Science You Can Use

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Dear Science: My car makes about 20 miles per gallon. I'm thinking about replacing it with a newer model that makes 30 miles per gallon. My neighbor says I should buy an all-electric vehicle, but I'm not sure this would save money. Advice? -- Buck R.

Dear Buck: Most cars on the road today, like yours, are powered by an internal-combustion gasoline engine. Let's call such a car an "internal-combustion-engine automobile" (ICEA). An all-electric automobile (AEA), in contrast, is powered entirely by electric motors that get their energy from onboard batteries. These batteries must be recharged frequently from an external source -- typically from a charger in your house or from public charging stations.

Before you compare the costs of purchasing and operating an AEA, and an ICEA, you should first determine whether an AEA can meet your transportation needs. As of 10 March 2022, AEAs were not well suited for driving more than 250 miles per day, for the following reasons. Assume today's least expensive, five-passenger, mass-produced AEA (a Chevrolet Bolt).

a. The farthest the AEA can travel between charges is about 250 miles.
b. You can buy gasoline "almost anywhere". In contrast, charging stations that can provide a 250-mile charge for the AEA in under two hours are rare and 90% are located near Interstate highways.
c. The fastest chargers that are easily accessible on the Interstate highway system today would take at least 2.5 hours to provide a 250-mile charge for the AEA. The fastest AEA chargers that you can install in your home for that AEA would take about six hours to provide a 250-mile charge.

If (a) – (c) don't rule out an AEA for you, you next need to specify a usage scenario for an ICEA, and for an AEA, of interest to you. These scenarios need to identify as much as you can about what contributes to the cost of each scenario. For each scenario, add all costs and divide by the average number of miles you will drive in 10 years. (The average distance a passenger vehicle in the US is driven in 10 years is about 100,000 miles.) The result is the average cost per mile for that scenario. Here's a list of typical items you need to consider when computing those costs.

d. Purchase cost. Assuming the federal tax credits in effect on 10 March 2022, there is at least one AEA (the 2022 Chevrolet Bolt) that can travel about 250 miles between charges and its purchase price is about the same as the average new ICEA ($30,000).
e. Insurance and licensing costs. The insurance and licensing costs for an AEA and an ICEA whose purchase costs are comparable, are comparable. For estimation purposes, assume this is $2000 per year.
f. Gasoline and electrical energy costs. These vary over time. You will have to make your best guess at what they will be. For example, you could assume that gasoline will cost $5.00 per gallon and electricity will cost 15 cents per kilowatt-hour (KWH), on average, over the next 10 years. Based on those figures, electricity will cost about 10 cents per

mile for a Chevy Bolt, and gasoline will cost about 15 cents per mile for a 30-mile-per-gallon ICEA. If you drive 10,000 miles per year, therefore, an AEA comparable to the Chevy Bolt will use about $1000 per year in electricity, and a 30 mile-per-gallon ICEA will consume about $1500 in gasoline per year.

g. Cost of installing an AEA charging system in your home. A system that can fully charge a Chevy Bolt in six hours in your home will cost about $3,000 to install.
h. Cost of maintenance. Because AEAs have fewer moving parts than ICEAs, in theory an AEA should be less expensive to maintain than an ICEA. For estimation purposes, assume that on average, an AEA will cost $500, and an ICEA, $1000, per year to maintain.

Let's look what these considerations imply (over 10 years and 100,000 miles) for three examples in which the AEA is a Chevy Bolt, and the ICEA makes 30 mpg and has a purchase price comparable to the Bolt's ($30,000).

Example 1. Assume (d) – (h) are as above. Then the ICEA will cost about $75,000 (75 cents per mile). The AEA will cost about $66,000 (66 cents per mile).

Example 2. Assume (d) – (h) are as above with one exception: gasoline will cost, on average, $10/gallon. Then the ACA will cost $66,000, and the ICEA will cost $90,000.

Example 3. Assume (d) – (h) are as above with two exceptions: gasoline will cost on average $10/gallon, and electricity will cost on average 20 cents per KWH. Then the AEA will cost $76,000, and the ICEA will cost $90,000.

These examples suggest that if gasoline and electrical energy prices remain roughly where they are today, the 10-year costs of the AEA and the ICEA assumed in the examples are comparable. If both gasoline and electrical energy prices double what they are today, the AEA becomes significantly less expensive to own and operate than the 30-mpg ICEA.

For more information, see David Gohlke and Yan Zhou, Argonne National Laboratory, https://publications.anl.gov/anlpubs/2019/03/151081.pdf).

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