

Electric Cars: the Wave of the Future or an Environmental Bait and Switch?

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Electric cars! Clean energy and a fun ride! Drive down the California coast with the top down and enjoy the fresh air! The article in the Sierra Club bulletin sure did look nice. But I live in North Carolina, where most of our electricity is generated by coal. Would an all-electric car really have a lower carbon footprint? Should I buy one today???

I contacted two experts whose scientific understanding I trust completely, and guess what? They disagreed! Andy Silber and I got our B.A.'s in Physics together at UC Berkeley. Andy went on to get a PhD in astrophysics, but his real passion is energy. He works with the Sierra Club on energy issues, and strongly advocates electric cars. Rich Muller was one of our professors at Berkeley, and he has recently been teaching a course called "Physics for Future Presidents". He thinks electric cars will never solve our problems. Before we hear from the experts, let's see what we can figure out on our own.

First, we'll calculate the carbon output of three different cars, each driven 40 miles in the city. When a gallon of gasoline is burned (8 pounds), the carbon in the gas combines with oxygen to produce 20 pounds of CO₂ – that's basic chemistry and does not depend on the efficiency of the engine.

2004 Subaru Outback (observed mileage, not up to expectations):

$$40 \text{ miles} \times 1 \text{ gal}/20 \text{ miles} \times 20 \text{ lb CO}_2/\text{gal} = 40 \text{ lb CO}_2$$

Toyota Prius (manufacturer predicted mileage):

$$40 \text{ miles} \times 1 \text{ gal}/50 \text{ miles} \times 20 \text{ lb CO}_2/\text{gal} = 16 \text{ lb CO}_2$$

The carbon footprint of an *electric* car depends on the source of electricity, which varies regionally. In the East, most electricity is generated by coal, which produces 2.1 lb CO₂/kWh (that's pounds of CO₂ per kilowatt-hour of electricity, [DOE](#)). In the West, a lot of hydro-electric power is used; that process produces no CO₂, but at the cost of drowned valleys.

Compare energy production in Raleigh North Carolina, and San Francisco California. Raleigh is served by Duke Energy, which depends on burning stuff for 60% of its energy, and has a carbon footprint of 1.2 lb CO₂/kWh ([Blue Sky](#)). San Francisco is served by PG&E, which gets about 60% of its power from hydroelectric plants, and has a net carbon footprint of 0.6 lb CO₂/kWh ([PG&E](#)).

A Chevy volt, which runs 40 miles on a full charge of 16 kWh, has a different carbon footprint in each city.

Chevy Volt in Raleigh

$$16 \text{ kWh} \times 1.2 \text{ lb CO}_2/\text{kWh} = 20 \text{ lb CO}_2$$

Chevy Volt in San Francisco:

$$16 \text{ kWh} \times 0.6 \text{ lb CO}_2/\text{kWh} = 10 \text{ lb CO}_2$$

By coincidence, both Raleigh and San Francisco are test markets for electric cars. In **Raleigh**, electric cars have a larger carbon footprint than hybrids. That means we're just exporting our pollution to the nearest coal plant. It's an **environmental bait and switch**. In **San Francisco**, all-electric cars really do reduce carbon emissions significantly. They've got much worse traffic in SF, too, so the cars spend a lot of time idling and producing fumes. Electric cars should **clear the air**.

Andy, who loves electric cars, lives in Seattle. About 90% of their electricity is produced by hydropower*. Carbon-wise, that's clean power. I asked him, "what about the rest of us?" He reminded me that, not only do existing power sources vary regionally, the potential for clean power also varies. Hydro power is possible in the Northwest, solar in the Southwest, wind in the Midwest, and ... coal everywhere east of the Mississippi. Here in Raleigh we don't have much potential for local clean power generation. So the issue is power transmission, and our existing power transmission technology cannot move electricity more than a few hundred miles. Andy thinks it can happen, but it will take years, if not decades.

Rich Muller still lives near San Francisco. His biggest concern about electric cars is the prohibitive cost of batteries. The cost of batteries is predicted to decrease gradually with time, but again we're talking years to decades. I asked "should we pay for them anyway?", and he said that China produces more CO₂ than the US, so our money would be better spent improving their factories.

So, currently electric cars are not the right choice nationwide. There's really not much point in building a network of plug-in charging stations in areas powered by coal. Electric cars don't have the range to drive between areas with different types of power, so it's best to use them only in areas that already have carbon neutral electricity.

For electric cars to be the right choice nationwide, we need to make two significant technological advances. First, we need to generate and transport only carbon-neutral electricity. Second, we need to invent a new, cheaper type of battery.

The astute reader will note that I have said nothing about the manufacture or disposal of cars and batteries. Those topics must wait for now. Based on carbon footprint per mile driven, the myth

Electric cars can save the future ... is PLAUSIBLE, depending on where you live

Resources

Andy Silber's energy blog:

<http://www.sustainablewestseattle.org/2010/08/the-energy-blog-a-plug-on-your-next-car/>

Rich Muller's Physics course: <http://muller.lbl.gov/teaching/physics10/pffp.html>

Sierra Club on electric cars: <http://www.sierraclub.org/electric-vehicles/myths.aspx>

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