New study on costs and benefits of new transportation technologies the most comprehensive to date

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powertrain, from the conventional to the cutting-edge.

Advanced vehicle technologies are sometimes more expensive to purchase than conventional technologies but often pay for themselves in reduced operational costs. Now a new study from the U.S. Department of Energy's (DOE) Argonne National Laboratory offers the most complete understanding yet of the costs of owning and operating a vehicle, and how those costs vary by powertrain, from the conventional to the cutting-edge.

Building on its pioneering past work quantifying the costs and benefits of new transportation technologies, Argonne published "Comprehensive total cost of ownership quantification for vehicles with different size classes and powertrains." The study considers vehicle purchase cost, depreciation, financing and fuel costs, in addition to aspects missing from previous technical analysis: costs related to insurance, maintenance and repair, and taxes and fees—all to calculate a holistic total cost of ownership (TCO).

"There has been a lot of past research on the cost of vehicles and the cost of fuel, but these other operating costs haven't been studied in quite the same detail before," said David Gohlke, an energy and environmental analyst at Argonne and co-author of the study. "There were gaps in the data, especially with respect to alternative fuel powertrains—electric vehicles, fuel cell vehicles. They are newer to the road, so it was hard to know, for instance, their historic needs for maintenance over their operational life. Our analysis helped fill those data gaps."

The study, sponsored by the DOE's Office of Energy Efficiency and Renewable Energy's Vehicle Technologies Office, is the result of a collaboration between Argonne and four other DOE national labs: Lawrence Berkeley National Laboratory, National Renewable Energy Laboratory, Oak Ridge National Laboratory, and Sandia National

Laboratories.

The report covers light-duty passenger vehicles—compact and midsize sedans, small and large sport utility vehicles, and pickup trucks—as well as medium-/heavy-duty commercial vehicles: semi-tractors; medium-duty vans and pickups; transit buses; box, utility aerial and dump trucks; and garbage trucks. The study looked at several powertrains: internal combustion engine, hybrid electric vehicle, plug-in hybrid electric vehicle, fuel cell electric vehicle and battery electric vehicle.

Key findings include insights into vehicle depreciation, an in-depth examination of insurance premium costs, comprehensive maintenance and repair estimates, an analysis of all relevant taxes and fees, and considerations of specific costs applicable to commercial vehicles.

The study finds, for instance, that battery electric vehicles have maintenance costs 40% lower than ICE vehicles. Overall, hybrid electric vehicles tend to be the lowest-cost powertrain. Hydrogen-powered fuel cell electric vehicles will reach cost parity with conventional vehicles as the price of hydrogen falls. Battery electric vehicles, meanwhile, will reach cost parity as battery prices drop. "There is uncertainty with how quickly these costs will drop," Gohlke noted, "but the technology is trending in the right direction."

Other findings of note include that cars depreciate faster than light trucks, and that older electric vehicles have a greater depreciation rate than newer electric vehicles. Light-duty vehicle insurance costs are comparable for different powertrains, and vehicle size and vocation both affect incurred costs for medium/heavy-duty commercial vehicle insurance. Light-duty vehicle taxes and fees are comparable across powertrain types and size classes, though marginally higher registration fees exist for alternative fuel vehicles in many states. Many electric tractor trailers would be affected by additional battery weight, reducing

the available payload capacity, and this cost can be substantial. Electric vehicle charging for commercial vehicles can be time-consuming; if this charging is paid at an hourly rate, labor can cause this cost to dominate total cost of ownership.

For a simulated small sport utility vehicle in 2025—modeled using Autonomie, Argonne's tool for simulating vehicle energy consumption and performance—the hybrid electric vehicle has the lowest cost, followed by the conventional internal combustion engine vehicle. In the realm of commercial vehicles, the study shows that long-haul battery electric vehicle semi-tractors, which are the most expensive today due to their large batteries, will become the least expensive powertrain in 2035 as battery prices continue to drop. However, for local delivery vehicles such as the Class 4 truck, the battery electric vehicle is the lowest cost option in 2025, the baseline year for the study's modeling.

The study's results will inform future research related to vehicle technology, contribute to Argonne's regular assessments of the potential benefits from the technologies being developed by the DOE and others, and improve Argonne's Alternative Fuel Life-cycle Environmental and Economic Transportation (AFLEET) tool, which assists fleet managers with examining the economic and environmental costs of alternative fuel vehicles. "Fleet owners are particularly sensitive to the bottom line and choose vehicles that can perform the necessary work at the least cost," said Andrew Burnham, an environmental scientist at Argonne, creator of AFLEET, and co-author of the study, "so making this data publicly available and accessible with AFLEET will help them in planning alternative fuel vehicle purchases."

Provided by Argonne National Laboratory