U.S. Department of ENERGY | Office of Energy Efficiency & Renewable Energy

Light Duty Vehicle Greenhouse Gas Life Cycle Assessment

An Assessment Using R&D GREET 2024

Argonne National Laboratory's Research & Development Greenhouse gases, Regulated Emissions, and Energy use in Technologies (R&D GREET®) model analyzes the life cycle impacts of vehicle, fuel, chemical, and material technologies. These analyses guide research and development and decision-making for current and future transportation and energy systems.

Comparing light duty vehicle-fuel combinations

R&D GREET can be used to compare and contrast the complete greenhouse gas (GHG) emission impacts for all components of a vehicle's life cycle. For instance, researchers can assess the GHG emission impacts between gasoline and electric vehicles (EVs), including emissions from vehicle production and end-of-life, fuel production and use, and facility construction (i.e., embodied emissions in fuel production facilities).

Figure 1 shows this comparison in action by calculating the life cycle GHG emissions of two representative light-duty sports utility vehicles: one a gasoline-powered internal combustion engine (ICE) vehicle and the other an EV. This comparison looks at the emissions produced per mile (g CO_2e/mile). Each vehicle is using a representative fuel: E10 gasoline for the ICE and the U.S. average electricity grid generation mix[1] for the EV. For the ICE, fuel use (i.e., gasoline combustion in the vehicle during use) is the greatest contributor to GHG emissions, while fuel production (i.e., generating electricity) is the

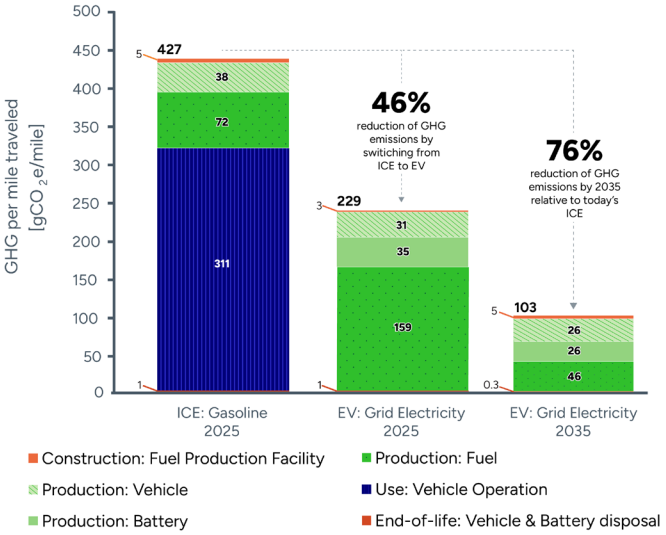

FIGURE 1: Electric vehicles today produce 46% fewer GHGs than their comparable gasoline vehicles on a life cycle basis, with even deeper reductions by 2035.
The life cycle GHG emissions on a per-mile basis for representative electric and gasoline light-duty passenger vehicles (small, sports utility vehicles). Life cycle GHG emissions include those from construction of the fuel production facility (e.g. oil well and electricity generation equipment), vehicle and battery production[2] and end-of-life, and production and use of fuel in the vehicle. Source: R&D GREET 2024; Simulation year: 2025. All years use 2023 NREL Standard Scenarios Midcase for estimated electricity grid generation mix.

biggest contributor for EVs. Overall, R&D GREET shows that the 2025 EV produces 46% less GHG emissions than a comparable ICE vehicle. In 2035, R&D GREET predicts that the EV will produce 76% less GHG emissions than the 2025 ICE.

Tracking Trends and Forecasting the Future: Fuels and Vehicles

As shown above, R&D GREET can also perform future projections of light-duty vehicle production, use, and disposal emissions. This comparison holistically integrates the full life cycle of light-duty vehicles in the future.

Figure 2 shows the trends in time for ICEs and EVs. From 2025 to 2050, ICEs are projected to reduce their life cycle GHG emissions by 28% down to 306 gCO_2e/mile, primarily through improving the vehicle's fuel economy (i.e., MPG). Only small improvements to gasoline fuel production or vehicle production technology are expected. In contrast, EVs sold in 2050 are expected to have life cycle GHG emissions of 77 gCO_2e/mile, a 66% reduction from 2025. While ICEs benefit from vehicle fuel economy improvement, EVs benefit from both fuel economy improvement and a cleaner fuel as clean electricity deployment increases. As a result, the GHG emission gap between EVs and ICEs is widened by 2050.

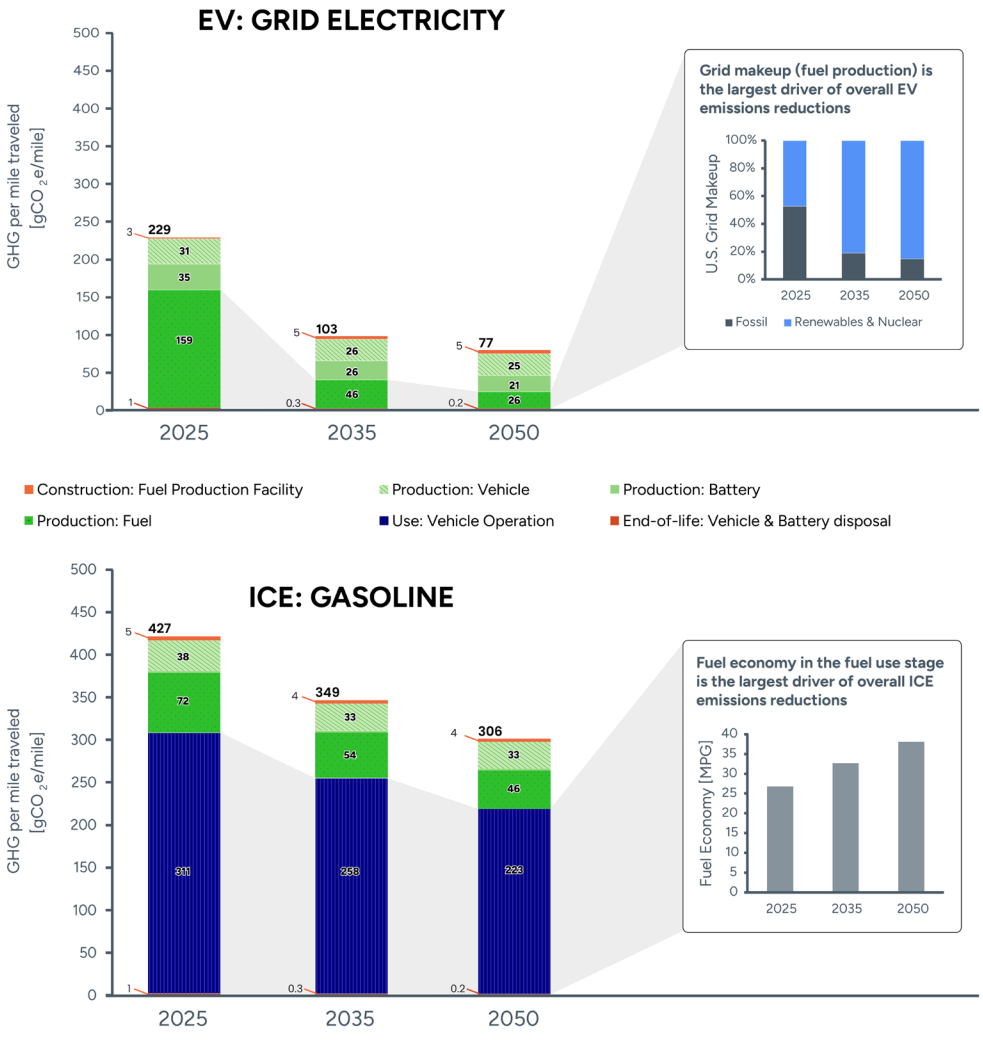

FIGURE 2: EVs projected to dramatically reduce GHG emissions as U.S. grid decarbonizes.
The GHG emissions per mile for 2025, 2035, and 2050 for light-duty sports utility vehicles. GHG emissions include those from construction of the fuel production facility, vehicle and battery production[2] and end-of-life, and production and use of fuel in vehicle. Source: R&D GREET 2024; Simulation years: 2025, 2035, and 2050. All years use 2023 NREL Standard Scenarios Midcase for estimated electricity grid generation mix.

1 The U.S. grid is powered by a mix of power plants that use different fuel sources to generate electricity (e.g., coal, natural gas, wind, solar, nuclear, and others)

2 Lead-acid battery production emissions for ICE vehicles are included in the "Production: Battery" category, but they are negligible.