

What will it cost to cut the carbon footprint of cars sold in the United States?

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A new study led by Argonne National Laboratory has found that electric vehicles will soon have the potential to cost less to own and operate than traditional gas vehicles, all while cutting greenhouse gas emissions by half over the lifetime of the vehicle.

Electric vehicles (EVs) make up a rapidly growing share of the new car market, but buying and owning one of these vehicles has historically come at a premium. EVs reduce [greenhouse gas emissions](#), but by how much, and at what cost?

The U.S. Department of Energy (DOE) set out to find out.

In a new assessment led by DOE's Argonne National Laboratory, U.S. DRIVE estimated the costs and greenhouse gas emissions for vehicles over their entire life cycle, both with current (2020) and potential future (2030-2035) technologies. U.S. DRIVE, which stands for United States Driving Research and Innovation for Vehicle Efficiency and Energy Sustainability, is a voluntary government-industry partnership that includes DOE and multiple automotive, energy and utility companies.

Their report, an update of one first [published in 2016](#), shows that some [electric vehicles](#) may soon become less expensive to own and operate than traditional gas-powered vehicles, all while cutting greenhouse gas emissions by more than half.

The results came as an exciting surprise to the report's authors.

"Considering prior analyses, I assumed that [carbon reduction](#) was going to come at a cost, but our results showed that carbon reduction can be done at a cost-negative basis," said Jarod Kelly, an energy systems analyst at Argonne and the report's lead author. This pathway to cost-negative decarbonization was most promising for some of the battery electric vehicles. However, the authors stressed that cost-negative decarbonization would be possible only with continued advancement in battery technology and if the DOE meets its targets for decarbonizing the [electric grid](#).

U.S. DRIVE's cradle-to-grave (C2G) analysis looked at the costs and greenhouse gas emissions of several vehicle and fuel technology options

over the vehicles' life cycles. This included [resource extraction](#) ("cradle"), transformation of those resources into fuels and vehicles, fuel use while on the road, and recycling the vehicle at the end of its journey ("grave"). The analysis also included an assessment of the cost of each vehicle per mile driven and the cost of avoided greenhouse gas emissions.

For this report, U.S. DRIVE chose to focus on the most popular vehicle types in America, mid-sized sedans and small SUVs. They assessed vehicle and fuel combinations including [internal combustion engines](#) with conventional and biofuels, hybrid and plug-in hybrid electric vehicles, battery electric vehicles with varying vehicle ranges, and hydrogen fuel cell vehicles.

"The most exciting part of the project was being able to work so closely with industry and government and other national labs," said Kelly. In addition to Argonne and the DOE, the U.S. DRIVE report called upon experts from some of the biggest automakers, including General Motors and Ford. It also involved gas and energy experts at Chevron, the Electric Power Research Institute (EPRI) and the DOE's National Renewable Energy Laboratory.

"This type of research is not done by one entity or one institution," said Amgad Elgowainy, a senior scientist who leads Argonne's Electrification and Infrastructure group and a report co-author. He said this study is a culmination of the team's work and will inform decisions on how to best advance government goals and industry targets. "It takes government, industry and utility companies coming together to determine the potential of various technology options to inform pathways forward. By working together, we can come up with credible analysis to inform the decarbonization of the automotive sector."

Among the reasons Argonne was tapped to lead the study is the

Laboratory's global leadership in cradle-to-grave and life-cycle analyses; the Lab also has expertise in modeling greenhouse gas emissions, battery material composition and vehicle simulations. The U.S. DRIVE team used Argonne's Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) model to quantify greenhouse gas emissions from both the fuel and vehicle production life cycles. Meanwhile, vehicle fuel economies, cost and component sizing were estimated using Argonne's vehicle simulation tool, Autonomie.

One of the challenges in evaluating lifetime greenhouse gas emissions is that all vehicles are not created equal—the most environmentally friendly vehicles on the road are often the most energy-intensive to manufacture. A cradle-to-grave analysis allows for an "apples-to-apples" comparison to see how different powertrain and fuel technologies compare on the same economic and environmental scales.

The U.S. DRIVE study set out to determine vehicle technology pathways with potential for large reduction in lifetime greenhouse gas emissions. Researchers accounted for all carbon emissions associated with making and using the vehicle, as well as making and using the fuel. For electric vehicles, this meant the analysis considered the greenhouse gas emissions from the power used to charge the vehicle and the power used to mine the materials for the battery and other vehicle components.

Multiple technology pathways can reduce the carbon footprint of vehicles. One approach weighs the potential of different power trains, like hybrid electric, batteries and fuel cells. Another focus is on improving the overall vehicle efficiency so that it runs on less fuel. A combination of these approaches might be necessary to achieve even deeper decarbonization. Biofuels, clean hydrogen, and electricity are potential low carbon alternatives to gasoline. The U.S. DRIVE report evaluated the potential of each of these pathways to reduce greenhouse gas emissions and the associated cost. This helped the team identify the

most promising pathways for decarbonizing vehicles now and in the future.

When it comes to a low-carbon future, there is reason for hope, the researchers said. When combining vehicle efficiency gains with low-carbon fuels, greenhouse gas emission reductions more than doubled in most cases compared to vehicle efficiency gains alone.

Kelly said that by far the biggest difference between this study and the one released in 2016 is the rapid advancement of battery technology. Analyses revealed that electric vehicle batteries not only reduce carbon significantly, but also could potentially lower ownership cost. The cost of electric vehicle batteries has decreased dramatically over the past decade and the trend is projected to continue.

"Decarbonization is one of the primary ways we can combat climate change," said Elgowainy. This study, he says, aligns with U.S. goals for decarbonizing the transportation sector—the government hopes that by 2030, half of all new vehicles sold will be zero-emission, such as battery electric vehicles. Elgowainy stresses that there is no need to wait to make an impact. "Electric vehicles are a very attractive option now, because even with today's grid, you can cut your emissions in half," he said. "Because the grid gets cleaner every year, we are looking at a promising clean-energy future for cars in the U.S."

Now that the U.S. DRIVE team has completed their cradle-to-grave analysis for light-duty vehicles, they have started undertaking a similar study for medium and heavy-duty vehicles.

More information: The report titled Cradle-to-grave lifecycle analysis of U.S. light-duty vehicle-fuel pathways: a greenhouse gas emissions and economic assessment of current (2020) and future (2030-2035) technologies by J. Kelly et al is [available here](#).

Provided by Argonne National Laboratory

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