

The *blue hydrogen* industry as a main contributor to the development of Saudi Arabia

Lorenzo A. Hernandez*

Mailing address: Saudi Aramco, DOB (Dammam Office Building), 3rd floor, R-364, Dammam-Khobar Highway, 34472, Saudi Arabia

DOI: <https://doi.org/10.5281/zenodo.7092501>

Published Date: 19-September-2022

Abstract: In parallel with other initiatives for reaching zero carbon emissions, the potential of blue hydrogen to decarbonize heavy industries has seen its star rise fast. A global transformation of energy sectors is underway. To support a future where all our energy comes from clean sources, the world needs clean, flexible, storable and safe fuels. Recently, some topics have been as prominent in energy discussions as the importance of hydrogen in future energy systems. Hydrogen has all the characteristics indicated as a fuel for this world. When hydrogen is used as a fuel, it produces no carbon emissions, only water. It can safely be used in a broad range of applications. The more hype is generated around it, the higher the expectations have grown. Across developed and developing nations alike, the race to produce carbon free hydrogen is on. And the KSA is right in the mix.

Keywords: Blue hydrogen; Zero carbon emissions; Energy; Clean sources; Fuel.

1. THE POTENTIAL FOR HYDROGEN IN SAUDI ARABIA

Recently, some topics have been as prominent in energy discussions as the importance of hydrogen in future energy systems. Hydrogen has all the characteristics indicated as a fuel for this world. When hydrogen is used as a fuel, it produces no carbon emissions, only water. It can safely be used in a broad range of applications.

The more hype is generated around it, the higher the expectations have grown. Across developed and developing nations alike, the race to produce carbon free hydrogen is on. And the KSA is right in the mix.

A Saudi Arabian hydrogen industry could generate thousands of jobs and it could add billions of dollars to GDP over coming decades. Managed well, it could help to reliably integrate extensive renewable generation into the electricity grid and automotive industry. Using hydrogen, we can reduce use of fossil fuels and we can reduce carbon emissions, in Saudi Arabia and around the world.

The eagerness toward use of hydrogen is expected. If the energy companies can find a way to produce and store blue hydrogen in a cost-effective manner, all industries could see their emissions dramatically reduced. As such, businesses around the world have begun investing huge efforts into “the ultimate clean energy source.”

2. THE FUTURE OF HYDROGEN IN SAUDI ARABIA

The Kingdom of Saudi Arabia (KSA) is leading the way to a hydrogen-powered future given its strong fundamentals, including ample natural resources, technological expertise, and economic stability. The KSA has pledged to build more hydrogen production sites across the country to provide energy for key industrial sectors.

By investing in blue hydrogen, the KSA is putting itself in a strong position to diversify its energy production chain and industrial capabilities, and meet the goals laid out by the country’s leadership as part of Vision 2030.

The KSA is also one of the first countries in the Middle East to build a hydrogen refueling station to promote hydrogen-powered transport.

Gaseous hydrogen can be transported through pipelines much like natural gas is today. These pipelines are generally located where large hydrogen users, such as petroleum refineries and chemical plants, are concentrated; such as in the Eastern Province and Yanbu’. One possibility for rapidly expanding the hydrogen delivery infrastructure is to adapt part of the natural gas delivery infrastructure to accommodate hydrogen.

Several projects are currently ongoing to transport large volumes of hydrogen to customers in different areas in the KSA. The network contributes to the development of the downstream industry, the optimization of natural resources, and the increase of energy savings within the Kingdom.

These projects continue to demonstrate the commitment to the Kingdom and Vision 2030. By leading the development of hydrogen infrastructure, Saudi Arabia is not only bringing infrastructure and expertise in gas supply solutions and technology, but also driving local investments, talent opportunities, and the development of the local supply chain.

3. HYDROGEN, WHAT IS IT AND HOW IS IT PRODUCED?

Hydrogen, a colorless, odorless, tasteless, flammable gaseous substance, is the simplest member of the family of chemical elements.

Hydrogen industrial production comes in three types: gray, blue, and green.

- **Gray hydrogen** – Gray hydrogen production has been accommodated for many years already. It is extracted from oil or produced by reforming natural gas into hydrogen and CO₂ and storing the hydrogen, but the CO₂ is not captured and it is a greenhouse gas that contributes to climate change.
- **Blue hydrogen** – Blue hydrogen follows the same process of splitting, but carbon emissions in the production process are captured, sequestered, or repurposed so that they do not contribute to global warming. Carbon-capture technologies prevent the harmful CO₂ from being released into the atmosphere. As the greenhouse gasses are captured, this mitigates the environmental impact on the planet.
- **Green hydrogen** – Green hydrogen is produced from zero-emission renewable energy sources.

4. TECHNOLOGIES FOR PRODUCING HYDROGEN

There is still a debate over how to most effectively source and use hydrogen in the transition to carbon neutrality.

Gray hydrogen production consists of reforming natural gas into hydrogen and CO₂ and storing the hydrogen, but the CO₂ is not captured.

Green hydrogen is currently seen as the best one as it's emission free. An electric current produced by renewable electricity is used to separate water into oxygen and hydrogen using electrolysis. However, it's very expensive due to the high cost of supply chain logistics and electrolysis that produce hydrogen in this way, and the renewable energy required isn't reliable enough to meet hydrogen demand.

Blue hydrogen on the other hand is currently around half the price of green hydrogen, and is made using natural gas, through separating it from the hydrocarbons that make it up through the application of heat, also known as reforming.

5. CO₂, WHAT IT IS, AND THE IMPORTANCE OF CAPTURING IT

Carbon dioxide is an acidic colorless gas with a density about 53% higher than that of dry air. Carbon dioxide molecules consist of a carbon atom covalently double bonded to two oxygen atoms. It is present in deposits of petroleum and natural gas. Carbon dioxide has a sharp and acidic odor and generates the taste of soda water in the mouth. At normally encountered concentrations it is odorless.

Most of the carbon dioxide (CO₂) produced in the hydrogen production process can be captured and stored permanently. This is what's referred to as carbon capture and storage (CCS). This technology has still not been deployed at any real scale.

Also, the CO₂ can be captured and used as an industrial process that makes an economically valuable product using CO₂ at concentrations above atmospheric levels. CO₂ is either transformed using chemical reactions into materials, chemicals and fuels, or it is used directly in processes such as enhanced oil recovery. CO₂ gas is used to make urea (used as a fertilizer and in automobile systems and medicine), methanol, inorganic and organic carbonates, polyurethanes and sodium salicylate. Carbon dioxide is combined with epoxides to create plastics and polymers.

6. POTENTIAL INDUSTRIES IN SAUDI ARABIA

There are several industries with a long history of using hydrogen, refining petroleum, treating metals, fertilizer, and processing foods. But this paper is focused on three of them. Two are related to the use of hydrogen and one is related to the CO₂ produced during the obtention of hydrogen.

6.1 Hydrogen fuel cells to produce electricity

Hydrogen is used to produce clean and silent energy for a variety of applications where doing so meets an immediate need and also offers a genuine benefit. This is the case for power supply to isolated regions that are not connected to the power grid; sensitive sites that require reliable backup energy; and portable power generators used for outdoor events.

In the power sector hydrogen presents opportunities for assisting with providing energy storage solutions for off-grid electricity systems, and in balancing electricity systems, shifting oversupply of electrical energy temporally and/or geographically.

6.2 For clean transportation

Hydrogen used in a fuel cell allows us to produce electricity directly on board a vehicle with an electric engine. The hydrogen is combined with oxygen to produce electricity; these "zero-emission" vehicles release only water.

The use of hydrogen for transportation will require greater policy intervention. In the road transportation sector, cost reductions in hydrogen fuel cell technology and construction of hydrogen refueling infrastructure will be needed for the market to develop. The great challenge is the time required to replace the vehicle fleet. There is strong potential for hydrogen to be used in transport, and in particular in the heavy-duty vehicle market segment. Policy and regulation are likely to play an important role in the development of hydrogen refueling infrastructure, particularly in the early stages of adoption.

6.3 CO₂ to booster the chemical industry

The chemicals industry is an essential part of economic diversification in Saudi Arabia. In line with Vision 2030, Saudi Arabia has already embarked on a transformational program that will generate significant industrial growth in various sectors, and the chemicals sector in all segments will play a major play role in meeting demand from Africa, Europe and Asia, and also in meeting demand from significant growth in the domestic energy sector.

For that reason, CO₂ as a sub-product from hydrogen production could be used in different ways to produce polymers, fertilizers, proteins, foams, and others. An example is the tentative projects for building PPC plants.

7. CONCLUSION

Use of hydrogen is not new. It has been used for a long time. But now, hydrogen is back to business with all its potential. It can be used to support reduction in greenhouse gas emissions by 2050, and Saudi Arabia will play a key role in the world for this development.

Declaration of interest

The author reports no conflicts of interest. The author alone is responsible for the content and writing of this article.

ACKNOWLEDGEMENTS

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

REFERENCES

- [1] William Licht, (June 2019), The Path to Low Carbon Hydrogen: Infrastructure Deployment, MIT-Energy Initiative-Spring Symposium
- [2] CALSTART Report (December 2016), Best Practices in Hydrogen Fueling and Maintenance Facilities for Transit Agencies.
- [3] COAG Energy Council Hydrogen Working Group (2019), Australia's National Hydrogen Strategy.
- [4] Air Products. "Accelerating the Energy Transition." Accessed February 1, 2022.<https://www.airproducts.com/campaigns/energytransition>
- [5] "H₂ Energy and Fueling Station." Accessed December 26, 2021.<http://www.airproducts.com/industries/Energy/Power/modal-hydrogen-station>.
- [6] "Gasification Services and Solutions." Accessed February 21, 2022. <https://www.airproducts.com/applications/syngas-solutions/gasification-services-and-solutions>