

PAPER 118 – HYDROGEN ECONOMY: PANACEA TO AIR POLLUTION PROBLEMS AND PROSPECTS FOR A CLEANER PLANET EARTH

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ABSTRACT

One of the biggest issues facing planet Earth is environmental degradation brought on by human activities. Studies have shown that 89% of the pollution that exists on Earth today is due to the use of fossil fuels. To green the world and provide clean, sustainable energy, engineers and scientists have been looking for a pollution-free, readily available fuel choice for the transportation and industrial sectors. The hydrogen gas economy has been chosen as the greatest solution. This hydrogen economy has the potential to displace the need for fossil fuels. This review study discourses the possibility of using hydrogen gas as an energy source to create a cleaner planet through decarbonization. The role of hydrogen as the foundation for greener and cleaner energy in the industrial and transport sectors, utilizations on its zero emissions, increasing electrification through fuel cell technology, and profits of hydrogen economy on the environment were substantially discussed. With a hydrogen economy, planet earth will reach its natural state of equilibrium.

KEYWORDS: Climate Change: Cleaner Earth: Clean Energy: Clean Environment: Pollution Free

1. INTRODUCTION

Globally, air pollution has detrimental consequences on the environment, human health, other living things, and materials. In particular in industrialized and emerging nations, it is a serious and widespread public health issue. Industrial and transportation emissions are significant sources of poor urban air quality in both industrialized and developing nations. (Balat, 2008). Despite the implementation of sound and strategic environmental policies, ongoing air monitoring, and evaluation, the issue of air pollution remains a critical problem that has yet to be fully addressed on both regional and global scale. This is because strict adherence to environmental laws and regulations has failed in light of the current state of global climate change, unpredictable weather patterns, ongoing environmental degradations, and imbalances in equilibrium. Additionally, the diversity in air pollution patterns highlights the need for workable solutions that aim to significantly reduce air pollution (De Nicola, 2016).

According to the World Health Organization (2020), air pollution is the leading environmental health concern in the world and is directly linked to seven million annual fatalities, mostly from cancer and cardiopulmonary/kidney illness (Silva, R. A., et al., 2013). Air pollution has been related to cognitive health impairments such as accelerated cognitive aging and decreased memory and intellect, in addition to its well-known impact on disease burden (Clifford, A., Lang, L., Chen, R., Anstey, & K. J. & Seaton, 2016). Additionally, a recent body of economics study has shown how these negative health effects manifest themselves in economic outcomes (Zivin, J. G. & Neidell, 2018). He, J., (2019) discovers evidence of diminished output at two industrial facilities in China as a result of elevated air pollution. A refinery's closure in Mexico City is also used by Hanna, R., and Oliva, P. (2015) to demonstrate how air pollution decreased as a result. Fossil fuel consumption results in the release of various poisonous gases, dangerous hydrocarbons, and airborne particles during industrial processes, transportation, electricity generation, and other activities. As a result of human activity, this pollution has expanded globally and continues to exist. These pollutions can be sporadic or seasonal, and they are typically restricted to particular locations within communities that are influenced by geological and geographical variables. It is a specific type of pollution that is of interest and concern since its constituent parts and amounts have become exceedingly diverse and substantial, creating a noticeable imbalance in the typical composition of the air. The most prevalent air pollutants include sulfur oxides, nitrogen, greenhouse gases, particulate matter (such as dust and smoke), and various chemical compounds (hydrocarbons). These pollutants are primarily produced by the combustion of fossil fuels (coal, oil, and natural gas), as well as biomass, such as bush or forest or wood burning, and agricultural residues.

2. IMPACTS OF THE HYDROGEN ECONOMY ON REGIONAL AIR POLLUTION, ALTERNATIVE ENERGY, AND CLIMATE CHANGE

Numerous studies and evaluations of industrial and transportation-related emissions from the environment center on three main problems: air pollution, energy security, and climate change.

2.1. Climate Change

Since publishing its first report in 1989, the Intergovernmental Panel on Climate Change (IPCC) of the United Nations has propagated the theory that climate change is causing persistent global warming because greenhouse gases (GHG), particularly anthropogenic carbon dioxide and ozone in the atmosphere, are preventing heat from radiating into space. (IPCC, 2014)

The Arctic is one of the regions on the planet that is most vulnerable to climate change. The Arctic Climate Assessment report of 2004, which was conducted by leading scientists from countries that border the Arctic Circle, warned that the warming over Greenland could result in the complete melting of the Greenland Ice Sheet, leading to a sea level rise of about seven meters (23 feet) (IASC & Committee, 2004). More recent studies suggest that this process may occur faster than anticipated. According to a study by the Arctic Monitoring and Assessment Programme, the Arctic has been warming at a rate of nearly twice the global average in the last decade (AMAP, 2021). This warming trend has already had significant impacts on the region, including melting permafrost, changing sea ice patterns, and altering ocean currents.

One of the primary drivers of climate change is the increasing concentration of greenhouse gases in the atmosphere, particularly carbon dioxide. These gases trap heat and prevent it from escaping into space, leading to a warming planet. Carbon dioxide concentrations have been increasing at an accelerating rate in recent years and are now at their highest levels in more than three million years. In 2017, atmospheric concentrations of carbon dioxide surpassed 400 parts per million (ppm), a level that is considered dangerous for the long-term stability of the planet's climate (NASA, 2018). The continued burning of fossil fuels for energy, along with deforestation and other human activities, is responsible for the majority of these emissions.

It is now widely accepted that human-made gases are the predominant cause of observed global warming. According to the Intergovernmental Panel on Climate Change (IPCC), the major climatic changes already taking place may be "irreversible" for centuries to come if strong and sustained reductions in carbon dioxide and other greenhouse gas emissions are not achieved (IPCC, 2021). The IPCC has recommended a range of mitigation and adaptation measures to address the impacts of climate change, including reducing emissions, transitioning to renewable energy sources, and investing in infrastructure and technology to adapt to changing conditions.

One promising solution for reducing carbon emissions is the transition to a hydrogen economy and fuel cell technology. Hydrogen is a clean-burning fuel that can be produced from renewable sources, such as wind or solar power. When used in fuel cells, hydrogen produces electricity with only water and heat as byproducts. According to the Hydrogen Council, if governments and industry work together to scale up the production and use of hydrogen, it could account for up to 18% of the world's total energy demand by 2050 and reduce global CO₂ emissions by up to six gigatons per year (Hydrogen Council, 2021). This transition would not only reduce carbon emissions but also create new job opportunities and stimulate economic growth.

In summary, the urgency of addressing climate change has become increasingly clear in recent years. The consequences of inaction are severe and potentially irreversible, particularly in vulnerable regions like the Arctic. It is critical to take bold and immediate steps to reduce carbon emissions and transition to cleaner, more sustainable energy sources. The transition to a hydrogen economy and fuel cell technology is one promising solution that could help address this urgent problem. Apart from major effects on CO₂ emissions, non-CO₂ emissions spread into the environment will also be drastically reduced on adoption of hydrogen gas technology (hydrogen economy) in the transportation sector (cars, light-duty vehicles, heavy trucks). The forecasts for the emission levels of CO, NO_x, volatile organic compounds (VOCs), and particulate matter will be dramatically decreased by more than 70% for NO_x and other pollutants (Muhibbu-din, I.,2020).This will undoubtedly help and enhance the planet Earth's air quality, recover, and revitalize good air quality life on the planet. [Osama et al, 2020].Worldwide economic transition to hydrogen economy is anticipated.

2.2. Alternative Energy

The world continues to face an energy crisis due to the depletion of fossil fuel resources and the increasing problem of environmental pollutions (Ullah et al., 2019; Mannan et al., 2018). In addition to the decreasing supplies of crude oil and political instability in regions with significant oil reserves, the demand for alternative fuels is driven by increasingly stringent pollution regulations (Mannan et al., 2018). Many alternative fuels have been proposed, including biodiesel, methanol, ethanol, hydrogen, boron, natural gas, liquefied petroleum gas (LPG), and Fischer-Tropsch fuel, p-series. Among these, hydrogen gas energy is the most abundant and prevalent element in the universe (Wang et al., 2020). It also has the highest specific energy content of all conventional fuels. Among others, hydrogen economy is technically possible, economically viable, environmentally acceptable, and widely accessible as an alternative fuel (Muhibbu-Din et al., 2022) (Meher LC, Sagar DV, & Naik SN,2006).The potential of hydrogen gas as an energy carrier gained significant attention following the global energy crisis of 1974 (Meher et al., 2006, Muhibbu-Din et al,2021). Although hydrogen is not readily available in a usable form, it possesses exceptional properties that make it a promising energy carrier (Mazloomi & Gomes, 2019). These qualities include being lightweight, abundant, and ecologically friendly. Hydrogen gas energy is not an inherent primary energy found in nature. An additional energy source must be available before hydrogen can be produced, just like

electricity. Hydrogen burns cleanly and produces just water and a negligible quantity of nitrogen oxides as waste products. Because of its quick burning speed, high effective octane rating, lack of toxicity and inability to generate ozone, hydrogen is an extremely unique fuel for use in transportation and industrial sectors (Muhibbu-din et al., 2020).

Compared to methane and gasoline, it has substantially greater air flammability boundaries. A combination of clean coal, fossil fuels (with carbon sequestration), nuclear energy, and large-scale renewables can be used to make hydrogen, which could eventually overtake other fuels as the primary source for transportation and industry. On a longer time period, large-scale hydrogen generation will likely occur. The alternatives for producing hydrogen in the short and medium term are first focused on distributed hydrogen generation from electrolysis of water with sunshine (Muhibbu-din et al., 2021) and natural gas reformation. A total of 40 million tons of hydrogen may be produced annually using each of the centralized or decentralized hydrogen production technologies. Because it may be produced indefinitely in the future using renewable energy sources, hydrogen will play a significant role in the development of sustainable, clean energy (Muhibbu-din et al., 2021)

The world stands to gain from a hydrogen economy in a number of ways, including energy security with no or less reliance on oil imports, sustainability by utilizing clean, renewable energy sources, improved urban air quality due to emissions of almost no carbon, hydrocarbon, heavy metals, greenhouse gases, NO_x, and other pollutants at the point of use, and economic viability by potentially influencing the future.

When generated from clean sources, which are now being prioritized as governmental goals, hydrogen will offers a variety of advantages as a clean energy carrier. The development of a sizable market for hydrogen as an energy source offers practical answers for both the security of the energy supply and the reduction of emissions. Because hydrogen emits no pollutants when it is used up, it prevents emissions caused by the transportation and industrial sectors. In contrast to other alternative fuels, hydrogen as a secondary energy carrier that can be produced from any (locally available) primary energy source, which can help diversify the sources and supplies of automotive fuel while also providing the long-term possibility of being entirely produced from renewable energies. Through the utilization of fuel cells, hydrogen might also be utilized as a medium for storing electricity. Various techniques are being used to mass-produce hydrogen. Due to its abundance, hydrogen can be created using a variety of techniques, some of which are clean and green, or extracted from a wide range of substances and molecules. Various feed stocks, including fossil and renewable resources, can be used to make it. Hydrogen can be produced using a variety of process technologies, including chemical, biological, electrolytic, photolytic, and thermochemical. According to Muhibbu-din et al. (2020), common ways for producing hydrogen include steam methane reforming, gasification of coal and other hydrocarbons, electrolysis of water, hydrogen from biomass, and hydrogen from nuclear energy.

2.3. Regional Air Pollution

The adoption of hydrogen fuel vehicles might dramatically reduce regional or local air pollutants, which are the source of noise, ozone, and acid rain as well as particle matter (Balat, 2008). As opposed to fossil fuels, emissions of NO_x, SO₂, and particulates can be decreased by 70-80%. This is a significant advantage of hydrogen, particularly in heavily populated places. The need for enhancing urban air quality is expanding and becoming more important as there are more megacities around the world.

Various world energy scenarios have a wide range of expectations for the future contribution of hydrogen to the global energy system. In the future energy scenarios, hydrogen gas energy will play a significant role as an energy transporter. With stringent climate regulations, fluctuating oil and gas prices, and technology advancements in hydrogen vehicles, fuel cells, and carbon capture and storage, hydrogen gas energy will become a feasible choice. Recent studies suggest that hydrogen vehicles are expected to be adopted by 70% of the world's population by 2050, leading to a significant global demand for the fuel under favorable conditions (Li et al., 2018; Wang et al., 2020)) and a large increase in renewable energy sources, especially solar energy that will be used to produce hydrogen, will also occur. (Muhibbu-din et al. 2022).

3. CONCLUSIONS

In conclusion, the hydrogen economy offers the chance to solve all of the major energy policy objectives in the industrial and transportation sectors and has significant potential to mitigate the consequences of climate change and address the problem of air pollution. Additionally, the hydrogen economy produces electricity using hydrogen fuel cells to create power. However, utilizing hydrogen as a fuel will be the most straightforward method to accomplish carbon capture and storage without upsetting the balance of the earth's CO₂ consumption. The hydrogen economy holds the key to resolving the air pollution problem, aiding in the global clean-up, and reconciling planet earth with nature.

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