PROPANE-MADE HYDROGEN

BY ROBERT RAPIER

June 2, 2020

INTRODUCTION

The world is transitioning to a low-carbon future. This transition is being aided by legislation aimed at curbing greenhouse gas emissions, as well as rapidly declining costs for renewables like wind and solar power.

In fact, in the last decade, no country has seen its carbon dioxide emissions decline more than the United States. But the primary reason for that decline often surprises many people.

Natural Gas Drives Lower Carbon Emissions

The shale gas boom in the U.S. caused nearly a **90% increase** ↗ in U.S. natural gas production between 2005 and 2020. This resulted in a collapse in U.S. natural gas prices, and helped drive coal-fired power plants to switch to natural gas to generate firm power. That has been the **primary driver** ↗ in the drop in U.S. carbon dioxide emissions, with the growth of renewables actually making the second largest contribution.

Thus, ironically a fossil fuel has already helped drive the transition to a low-carbon fuel. This begs the question whether there are other fossil fuels that can help drive this transition. Indeed, there are.

One of the byproducts of this surge of natural gas production has been an increase in the production of natural gas liquids. These liquids are removed from natural gas during the production process, and consist of ethane, propane, butane, and higher hydrocarbons.

PROPANE'S POTENTIAL

Propane is the lightest of these gases that is easily transportable as a liquid under pressure. Just as natural gas production surged, propane production jumped from 182 million barrels in 2005 to nearly **600 million barrels ↗** in 2019.

How could propane help with the move to a low-carbon future? One way is through hydrogen production.

Hydrogen is the lightest element, as well as the most abundant element in the universe. It can be used as a source of power, and it plays a critical role in many petrochemical processes.

When hydrogen is combusted, it forms water. Therefore, hydrogen can be used as a low-carbon fuel source. Hydrogen can be combusted directly, or it can be used in a fuel cell to produce electricity.

Since hydrogen itself produces water when combusted, it is envisioned by many as the key to a cleaner energy future. President George W. Bush touted the potential for a "hydrogen economy" in his 2003 State of the Union address. Billions of dollars have subsequently been allocated to achieve this vision.

HYDROGEN PRODUCTION

But hydrogen must first be produced. Over 95% of the world's hydrogen is produced using steam methane reformers (SMR). In this reaction, natural gas is reacted with steam at an elevated temperature to produce carbon monoxide and hydrogen. A subsequent reaction — the water gas shift reaction — then reacts additional steam with the carbon monoxide to produce additional hydrogen and carbon dioxide.

The ultimate products of this reaction are carbon dioxide and hydrogen. Like methane, propane can be steam reformed, albeit at milder temperatures. The methane SMR reaction takes place at temperatures of 750°C to 950°C, but propane can be reformed to hydrogen at 200°C to 350°C. The lower temperatures reduce the energy requirement, and hence the carbon footprint, for producing hydrogen from propane.

But what about the carbon dioxide? Whether propane is directly combusted or reformed, all of the carbon in the propane still ends up as carbon dioxide. Direct combustion of propane in a vehicle (common in many parts of the world) has a **lower carbon footprint ↗** than does gasoline or diesel, but those carbon emissions do still end up in the atmosphere.

THE REFORMING ADVANTAGE

Converting the propane to hydrogen offers a way to capture those carbon dioxide emissions at the source. When the hydrogen product of an SMR is purified, the primary impurity is the carbon dioxide. That is separated at the source, and the carbon dioxide can then be sold into the commodity carbon dioxide market (for use in carbonated beverages and refrigeration). There are other uses for the carbon dioxide as well, but as a last resort it could be pumped back into the ground and sequestered.

The hydrogen can then be used to produce a (nearly) carbon-free source of power. I say "nearly," because there are still a small amount of emissions associated with the production of propane and subsequently hydrogen, but these are a small fraction of the emissions of simply burning a fossil fuel.

This isn't merely a theoretical exercise. Amazon, as just one example, is buying hydrogen fuel cell forklifts for its warehouses. The Energy Information Administration (EIA) **reports ↗** that there are now about 80 fuel cell power plants operating in the U.S. with about 190 megawatts (MW) of electric generation capacity. In addition, there are about 60 hydrogen refueling stations operating in the U.S.

It seems likely the hydrogen use will grow as the world embraces low-carbon power. As natural gas has already shown, some fossil fuels like propane can aid in this transition.

ABOUT THE AUTHOR

Robert Rapier is a chemical engineer in the energy industry. He has 25 years of international engineering experience in the chemical, oil and gas, and renewable energy industries, and holds several patents related to his work. He has worked in the areas of oil refining, oil production,

synthetic fuels, biomass to energy, and alcohol production, and currently serves as Director of Engineering for Arizona-based ZHRO Power.

He is author of The Energy Strategist at Investing Daily, and of the book Power Plays: Energy Options in the Age of Peak Oil. Robert has appeared on 60 Minutes, The History Channel, CNBC, Business News Network, CBC, and PBS, and his energy-themed articles have appeared in numerous media outlets, including the Wall Street Journal, Washington Post, Christian Science Monitor, Forbes, and The Economist.