LCRI LOW-CARBON RESOURCES INITIATIVE

EPRI GTI ENERGY

EXECUTIVE SUMMARY

ASSESSMENT OF LOW-CARBON FUEL PATHWAYS FOR LIGHT-DUTY VEHICLES

In the past decade, electric vehicles (EVs) with suitable driving performance have become available. While electrification of the vehicle industry remains early in development, market growth is rapid and well-aligned with the need to reduce emissions. However, EVs face adoption challenges, notably in applications such as long-distance driving or for drivers without access to home charging. To achieve deep emissions reductions goals across the transportation sector and global economy, alternative low-carbon fuels will likely be required to address difficult-to-electrify use cases in the light-duty vehicle market.

Greenhouse gas (GHG) emissions from conventional vehicles are significant: light-duty vehicles with internal combustion engines emit approximately 10,000 lb (4.6 metric tons) of carbon dioxide (CO_2) each year.[1] Worldwide, passenger cars and light commercial vehicles are responsible for 46% of GHG emissions in the transportation sector.[2] In the United States, light-duty vehicles generate approximately 17% of overall emissions, which excludes the emissions associated with fuel production and distribution. Successfully decarbonizing this sector requires the development, deployment, and consumer adoption of affordable alternative fuels (including electricity), vehicles that can use the fuels, and infrastructure to deliver fuel whenever and wherever it is needed. Average household spending on vehicle fuels increased from about $2800 per year in 2021 to about $5000 per year in May of 2022.[3] Hence, there is also market potential for technologies that can reduce consumer fuel costs.

Key findings from the full report include the following:

- Due to the relatively long life of light-duty vehicles and hence slow turnover of the light-duty vehicle stock, in the absence of policies to accelerate the retirement of older vehicles, any solution that requires changes to vehicles will take a considerable amount of time to penetrate the market. As a result, mass market deployment of most alternative fuels is not expected within the 2030–2040 timeframe.
- In the past, a variety of alternative fuels for light-duty vehicles were developed and demonstrated, but failed to achieve commercial success and public adoption. The vehicle industry needs to build on lessons learned from these failed attempts. The most successful deployment of an alternative fuel was the use of diesel in Europe. However, low-carbon alternative fuels, such as methanol, dimethyl ether, and renewable natural gas, require extensive changes to fuel production and delivery systems, and are more difficult to deploy.
- To reduce overall vehicle emissions, an alternative fuel must be widely adopted. In order to achieve this adoption, an alternative fuel needs to have three key characteristics: consumer acceptance of both the fuel and vehicle based on a better experience or other obvious benefit, the automotive industry's willingness to engineer vehicles for the fuel, and existing or relatively low-cost manufacturing and distribution infrastructure that allows fuel suppliers to be profitable.

1. U.S. Environmental Protection Agency. "Greenhouse Gas Emissions from a Typical Passenger Vehicle." Updated June 30, 2022. https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle
2. Tiseo, Ian. "Distribution of carbon dioxide emissions produced by the transportation sector worldwide in 2020, by subsector." Statista. December 14, 2021. https://www.statista.com/statistics/1185535/transport-carbon-dioxide-emissions-breakdown/
3. Domm, P. "Households are now spending an estimated $5,000 a year on gasoline." CNBC. May 18, 2022. https://www.cnbc.com/2022/05/18/households-are-spending-the-equivalent-of-5000-a-year-on-gasoline.html

- Most proposed alternative fuels have failed on one or more criteria. However, with adequate research and investment, some alternative fuels present the potential for success.

In addition to continued advances in EV performance and fueling infrastructure, the most likely alternative fuel solutions are the following:

- The incremental deployment of a drop-in (replacement) or renewable fuel that can work in dual-fueled vehicles
- Development of hydrogen fuel cell vehicles (e.g., in use cases that take advantage of the longer range possible with hydrogen due to its high specific energy) that meet requirements for emissions reductions, automotive performance, and ease and safety of refueling

Regarding vehicle performance and cost, challenges for low- and zero-emission vehicles remain in the areas of driving range, cold weather operation, high upfront costs, limited options for vehicle purchase, refueling speed, and the infrastructure challenge of matching supply and demand as the market rapidly expands.

This report focuses on low-carbon alternative fuel candidates for light-duty vehicles and the associated fueling infrastructure. It describes criteria for a successful alternative fuel for light-duty vehicles, potential alternative fuels in this space (including drop-in fuels and low-carbon additives, natural gas, hydrogen fuel cells, and electricity), government alternative fuel policies and regulations, key trends and challenges, and recommended next steps.

The Low-Carbon Resources Initiative

This report was published under the Low-Carbon Resources Initiative (LCRI), a joint effort of the EPRI and GTI Energy addressing the need to accelerate development and deployment of low- and zero-carbon energy technologies. The LCRI is targeting advances in the production, distribution, and application of low-carbon energy carriers and the cross-cutting technologies that enable their integration at scale. These energy carriers, which include hydrogen, ammonia, synthetic fuels, and biofuels, are needed to enable affordable pathways to economy-wide decarbonization by mid-century. For more information, visit www.LowCarbonLCRI.com.

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