Union of Concerned Scientists

EXECUTIVE SUMMARY

Cleaner Cars from Cradle to Grave

How Electric Cars Beat Gasoline Cars on Lifetime Global Warming Emissions

HIGHLIGHTS

Electric vehicles (EVs) are a critical part of the American transportation future, given their potential to dramatically cut oil use and global warming emissions—especially when charged by low-carbon renewable electricity. New UCS analysis finds that, over its lifetime—from manufacturing to operation to disposal—a battery electric vehicle generates about 50 percent fewer global warming emissions than a comparable gasoline car. Based on the most recently available data on power plant emissions and EV sales, driving an EV produces global warming emissions similar to a gasoline vehicle that gets 68 miles per gallon, on average. To reach their full potential as a global warming solution, EVs must account for a larger share of vehicle sales, and the electricity grid must continue to shift from coal to more renewable resources.

Electric vehicles (EVs) are a critical part of the American transportation future, given their potential to dramatically cut global warming emissions—especially when charged by a clean electricity grid. Together with other oil-saving approaches, such as more efficient vehicles and advanced biofuels, EVs can help cut projected U.S. oil use in half over the next 20 years. EVs will also be essential to achieving the deep emissions reductions by mid-century needed to avoid the worst impacts of climate change.

This report compares battery-electric vehicles (BEVs) with similar gasoline vehicles by examining their global warming emissions over their "life cycles"—from the raw materials to make the car through manufacturing, driving, and disposal or recycling. Toward that end, we performed up-to-date assessments of the carbon footprints of BEVs, taking into account the latest information about electricity generation and BEV models. The two BEVs we modeled, midsize and full-size, are not specific to any particular manufacturer but are based on the two most popular BEV models sold in the United States today: the Nissan LEAF and the Tesla Model S. Our analysis reflects the BEVs available to American consumers and comparable gasoline vehicles.

Our analysis revealed that:

- **From cradle to grave, BEVs are cleaner.** On average, BEVs representative of those sold today produce less than half the global warming emissions of comparable gasoline-powered vehicles, even when the higher emissions associated with BEV manufacturing are taken into consideration. Based on modeling of the two most popular BEVs available today and the regions where they are currently being sold, excess manufacturing emissions are offset within 6 to 16 months of driving.

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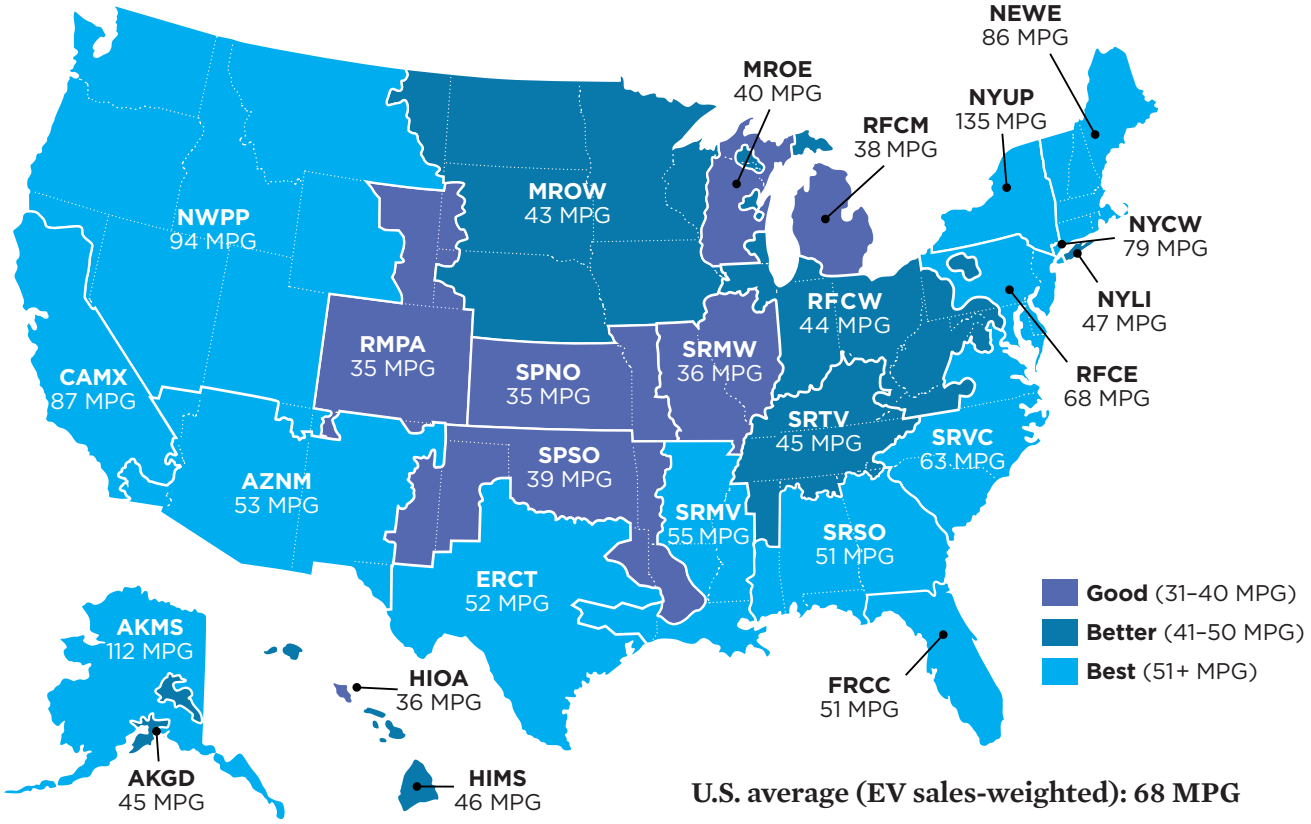
On average, battery-electric vehicles produce less than half the global warming emissions of comparable gasoline-powered vehicles; these emissions savings increase in regions of the country that get more of their electricity from renewable resources.

- **EVs are now driving cleaner than ever before.** Driving an average EV results in lower global warming emissions than driving a gasoline car that gets 50 miles per gallon (MPG) in regions covering two-thirds of the U.S. population, up from 45 percent in our 2012 report. Based on where EVs are being sold in the United States today, the average EV produces global warming emissions equal to a gasoline vehicle with a 68 MPG fuel economy rating.
- **EVs will become even cleaner as more electricity is generated by renewable sources of energy.** In a grid composed of 80 percent renewable electricity, manufacturing a BEV will result in an over 25 percent reduction in emissions from manufacturing and an 84 percent reduction in emissions from driving—for an overall reduction of more than 60 percent (compared with a BEV manufactured and driven today).

Global Warming Emissions from Driving Electric Vehicles

Although a BEV has no tailpipe emissions, the total global warming emissions from operating it are not insignificant; they depend on the sources of the electricity that charge the vehicle's batteries and on the efficiency of the vehicle. We estimated the global warming emissions from electricity consumption in the 26 "grid regions" of the United States (see Figure ES-1)—representing the group of power plants that together serve as each region's primary source of electricity—and we rated each region based on how charging and using an EV there compares with driving a gasoline vehicle. We also estimated, based on recent sales data, the average efficiency of new EVs (battery-electric and plug-in electric vehicles combined) sold in the United States in 2015.

FIGURE ES-1. Electric Vehicle Global Warming Pollution Ratings and Gasoline Vehicle Emissions Equivalents by Electricity Grid Region



Note: The MPG (miles per gallon) value listed for each region is the combined city/highway fuel economy rating of a gasoline vehicle that would have global warming emissions equivalent to driving an EV. Regional global warming emissions ratings are based on 2012 power plant data in the EPA's eGRID 2015 database (the most recent version). Comparisons include gasoline and electricity fuel production emissions. The 68 MPG U.S. average is a sales-weighted average based on where EVs were sold in 2014.

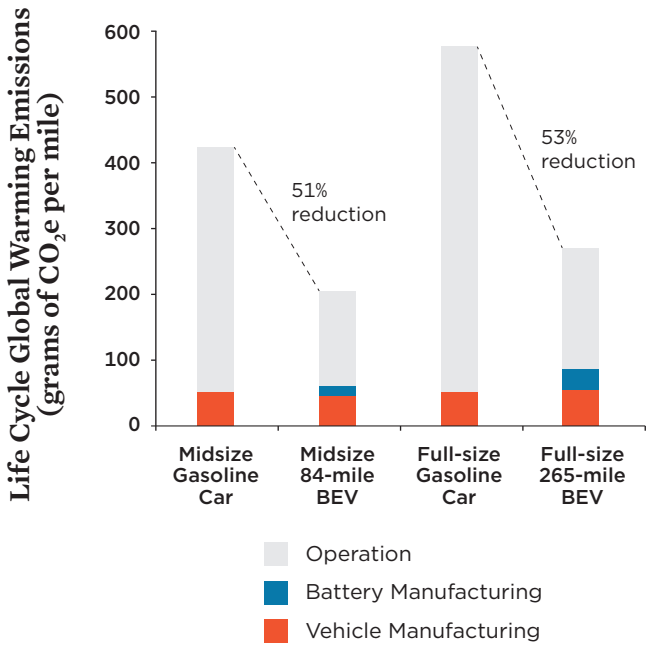
SOURCE: EPA 2015C; IHS 2015.

We found that: (1) driving the average electric vehicle in any region of the country produces lower global warming emissions than the average new gasoline car achieving 29 MPG; (2) our ratings in 20 out of 26 regions have improved since our 2012 report; and (3) more than 66 percent of Americans—up from 45 percent just three years ago—live in regions where powering an EV on the regional electricity grid produces lower global warming emissions than a 50 MPG gasoline car.

Comparisons between electric vehicles and gasoline cars look even more attractive when one considers that many EVs are currently being sold and driven in areas where the electricity grid is cleaner than the U.S. mean. As a result, based on calculations that weighted where EVs were sold in 2014, driving an EV in the United States produced global warming emissions equal to a gasoline vehicle with 68 MPG during operation.

Emissions from operating electric vehicles are likely to keep falling, as national data from 2013 to 2015 show a declining percentage of electricity generated by coal power and an increase in renewable resources such as wind and solar. Additionally, the Clean Power Plan finalized by the U.S. Environmental Protection Agency (EPA) in 2015 offers opportunities for even greater progress, as states must collectively cut their 2005 power-sector carbon emissions 32 percent by 2030. Meanwhile, many EV owners are pairing electric vehicle purchases with home investments in solar energy. With increasing levels of renewable electricity coming onto the grid, with carbon standards for fossil-fuel power plants beginning to be implemented, and with continued improvements in vehicle technologies, the emissions-reduction benefits of EVs will continue to grow.

FIGURE ES-2. Life Cycle Global Warming Emissions from the Manufacturing and Operation of Gasoline and Battery-Electric Vehicles



Notes: We assume that the midsize vehicles are driven 135,000 miles over their lifetimes and the full-size vehicles 179,000 miles. The difference in the two mileages derives from the dissimilar uses of 84-mile-range and 265-mile-range battery-electric cars, as described in Chapter 2. We further assume that a consumer buying a BEV would drive it the same total of miles as a corresponding gasoline vehicle. We use U.S. average electricity grid emissions to estimate manufacturing emissions, while the average electricity grid emissions intensity during vehicle operation are based on a sales-weighted average of where EVs are being sold today.

Global Warming Emissions from Manufacturing Battery-Electric Vehicles

Global warming emissions occur when manufacturing any vehicle, regardless of its power source, but BEV production results in higher emissions than the making of gasoline cars—mostly due to the materials and fabrication of the BEV lithium-ion battery. Under the average U.S. electricity grid mix, we found that producing a midsize, midrange (84 miles per charge) BEV typically adds a little over 1 ton of emissions to the total manufacturing emissions, resulting in 15 percent greater emissions than in manufacturing a similar gasoline vehicle. However, replacing gasoline use with electricity reduces overall emissions by 51 percent over the life of the car.

A full-size long-range (265 miles per charge) BEV, with its larger battery, adds about six tons of emissions, which increases manufacturing emissions by 68 percent over the gasoline version. But this electric vehicle results in 53 percent lower overall emissions compared with a similar gasoline vehicle (see Figure ES-2).

In other words, the extra emissions associated with electric vehicle production are rapidly negated by reduced emissions from driving. Comparing an average midsize midrange BEV with an average midsize gasoline-powered car, it takes just 4,900 miles of driving to "pay back"—i.e., offset—the extra global warming emissions from producing the BEV. Similarly, it takes 19,000 miles with the full-size long-range BEV compared with a similar gasoline car. Based on typical usages of these vehicles, this amounts to about six months' driving for the midsize midrange BEV and 16 months for the full-size long-range BEV.

Meanwhile, the global warming emissions of manufacturing BEVs are falling as automakers gain experience and improve production efficiency. With a focus on clean manufacturing, emissions could fall even more. There are many ways in which the EV industry might reduce these manufacturing-related emissions, including:

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Technicians test the performance of EV battery packs during vehicle manufacturing and assembly. Batteries increase EVs' manufacturing-related emissions compared with gasoline vehicles, but the excess manufacturing emissions can be offset in 6 to 16 months of average driving.

- Advances in manufacturing efficiency and in the recycling or reuse of lithium-ion batteries;
- The use of alternative battery chemistries that require less energy-intensive materials; and
- The use of renewable energy to power manufacturers' and suppliers' facilities.

Recommendations

To accelerate the U.S. transition to a low-carbon future, we recommend the following:

- Under the EPA's Clean Power Plan, states should develop and implement strong compliance plans that prioritize renewable energy and energy efficiency in meeting their emissions-reduction targets.
- Policy makers at all levels of government should adopt new or strengthened policies and programs for increasing energy efficiency and the deployment of renewable energy. These options include renewable electricity standards, energy-efficiency resource standards, carbon-pricing mechanisms, tax incentives and other financial incentives, and improvements in grid operation, transmission, and resource planning.
- Government and the private sector should support more research aimed at decreasing the global warming emissions associated with making electric vehicles' batteries, increasing the efficiency of their operation, and improving the processes for battery recycling or reuse. By supporting this emerging sector, we can help encourage manufacturers not only to reduce manufacturing emissions but also to lower the batteries' costs.
- To increase the benefits of electric vehicles—especially those in regions where global warming emissions from electricity generation are higher than the U.S. average— policies should support consumers who consider investing in cleaner sources of electricity, such as by installing rooftop solar photovoltaic systems or purchasing renewable energy credits.
- Electric vehicle makers and their suppliers should raise the percentage of renewable electricity they use to build these cars. The Union of Concerned Scientists estimates that, with a future 80 percent renewable electricity grid, manufacturing emissions alone could decrease by more than 25 percent compared with manufacturing BEVs today.

Electric vehicles provide benefits both in carbon emissions and oil savings, with the greatest emissions benefits occurring in regions with the lowest-carbon electricity sources. To reach their full potential, EVs must account for a larger share of vehicle sales while the electricity grid shifts from coal to low-carbon renewable sources. Moving forward with both of these transitions constitutes a critical strategy for cutting projected oil use in half over the next 20 years and putting the United States on a trajectory toward net-zero climate emissions by mid-century.

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