IJAAR PUBLISHING®

African Journal of Business and Economic Development | ISSN: 2782-7658
Vol. 5, Issue 5 (2025) | www.ijaar.org/ajbed

ECONOMIC IMPORTANCE OF THE UTILIZATION OF HYDROGEN IN NIGERIA

Isah Jatto[1]; Enejoh Omejeh[1]; Ahmad Abdulrazaq Itopa[1]

[1]Kogi State Polytechnic Lokoja, Kogi State

Abstract

Nigeria, with its growing population and heavy dependence on fossil fuels, faces significant energy and environmental challenges. The adoption of hydrogen as an alternative energy source offers a viable solution due to its clean, renewable, and versatile nature. This paper reviews the economic importance of hydrogen utilization in Nigeria, exploring its production from both conventional and renewable sources. The study highlights hydrogen's potential to replace fossil fuels, mitigate environmental degradation, and support sustainable development. Key economic benefits include promoting a healthier climate, reducing the adverse economic effects of fossil fuel dependency, creating employment opportunities, attracting domestic and foreign investment, and enhancing energy security. By integrating hydrogen technologies, Nigeria can diversify its energy mix, reduce reliance on oil exports, and strengthen its economy. The findings underscore the urgent need for Nigeria to embrace hydrogen energy policies as part of its sustainable development agenda.

Keywords: Hydrogen energy, renewable energy, fossil fuels, economic development, energy security, sustainable development, Nigeria

Jatto, I., Omejeh, E., & Itopa, A. A. (2025). Economic Importance of the Utilization of Hydrogen in Nigeria. *African Journal of Business and Economic Development. 5*(5), 32-41. DOI: https://doi.org/10.5281/zenodo.16459192

1.0 Introduction

Nigeria, home to more than 200 million people (James, 2018), is constantly dealing with outdated energy supplies and sources. The country is looking for alternative energy sources that have the potential to stop Nigeria's energy and environmental challenges. The adoption of hydrogen as an alternative energy source seems to be the best option for the country for its easy production and utilization. However, its development and deployment in the country face significant obstacles. The urgent need to transition from fossil fuels to sustainable energy sources is one of the most pressing challenges facing Nigerians today. Fossil fuels, which account for approximately 85% of the world's energy consumption, have been the primary driver of industrialization and economic growth for over a century (Carrasco-Jaima *et al*., 2017; Ahmad *et al*., 2021). However, their environmental impact, particularly the release of greenhouse gases like carbon dioxide (CO_2), has significantly contributed to global warming and climate change, threatening ecosystems and human health. This has necessitated a shift to renewable energy sources that are both sustainable and capable of meeting rising global energy demands in an environmentally responsible way.

Hydrogen, as a clean energy carrier, has recently received considerable attention due to its high energy density and potential to serve as a zero-emission fuel. Among the various methods for hydrogen production, photocatalytic water splitting has emerged as a promising technology. This process mimics natural photosynthesis by using light energy to split water into hydrogen and oxygen, thus providing a direct method to convert solar energy into a storable and transportable chemical fuel (Maeda, 2011; Colón, 2016). The fundamental mechanism involves the absorption of light by semiconductor photocatalysts that excite the electrons in the material, causing them to move from the valence band to the conduction band. This creates an electron-hole pair: the electron is free to move and participate in reduction reactions, while the hole (e.g., a positive charge left behind) drives oxidation reactions. These redox (reduction-oxidation) reactions are key to breaking down water molecules, producing hydrogen and oxygen gas (Xie *et al*., 2017; Yang *et al*., 2021).

One of the key motivations for pursuing photocatalytic water splitting is its potential to utilise solar energy, the most abundant renewable energy source. The sun emits a vast spectrum of light, with nearly 50% visible range, making it an ideal source for driving photocatalytic reactions (Momeni , 2016). Compared to traditional hydrogen production methods, such as steam methane reforming and electrolysis, photocatalysis offers several advantages. (Momeni , 2016). It is a one-step process that does not require external electricity or high temperatures, making it potentially more cost-effective and scalable (Kudo *et al*., 2002; Chang *et al*., 2020). Moreover, the use of water as a feedstock and the generation of oxygen as a by-product make it an environmentally friendly technology with no harmful emissions.

The review aims to provide a comprehensive overview of the economic importance of hydrogen utilization in Nigeria, focusing on the source materials and benefits to the country.

2.0 Sources of Hydrogen

Hydrogen is predominantly produced either by using conventional or renewable technologies; conventional technologies involve the methods of hydrocarbon reforming and pyrolysis where fossil fuels are the raw materials while renewable technologies involve the use of biomass or water as a feedstock for the production of hydrogen (Nikolaidis & Poullikkas, 2017).

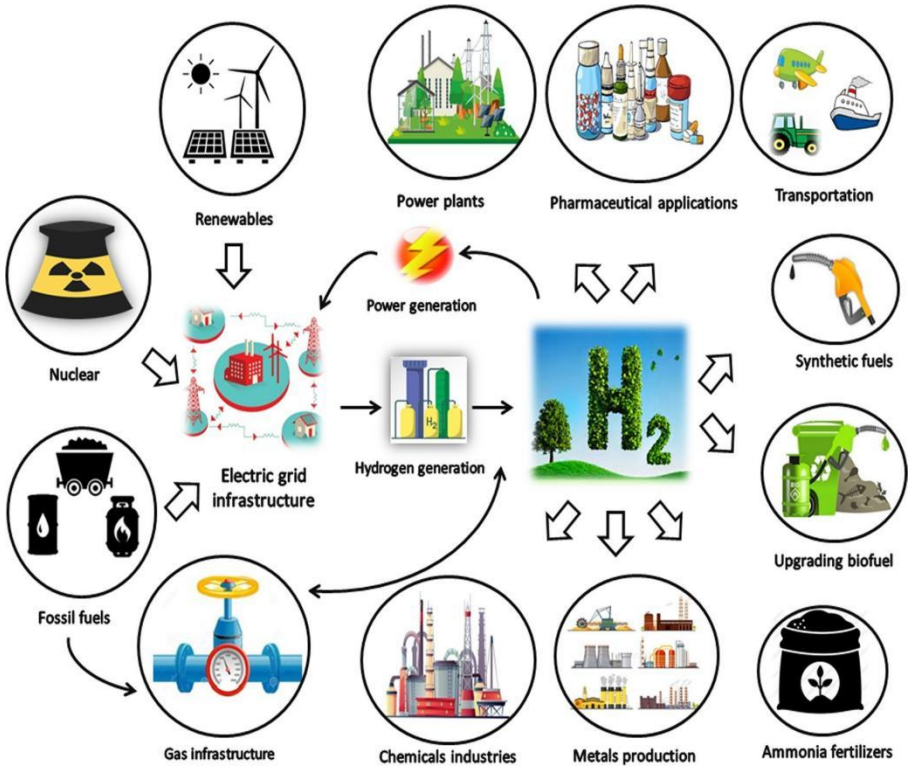


Figure 1: Sources and Routes of Hydrogen Production (Osman et al., 2022)

2.1 Using Fossil Fuels

There are a number of methods for creating hydrogen from fossil fuels, but the two primary ones are pyrolysis and hydrocarbon reforming. Nearly all of the demand for hydrogen is met by these most advanced and widely used techniques (Nikolaidis & Poullikkas, 2017). In particular, 48% of hydrogen produced to date came from natural gas, 30% from heavy oils and naphtha, and 18% from coal (Balat & Kirtay, 2010; Dincer & Acar, 2014; Kothari et al., 2008).

A number of hydrocarbon reforming techniques are used in hydrocarbon reforming to convert fossil fuels to hydrogen. The desulfurization unit, the reforming and cleanup sections, and ancillary units like pumps, compressors, expanders, heat exchangers, coolers, combustor, etc. make up a typical reforming plant that converts fossil fuels to hydrogen (Ersöz, 2008).

In the commonly used method of hydrocarbon (CHs) pyrolysis, the hydrocarbon itself serves as the sole source of hydrogen and is thermally decomposed by the subsequent general reaction (Nikolaidis & Poullikkas, 2017).

$$C_nH_m \rightarrow {}_nC + \tfrac{1}{2}\, mH_2 \qquad \text{(Marbán \& Valdés-Solís, 2007)}$$

While hydrogen is produced in a two-step process known as hydrogasification and methane cracking for heavy residual fractions (boiling point greater than 350 °C), elemental carbon and hydrogen are produced during the thermo-catalytic breakdown of light liquid hydrocarbons (boiling point between 50 and 200 °C) (Muradov, 1993).

2.2 Using Renewable Sources

Energy crops and crop residues, wood from forests and forest residues, grass, industrial residues, animal and municipal trash, and a variety of other materials are all sources of

biomass, a sustainable and renewable energy source (Demirbaş, 2001). Plants are a good source of biomass as they store light energy from the sun in chemical bonds through the photosynthetic process (McKendry, 2002). Plants and other forms of biomass can be made to produce hydrogen either through thermochemical or biological methods.

Biological processes are less energy-intensive and more environmentally benign because they function in moderate environments. However, they have been reported to produce modest rates and yields (mol H2/mol feedstock) of hydrogen, although this depends on the biomass materials utilized (Balat, 2010). On the contrary, thermochemical methods are significantly quicker and provide a larger stoichiometric yield of hydrogen, with gasification emerging as a viable choice due to environmental and financial factors (Demirbaş, 2001; Parthasarathy & Narayanan, 2014).

Aside biomass, water is another abundant material for the production of hydrogen through water-splitting processes like thermolysis, electrolysis, and photo-electrolysis (Steinfeld, 2014; Zhang et al., 2014).

3.0 Hydrogen as an alternative to fossil fuels

For an entirely sustainable energy transition, green hydrogen—which is produced from renewable resources—is the best option (Farias et al., 2022). Electrolysis is the most applied technique to obtain green hydrogen from the splitting of water and this technique enables the sector to take use of synergies, which lowers the cost of applied technol ogy and gives the power system flexibility. Green H_2 generated by electrolyzing water has therefore drawn more interest (Farias et al., 2022).

Hydrogen has nearly zero carbon emissions and can be obtained from renewable sources like biomass or water via photolysis and thus is believed to be a better option to fossil fuels (Farias et al., 2022). Plans for the use of hydrogen have been developed in about eight countries (Farias et al., 2022). However, the methods of hydrogen production heavily rely on the uses and particularities of each country (Lozano & Stromberg, 2022).

Global investments in renewable energy surpassed those in coal and natural gas in 2014, totaling about USD $286 billion. With an investment of almost 73%, Brazil was one of the developing nations that invested the most in processes utilizing renewable energy source (Farias et al., 2022). As a result, the fossil fuels that formerly dominated the means of production started to account for only 22% of the generation of electric energy, causing a shift in the Brazilian energy matrix (Vieira et al., 2021). Hydrogen started to be considered as a fuel that may take the place of petroleum-based products in the automotive sector as the use of renewable energy sources increased (Farias et al., 2022). Additionally, hydrogen could be used to generate secondary energy in solar, wind, and hydroelectric facilities, as well as to substitute coal as a fuel for thermoelectrical plants' turbines (Diniz Oliveira et al., 2021).

Green hydrogen can replace hydrocarbons as fuel for vehicles, thermal energy generation, and as an environmentally friendly raw material for industrial usage because it is a long-term renewable energy source that can be stored. Despite this, given the agreed-upon climatic and energetic targets, the most popular ways to obtain it are not those that are most prevalent in the long run. Nowadays, providing H_2 to about 90% of user industries is one of the major economic activities worldwide. Its significance is illustrated by the fact that in 2018, its supply surpassed 74 million tons, which translates to a more than 300% increase in demand compared to 1975 (Farias et al., 2022).

4.0 Economic Importance of Hydrogen Utilization

Nigeria's economy has long been dominated by the oil and gas sector, which accounts for approximately 90% of the country's export earnings. However, the volatility of global oil prices, coupled with the need to reduce greenhouse gas emissions, has necessitated a diversification of the country's energy mix. Hydrogen, a clean energy carrier, offers a promising solution.

4.1 Healthy Climate

From an environmental perspective, the current energy infrastructure (fossil fuel-based energy system) has a number of issues, including air pollution, global warming brought on by the burning of fossil fuels, acid rain, depleting and exhaustible energy sources, and greenhouse gas emissions. The global temperature may rise by 1.4 to 5.8 °C between 1990 and 2100 as a result of global warming. This will definitely result to sea level rise, severe weather, flooding, and heat waves. We must move to new technology that is free of carbon and falls under the category of environmentally friendly growth because of the severe issues with conventional fuels (Sharma et al., 2021).

To ameliorate these adverse effects of fossil fuels on the environment, green fuels have to be adopted as an alternative measure to curb the effects. Hydrogen has nearly zero carbon emissions and can be obtained from renewable sources like biomass or water via photolysis and thus is believed to be a better option to fossil fuels (Farias et al., 2022). Plans for the use of hydrogen have been developed in about eight countries (Farias et al., 2022). However, the methods of hydrogen production heavily rely on the uses and particularities of each country (Lozano & Stromberg, 2022).

Green hydrogen can replace hydrocarbons as fuel for vehicles, thermal energy generation, and as an environmentally friendly raw material for industrial usage because it is a long-term renewable energy source that can be stored (Farias et al., 2022).

Nigeria should join a host of other countries that are already keying into the green hydrogen energy policies to avert the disastrous effects of fossil fuel usages which are already apparent in the country.

4.2 Solution to Economic Effects of Fossil Fuels

The demand for fossil fuels has had a large impact on the economic growth of Nigeria as a country, the standard of living of its people, and its development. The total amount of growth of the country’s national product depends upon the mean amount of energy expended per capita. Aside, the economic growth of the world generally depends on the energy consumption and availability of fossil fuels (Solomon & Banerjee, 2006).

The production and utilization of hydrogen in Nigeria will likely improves the economic standard of the country, its development and standard of the citizens.

4.3 Employment Opportunities

One of the greatest challenges of the Sub - Saharan African economies today is the high rate of unemployment that has maintained a rising trend over the years. The problem of unemployment has been of great concern to the economists and policy makers in Nigeria since early 1980s. The effect of financial crisis on public and private sectors has led to renew attention on the phenomenon. It is a widely accepted view in economics that the growth rate of the Gross Domestic Product (GDP) of an economy increases employment and reduces

unemployment. The three most significant elements for the economy overall are productivity, income distribution and unemployment (Funlayo Akeju & Benedict Olanipekun, 2015)

Most energy-based countries in Nigeria are focused on fossil fuels. Hydrogen production, transportation, and utilization could create new job opportunities in the energy sector, contributing to Nigeria's economic growth.

4.4 Increased Investment

The development of hydrogen infrastructure, such as production facilities, transportation networks, and storage facilities, will require significant investment. Such developments will attract investment from domestic and international investors, taking Nigeria to an enviable height. Existing industries, such as oil and gas, can be retrofitted to produce hydrogen, attracting investment for upgrades and modifications.

The growth of a hydrogen industry will lead to the development of a local supply chain, creating opportunities for investment in industries such as manufacturing, logistics, and services. Investment in research and development will be necessary to improve the efficiency and cost-effectiveness of hydrogen production, transportation, and utilization. In addition, the growth of a hydrogen industry will require a skilled workforce, creating opportunities for investment in education and training programs.

Nigeria can attract Foreign Direct Investment (FDI) by partnering with international companies that have expertise in hydrogen production, transportation, and utilization. The development of export-oriented industries, such as green hydrogen production, can attract FDI from companies looking to tap into the global hydrogen market.

4.5 Increased Energy Security

Energy security and sustainable development have remained critical components of Nigeria’s myriad of burning national issues. In fact, one of the major problems of Nigeria today is energy insecurity. Every developed economy is built with the realization that a sustained availability of affordable energy in its various forms is fundamental to the provision of jobs, food, health services, education, housing, clean water and good sanitation (Okeke et al., 2014).

According to Oyedepo (2012), energy plays the most vital role in the economic growth, progress, and development, as well as poverty eradication and security of any nation. Uninterrupted energy supply is a vital issue for all countries today. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly (Okeke et al., 2014).

The utilization of hydrogen in Nigeria will help improve energy security in addition to a host of other significant benefits. Hydrogen can be used as a clean energy carrier, reducing Nigeria's reliance on fossil fuels and mitigating the impact of price volatility. Hydrogen production from renewable energy sources, such as solar or wind power, can increase the share of renewable energy in Nigeria's energy mix.

Nigeria can produce hydrogen domestically, reducing reliance on imported fuels and enhancing energy self-sufficiency. Hydrogen can be used as a substitute for imported fuels, such as diesel or petrol, reducing the country's fuel import bill.

5.0 Conclusion

Hydrogen is predominantly produced either by using conventional or renewable technologies from fossil fuels or renewable materials, respectively. The utilization of hydrogen in Nigeria will reduce the country's over reliance on fossil fuels and increase the standard of living of Nigerians by promoting healthy climate, providing job opportunities, increasing investment, and promoting energy security.

References

Chakravorty, A. & Roy, S., 2024. A Review of-Photocatalysis, basic principles, processes, and materials.. Volume 100155.

Moniz, S. J. A. *et al*., 2015. *Visible-light driven heterojunction photocatalysts for water splitting-a critical revie.* S.J.a. Moniz, S.a. Shevlin, D.J. Martin, Z.-X. Guo, J. Tang, w: Energy Environ. Sci.

Jang, J. S., Kim , H. G. & Lee, J. S., 2012. *Heterojunction semiconductors: a strategy to develop efficient photocatalytic materials for visible light water splitting.* s.l.:Catal. Today.

Gao, C. *et al*., 2015. *Synergistic effects in three-dimensional SnO2/TiO2/CdS multi-heterojunction structure for highly efficient photoelectrochemical hydrogen production.* s.l.:Sol. Energy Mater. Sol. Cells..

Chang, C. J. *et al*., 2020. *Improved H2 production of ZnO@ ZnS nanorod-decorated Ni foam immobilized photocatalysts.* s.l.:Int J Hydrogen Energy.

Kudo, A., Tsuji, I. & Kato, H., 2002. *AgInZn7S9 solid solution photocatalyst for H 2 evolution from aqueous solutions under visible light irradiation.* s.l.:Chem Commun.

Momeni , M. M., 2016. One-step synthesis of ZnO nanowires on Zinc foils and their photocatalytic properties. Volume 55, p. 686–91.

Yang, K. *et al*., 2021. Recent advances in CdS-based photocatalysts for CO2 photocatalytic conversion. Volume 418, p. 129344.

James, G., 2018. *Introduction to Nigeria*. Gilad James Mystery School.

Carrasco-Jaima, O. A. *et al*., 2017. *Synthesis and characterization of PbS/ZnO thin film for photocatalytic hydrogen production.* s.l.:Journal of Photochemistry and Photobiology A: Chemistry.

Ahmad , I. *et al*., 2021. *Boosted hydrogen evolution activity from Sr doped ZnO/CNTs nanocomposite as visible light driven photocatalyst.* s.l.:International journal o f hydrogen energy .

Maeda, K. & Domen, K., 2010. Photocatalytic water splitting: Recent progress and future challenges. 22(45), p. 453201.

Colón, G., 2016. *Towards the hydrogen production by photocatalysis.* s.l.:Appl. Catal. A Gen..

Xie, M. Y. *et al*., 2017. Hydrogen production by photocatalytic water-splitting on Pt-doped TiO2–ZnO under visible light.. Volume 70, pp. 161-167

Balat, H. (2010). *Hydrogen from biomass – Present scenario and future prospects*. *35*(14), 1–7.

Balat, H., & Kirtay, E. (2010). Hydrogen from biomass - Present scenario and future prospects. *International Journal of Hydrogen Energy*, *35*(14), 7416–7426. https://doi.org/10.1016/j.ijhydene.2010.04.137

Demirbaş, A. (2001). Biomass resource facilities and biomass conversion processing for fuels and chemicals. *Energy Conversion and Management*, *42*(11), 1357–1378.

https://doi.org/10.1016/S0196-8904(00)00137-0

Dincer, I., & Acar, C. (2014). Review and evaluation of hydrogen production methods for better sustainability. *International Journal of Hydrogen Energy*, *40*(34), 11094–11111. https://doi.org/10.1016/j.ijhydene.2014.12.035

Diniz Oliveira, T., Costa Gurgel, A., & Tonry, S. (2021). Potential trading partners of a brazilian emissions trading scheme: The effects of linking with a developed region (Europe) and two developing regions (Latin America and China). *Technological Forecasting and Social Change*, *171*(October), 1–51. https://doi.org/10.1016/j.techfore.2021.120947

Ersöz, A. (2008). Investigation of hydrocarbon reforming processes for micro-cogeneration systems. *International Journal of Hydrogen Energy*, *33*(23), 7084–7094. https://doi.org/10.1016/j.ijhydene.2008.07.062

Farias, C. B. B., Barreiros, R. C. S., da Silva, M. F., Casazza, A. A., Converti, A., & Sarubbo, L. A. (2022). Use of Hydrogen as Fuel: A Trend of the 21st Century. *Energies*, *15*(1), 1–20. https://doi.org/10.3390/en15010311

Funlayo Akeju, K., & Benedict Olanipekun, D. (2015). Unemployment and Economic Growth in Nigeria. *International Journal of African and Asian Studies*, *11*(4), 92–99. www.iiste.org

Kothari, R., Buddhi, D., & Sawhney, R. L. (2008). Comparison of environmental and economic aspects of various hydrogen production methods. *Renewable and Sustainable Energy Reviews*, *12*(2), 553–563. https://doi.org/10.1016/j.rser.2006.07.012

Lozano, A. M., & Stromberg, D. (2022). *Technological Assessment of Hydrogen (Future scenarios: sociological, environmental, economic, and energetic aspects)*.

Marbán, G., & Valdés-Solís, T. (2007). Towards the hydrogen economy? *International Journal of Hydrogen Energy*, *32*(12), 1625–1637. https://doi.org/10.1016/j.ijhydene.2006.12.017

McKendry, P. (2002). Energy production from biomass (part 1): overview of biomass. *Bioresource Technology*, *83*(83), 37–64.

Muradov, N. Z. (1993). How to produce hydrogen from fossil fuels without CO2 emission. *International Journal of Hydrogen Energy*, *18*(3), 211–215. https://doi.org/10.1016/0360-3199(93)90021-2

Nikolaidis, P., & Poullikkas, A. (2017). A comparative overview of hydrogen production processes. *Renewable and Sustainable Energy Reviews*, *67*, 597–611. https://doi.org/10.1016/j.rser.2016.09.044

Okeke, R. C., Izueke, E. M. C., & Nzekwe, F. I. (2014). Energy Security and Sustainable Development in Nigeria. *Oman Chapter of Arabian Journal of Business and Management Review*, *4*(3), 63–72. https://doi.org/10.12816/0019052

Osman, A. I., Mehta, N., Elgarahy, A. M., Hefny, M., Al-Hinai, A., Al-Muhtaseb, A. A. H., & Rooney, D. W. (2022). Hydrogen production, storage, utilisation and environmental impacts: a review. Environmental Chemistry Letters, 1-36.

Parthasarathy, P., & Narayanan, K. S. (2014). Hydrogen production from steam

gasification of biomass: Influence of process parameters on hydrogen yield - A review. *Renewable Energy*, *66*(June), 570–579. https://doi.org/10.1016/j.renene.2013.12.025

Sharma, S., Agarwal, S., & Jain, A. (2021). Significance of hydrogen as economic and environmentally friendly fuel. *Energies*, *14*(21). https://doi.org/10.3390/en14217389

Solomon, B. D., & Banerjee, A. (2006). A global survey of hydrogen energy research, development and policy. *Energy Policy*, *34*(7), 781–792. https://doi.org/10.1016/j.enpol.2004.08.007

Steinfeld, A. (2014). Solar thermochemical production of hydrogen. *Handbook of Hydrogen Energy*, *78*(5), 421–444. https://doi.org/10.1201/b17226

Vieira, B., Nadaleti, W. C., & Sarto, E. (2021). The effect of the addition of castor oil to residual soybean oil to obtain biodiesel in Brazil: Energy matrix diversification. *Renewable Energy*, *165*(March), 657–667. https://doi.org/10.1016/j.renene.2020.10.056

Zhang, Y., Ying, Z., Zhou, J., Liu, J., Wang, Z., & Cen, K. (2014). Electrolysis of the Bunsen reaction and properties of the membrane in the sulfur-iodine thermochemical cycle. *Industrial and Engineering Chemistry Research*, *53*(35), 13581–13588. https://doi.org/10.1021/ie502275s