

ALTERNATIVE FUEL INFORMATION SHEET: HYDROGEN

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What is a Fuel Cell

A fuel cell engine generates electrical energy through an electrochemical reaction, not combustion. This is done by combining hydrogen and oxygen to produce electricity, heat, and water. This is a very reliable and well-understood technology that provides high conversion efficiency and zero emissions based on the hydrogen source, durability, scalability, and quiet operation. Because of a fuel cell's ability to be scaled up and attached to additional fuel cells, this technology can be used for bus fleets, heavy-duty trucks, medium-duty trucks, and many other larger applications.

Efficiency

A fuel cell is two to three times more efficient than an internal combustion engine. Additionally, hydrogen can be used in internal combustion engines, but it is less efficient based on the volume of hydrogen needed. Hydrogen is a gaseous substance, so it has a low volumetric

Overview

Hydrogen is an alternative fuel source that has many different production processes. While this fuel source is relatively new to transportation there is active investment from large corporations and regulations for the research and development of this alternative.

energy density. This means that it has a low energy per unit volume. Specifically, based on mass hydrogen has nearly three times the energy content of gasoline (120 MJ/kg for hydrogen versus 44 MJ/kg for gasoline). But, based on volume, liquid hydrogen has a density of 8 MJ/kg and gasoline has a density of 32 MJ/L. So, for a vehicle to have the same range and capabilities as a gasoline-powered vehicle 5-13 kg of hydrogen would need to be stored (Hydrogen Storage, 2024).

Economic Benefits

The actual hydrogen compound is very abundant, but it is naturally found as a part of another compound. For use in a hydrogen fuel cell and to power a vehicle it must be separated into pure H₂ gas. Unfortunately, this is a very costly and energy-intensive process. Because of hydrogens' unique properties, production processes, and transportation, it results in a higher price per gallon. Based on the current data and technology hydrogen is sold for about \$14/ gallon. But, with economics of scale, this number is expected to be comparable to gasoline. Additionally, through decreasing overall production costs and hydrogen subsidies, the price per gallon is expected to drop (Yowell, 2022). But, even though incurring this cost, there is an overall net benefit of major decreases in GHG emissions and natural resource extraction throughout the life-cycle of a hydrogen-powered FCEV.

Environmental Benefits

The specific production process and energy inputs have a large impact on the overall emissions and usage of natural resources. But, once in its usage phase in a fuel cell-powered vehicle, this is considered a zero-emissions alternative. These production processes include natural gas reforming/ gasification, electrolysis, biomass-derived liquid reforming, and microbial biomass conversion. Each of these production processes can use fossil fuels, water, or waste products as inputs. So, the overall inputs make a large difference in the overall emissions during the life cycle of this energy source.

Conversion

The distribution of hydrogen is one of the largest limitations to hydrogen application. There are three major distribution methods: Pipeline, High-pressure tube trailers, and liquified hydrogen tankers. Pipeline is the least expensive and most effective mode of transportation, but there is limited capacity and availability of these pipelines throughout the US. They are currently located near refinery plants in Illinois, California, and the Gulf Coast. So, there are high upfront costs to develop the physical infrastructure for conversion.

Current Applications

Honda, Toyota, and Hyundai have started to heavily invest in the production of FCEVs and have already sold more than 6,500 FCEVs in California. However, there has also been investment from these same corporations in the required infrastructure to utilize these vehicles in the market. While the current costs of hydrogen need development, Ohio has been a major location of investment in the overall availability, feasibility, and compatibility of hydrogen. Through the bipartisan Infrastructure and Recovery Act, \$7 billion has been invested in multiple different hydrogen hubs. Ohio specifically has an advantage through the availability of low-cost natural gas for decreased production costs, a large workforce, and a large manufacturing capacity. Additionally, Ohio already has emerging hydrogen markets in large cities with connections to major research universities to aid in the growth and application of this alternative fuel.