HYDROGEN H_2 REPORT

MAKING THE ENERGY TRANSITION POSSIBLE

TACKLING EMISSIONS THROUGH TECHNOLOGY AND INNOVATION

BY ARJA TALAKAR

The world is evolving, driven in part by simple demographics. By 2050, the global population is expected to grow from its current level of 7.7 billion to 9.7 billion. For comparison purposes, in 1950, there were only 2.5 billion people.

The challenges — particularly surrounding energy production, consumption, and emissions — are also evolving. Global energy usage is projected to increase by nearly 50% over the next three decades.[1] The question producers and governments now face is how they can sustainably meet future demand without impeding economic development or undermining quality of life. Today, there are still roughly a billion people worldwide who lack access to reliable power. Solving this dilemma will require a blend of cost-competitive renewables, natural gas, and e-fuels, such as hydrogen. While an energy system dominated by wind and solar is undoubtedly the future, it cannot be built overnight. In the interim, we must look at how existing technologies and infrastructure can be leveraged to reduce global emissions and ensure the security of supply. The coexistence of energy sources, not competition, will be critical as we drive toward net zero.

TRANSFORMING POWER GENERATION

Fossil fuel-based power production represents a large portion of global greenhouse gas (GHG) emissions. According to the International Energy Agency (IEA), in 2018, coal-fired generation alone accounted for nearly 30% of all carbon dioxide (CO_2) emissions worldwide.[2]

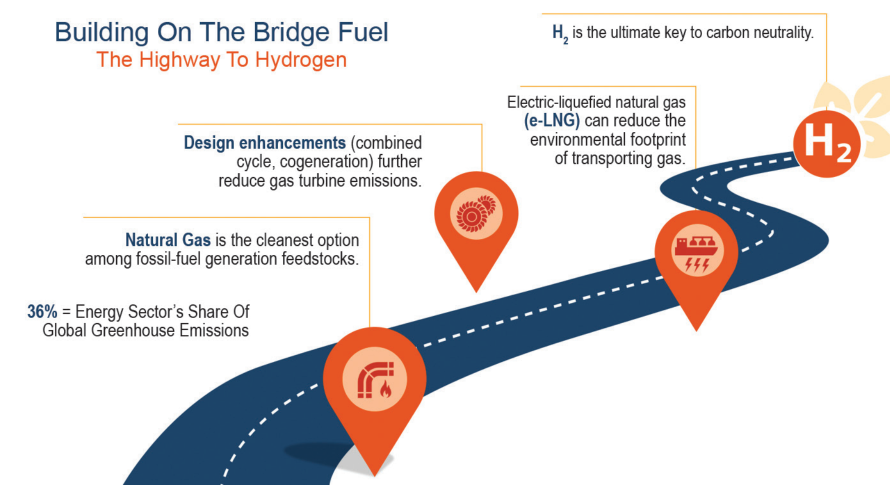

Figure 1. Path To Carbon Neutrality

Significant progress toward decarbonization is possible by replacing coal and other heavy fuel oil feedstocks with natural gas. When compared to coal-fired generation, burning natural gas in open-cycle gas turbines reduces specific carbon emissions by 25% to 50%. By converting to combined cycle operation, an additional 20% to 23% reduction in emissions is possible. In cogeneration applications, modern gas turbines' total energy efficiency with cogeneration can reach as high as 85%.[3] Since 2010, an estimated 600 million tons (544 million tonnes) of carbon savings globally have been captured by replacing coal-generating capacity with gas. This amount is equivalent to nearly 60% of the annual emissions from all of South America.[4]

In many regions of the world, gas turbines already serve as key enablers of clean grids by providing highly flexible and dispatchable generation to support electrical networks with high penetration from intermittent renewables. In the future, they will become even more critical as electrification trends toward full decarbonization, and the hydrogen economy starts to unfold.

By burning hydrogen as a fuel, either through the co-firing or complete displacement of natural gas, gas turbines can provide low-carbon or even carbon-free electricity.

Approximately 80 vol% hydrogen fuel content is needed to reach a 50% reduction in CO_2 emissions by mass. The amount of hydrogen required to operate large gas turbines at this level of hydrogen fuel mixture is not economically viable today. However, for smaller gas turbines, these levels are already within reach — especially when considering hydrogen flare gases from petrochemical sources.

Even with small amounts of hydrogen in the fuel, it is still possible to achieve impactful emission reductions. For example, adding only 10 vol% hydrogen to natural gas will reduce CO_2 emissions by 2.7%. For a 600-MW combined-cycle power plant that runs for 6000 hours a year at an average 60% efficiency, this would

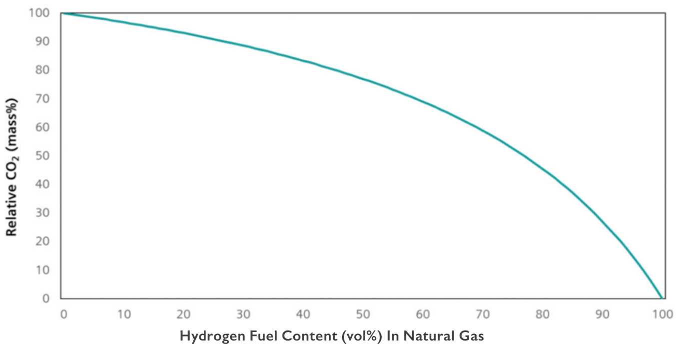

Figure 2. Hydrogen Volume Percentage (vol%) In The Fuel Versus The Relative CO_2 Emissions From The Combustion Process (Assuming 100% Combustion Efficiency)

equate to a reduction in approximately 1.39 million tons (1.26 million tonnes) of CO_2.

ADDRESSING EMISSIONS FROM PRODUCTION

As with any fuel, to truly achieve decarbonization, the production source's environmental impact must be considered.

In the case of natural gas, the industry has already made tremendous progress in cutting emissions across the supply chain through measures such as increased electrification of liquefaction plants (i.e., electric-liquefied natural gas [e-LNG]), digital transformation and optimization, waste heat recovery, carbon capture, etc. These efforts have gone a long way in reducing the total carbon footprint of gas-fired generation. Indirectly, they have also improved the sustainability of the hydrogen economy.

Today, more than 90% of all hydrogen produced is "gray," meaning it is derived from fossil fuels. The associated CO_2 emissions with this form of production (~9 tons [8 tonnes] of CO_2 per ton of hydrogen) are equal to or greater than the emissions avoided by displacing natural gas fuel in turbines. As a result, gray hydrogen is more commonly used as a feedstock in industrial processes to produce ammonia, methanol, petrochemicals, etc.

While hydrogen produced without any CO_2 emissions is possible today, it will likely take time for it to be utilized for power generation on a wide scale.

"Green" hydrogen is produced via water electrolysis (i.e., splitting water molecules into hydrogen and oxygen with an electric current). If the electricity comes exclusively from renewables, such as wind or solar, the entire production process is free of emissions. "Cyan" hydrogen is another emissions-free variant generated using molecule cracking with heat (i.e., pyrolysis). However, it is generally viewed as a longer-term prospect.

Several green hydrogen production projects are in development across the globe. These projects are bringing the world closer to capitalizing on green hydrogen. However, the primary obstacle remains the availability of renewable electricity. To fulfill the hydrogen demand forecasted by 2050 with green hydrogen, it's estimated that 4700 GW of new generating capacity from renewables (wind and solar) will be needed — nearly five times the world's current installed base.[5]

In the near-term, hydrogen produced via traditional processes, such as steam methane reforming of natural gas, can help bridge the gap. By incorporating carbon capture and storage (CCS) or carbon capture and usage (CCU), emissions can be kept to a minimum. This is commonly referred to as "blue" hydrogen and will play a key role in enabling truly clean power generation in the coming years.

Both green and blue hydrogen can serve as a clean and cost-efficient means of energy storage. In recent years, a variety of storage options have emerged, allowing short-term storage during the day and long-term storage through entire seasons. While batteries are well-suited to help manage the daily peak shift from mid-day to evenings, thermal and chemical solutions, like hydrogen, are a more suitable storage option for more extended periods.

Hydrogen is also highly dispatchable and can be transported via pipeline, truck, or rail. In effect, this expands the reach of renewable energy by enabling clean energy delivery to regions where solar and wind sources do not yet exist.

COEXISTENCE, NOT COMPETITION

When it comes to creating a low-carbon energy system, there is often a perception that the use of natural gas and e-fuels like hydrogen — particularly as a replacement for coal — conflicts with the impending build-out of solar and wind. However, in the coming decades, both hydrocarbons and renewables will be needed to ensure the security of supply and meet the world's growing demand for power.

The energy transition is ultimately a social project in which a wide range of interests must be negotiated to find a balance between sustainable, affordable, and reliable energy. This dilemma can only be solved through the coexistence of a diverse range of energy sources. To this end, the energy industry must come together with government and society to develop joint solutions that address the threat of climate change.

ABOUT THE AUTHOR

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