	1/30	4			26,700
Elec – worse efficiency, US			.30	.14	8,400
Elec – better efficiency, US			.25	.14	7,000
Elec – worse efficiency, VA			.30	.12	7,200
Elec – better efficiency, VA			.25	.12	6,000

For VA, .3 kWh/mi & 30 mi/gal, difference = $19,500.

Emissions Comparison, Gasoline vs. Electricity

The US average CO_2 emissions for 1 kWh of electricity was 0.40 kg (2019 statistics), and ranges from 0.10 kg in upstate New York to 0.72 kg in the Midwest. Thus, driving a car 200,000 mi produces lifetime emissions from energy usage for minimum, average, and maximum emissions are 5.25 tons, 20 tons, and 36 tons, respectively. Virginia is in the SRVC grid, which is 0.3 kg/kWh, so lifetime emissions sum to 15 tons. Using the higher (.3 kWh/mi) energy usage, it's 18 tons for Virginia, 6 to 43 tons for the range of national values.

In comparison, since burning a gallon of gas emits about 9.2 kg of CO_2, lifetime emissions are 74 tons.

The national range listed here excludes the Hawaiian island of Kauai (population about 70,000), which has slightly higher value.

Greenhouse emissions from manufacturing an EV.

For both electric and gas-powered cars, emissions from manufacturing is a small fraction of emissions from driving. The main extra component in an EV is the battery.

Manufacturing a 28 kWh battery in China generates emissions of about 3 tons [metric] CO_2-e according to Hao et al. (2017, *Sustainability*). The estimate includes raw materials though I don't know if the raw material estimate includes mining. For a 300 mi range at .25 kWh/mi, you need a 75 kWh battery, which would then cause about 8 tons emission. The article says that Chinese electricity generates twice the emissions per kWh as in the US, and that electricity counts for 40% of the emissions in creating the battery. Therefore, US manufacturing could generate 80% of the Chinese manufacturing, or 2.4 and 6.4 tons, respectively.

Interestingly, a column in Forbes Magazine arguing against the environmental usefulness of EVs says that a new EV "has already caused 30,000 pounds of carbon-dioxide emission" versus 14,000 pounds for a "conventional car". That's a difference of 16,000 pounds, or 7.3 metric tons, which is consistent with the reference above.

Links

[1] Car lifetimes: https://www.caranddriver.com/research/a32758625/how-many-miles-does-a-car-last/

[2] Electricity rates: https://www.chooseenergy.com/electricity-rates-by-state/

[3] Electricity CO_2 emissions: https://www.epa.gov/egrid/power-profiler#/

[4] Gas mileage: https://www.fueleconomy.gov/feg/contentIncludes/co2_inc.htm

[5] CO_2 emissions from EV manufacture: https://www.epa.gov/greenvehicles/electric-vehicle-myths

[6] Hao et al. (2017): https://www.mdpi.com/2071-1050/9/4/504/htm

[7] Against EVs: https://www.forbes.com/sites/tilakdoshi/2020/08/02/the-dirty-secrets-of-clean-electric-vehicles/?sh=6b5a5025650b