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Innovations in Green Hydrogen Production for a Sustainable Future by Oman Vision 2040

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Abstract

The global transition towards sustainable energy has elevated green hydrogen as a promising alternative to fossil fuels, with the potential to decarbonize critical sectors such as transportation, heavy industry, and energy storage. Green hydrogen, produced via electrolysis powered by renewable sources like solar and wind, emits no carbon, aligning with global climate goals. Oman, endowed with abundant solar and wind resources-particularly in regions like Thumrait, Marmul, and Dhofar-holds strategic potential for large-scale green hydrogen production. Although Oman Vision 2040 does not explicitly mention hydrogen, it emphasizes renewable energy and sustainability, making green hydrogen a compatible and transformative solution within the national agenda.

This paper explores the role of green hydrogen in supporting Oman's energy transition and its alignment with Vision 2040. It assesses technological options such as Proton Exchange Membrane (PEM) and Alkaline Electrolysis (AEL), both of which are central to Oman's hydrogen roadmap. While PEM is efficient and suitable for intermittent renewables, AEL offers cost-effectiveness and scalability. The study also examines the economic prospects of green hydrogen as a pathway for economic diversification, job creation, and global energy leadership. Environmentally, hydrogen use can significantly reduce emissions, though reliance on desalinated water remains a concern. The exploration of treated wastewater as an alternative feedstock is under review to ensure sustainability.

Socially, green hydrogen promises substantial co-benefits-enhancing rural energy access, fostering innovation, and developing human capital. With growing international demand, especially from Europe and Asia, Oman is well-positioned to become a clean hydrogen exporter. Through comprehensive analysis, this research highlights the technological feasibility, economic viability, and socio-environmental value of green hydrogen, advocating for its integration into Oman's sustainable development framework. The study provides policy recommendations to optimize hydrogen production and promote Oman as a global hub in the emerging hydrogen economy.

Keywords
Green hydrogen, Renewable energy, Oman Vision 2040, Electrolysis technologies, Energy transition

1. Introduction
The global shift towards green energy highlights green hydrogen as a viable alternative to fossil fuels. Produced through water electrolysis using renewable energy like solar or wind, green hydrogen emits no carbon, aiding decarbonization across sectors such as transport, industry, and energy storage (IRENA, 2020). Declining renewable electricity costs have further enhanced its economic feasibility and applications (IRENA, 2020). Oman Vision 2040 prioritizes economic diversification and sustainability by reducing reliance on oil and investing in renewable energy

(Oman Vision 2040 Document, 2024). Although hydrogen is not explicitly mentioned in the Vision, renewable energy is identified as a key driver for economic and environmental transformation.

Oman's abundant solar and wind resources, particularly in regions like Thumrait and Marmul, position it as a hub for large-scale green hydrogen production. Studies indicate the potential for solar energy to generate hydrogen at competitive costs, such as \$6.31 per kilogram (Figure 1) in high-intensity areas like Thumrait (Ahshan, 2021)

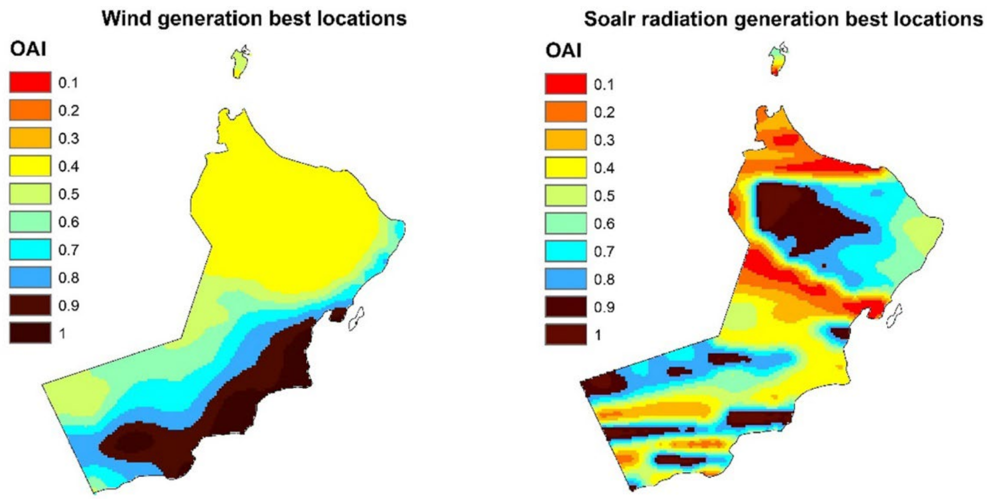

Figure 1. Distribution of priority locations for wind and solar energy generation in Oman. Source (Hereher & El Kenawy, 2020)

The chart illustrates the distribution of priority locations for wind and solar energy generation in Oman based on the Overall Assessment Indicator (OAI). The left panel shows wind energy suitability, and the right panel highlights solar radiation potential. The OAI scale (0.0 to 1.0) ranges from least suitable (red) to most suitable (dark brown). This visualization underscores Oman's strategic advantage in leveraging renewable resources for green hydrogen production, positioning the country to meet domestic energy needs and capitalize on growing demand in Europe and Asia for clean hydrogen.

The following research objectives inform this study:

1. To review the current state of green hydrogen technologies and their applications in Oman.
2. To assess the economic, environmental, and societal impacts of green hydrogen adoption in Oman.
3. To evaluate the alignment of green hydrogen initiatives with the goals of Oman Vision 2040.
4. To identify the challenges and opportunities for scaling green hydrogen production in Oman.

These objectives, therefore, underpin a comprehensive evaluation of green hydrogen, the aim of which involves ascertaining its potential contribution towards Oman's transformation to a sustainable energy nation by analyzing policy and investment options that are in sync with the said objectives.

2. Literature Review

Production of hydrogen is crucial in energy conversion, and noteworthy developments in Oman involve proton-exchange membranes (PEM) and alkaline electrolysers (AEL). PEM electrolysers regulate intermittent renewable energy, such as solar, while AEL systems are economically viable for large-scale production because of their alkaline stability (Yang et al., 2024; Ahmed, 2022). Platinum deposition methods improve the production of hydrogen and economic efficiency, particularly in areas of high solar irradiance such as Oman (Mastronardi et al., 2024). Oman aims for 70 GW of renewable energy by 2040 for 3.5 million tons of green hydrogen per year (Marzouk, 2024). Integrate renewable systems with floating photovoltaic configurations, PEM electrolysers, and fuel cell backup to effectively produce hydrogen and offset renewable energy volatility (Al Saadi & Ghosh, 2024). Emerging hydrogen production techniques such as the 18S model aim at resource utilization, cost management, and scalability through hydro, geothermal, and solar power (Dincer & Acar, 2017).

Photonic systems and heat recoveries are cost-effective, low-emission means of achieving Oman's sustainability objectives. Analysis indicates thermochemical cycles and photonic production of hydrogen as being less efficient but contribute towards a decrease in greenhouse gas emissions to support Oman's transition towards cleaner energy (Ahmed et al., 2022). Life cycle analyses point to the significance of green hydrogen in water electrolysis and renewable decarbonization (Nnabuife et al., 2022). Floating photovoltaic (FPV) arrays combined with electrolysers provide hybrid systems that enable scalable production of hydrogen in sun-rich areas like Oman, enhancing the sustainability of green hydrogen (Al Saadi & Ghosh, 2024).

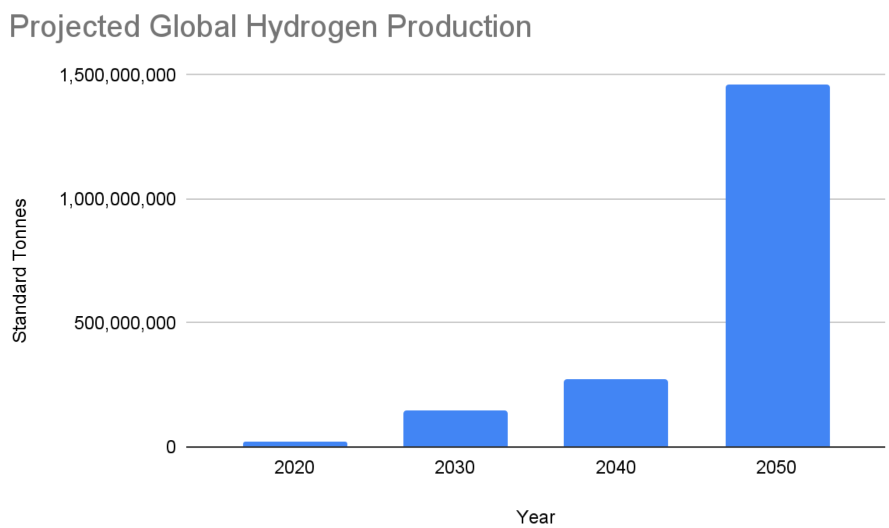

Figure 2. Projected global hydrogen production.

The advancement in hydrogen production technology provides an excellent opportunity for global hydrogen production. The global hydrogen production was estimated to be 20852594 standard tonnes in 2020. This Figure 2 is projected to increase to 144850374, 270276598, and 1462736371 standard tonnes by 2020, 2020, and 2050, respectively.

In summary, the growth in PEM and AEL electrolysers and the hybrid FPV systems shows a progressive shift in producing hydrogen using renewable energy sources. These advancements are vital for Oman's renewable energy plan, under its vision for 2040, to warrant that hydrogen will be both a domestic energy source and an export product.

Green hydrogen's economic feasibility in Oman faces challenges due to the high costs of electrolysers and renewable electricity. However, production costs in regions like Thumrait and Marmul are competitive at approximately USD 6.31 per kilogram (Ahshan, 2021). Integrating wastewater treatment into hydrogen production, such as at the Al Ansab plant, could generate significant economic gains, with potential annual revenues of 49.73 million OMR. This circular economy model combines water reuse with green energy policies to enhance sustainability and resource efficiency (Barghash et al., 2022). Expanding renewable capacities, particularly in Duqm and Al Wusta, also supports hydrogen synthesis systems for producing 1 million metric tons of green ammonia annually, reinforcing Oman's efforts to diversify its energy mix and reduce carbon emissions (Al-Badi et al., 2022).

Floating photovoltaic (FPV) systems in Oman harness high solar irradiation for decentralized hydrogen production, enabling a 22MW PEM electrolyzer to generate more than 800,000 kg of hydrogen annually with minimal fossil fuel consumption (Al Saadi & Ghosh, 2024). Although efficient, PEM electrolysers are surpassed by alkaline electrolysers in terms of cost and environmental footprint, thus the latter is more suitable for large-scale production. Platinum-based electrochemical deposition improves efficiency and lowers the cost, making it easier for Oman to upgrade sustainable hydrogen production in line with Vision 2040's economic and environmental visions (Mastronardi et al., 2024).

Oman's green hydrogen strategy facilitates decarbonization across the world, employing the Life Cycle Assessment (LCA) to minimize the environmental footprint. Recycling water used in oil activities for hydrogen production via dark fermentation and electrolysis decreases emissions and saves water, offering a sustainable option for its water-scarce environment (Barghash et al., 2024). This approach is in line with Oman Vision 2040, which prioritizes resource management to tackle water scarcity (Oman Vision 2040, 2024). The use of renewable energy from solar and wind enhances environmental advantage through decreased dependence on fossil fuels and promotion of climate change efforts (Vallejos-Romero et al., 2023).

Green hydrogen schemes offer both jobs and environmental rewards but are hampered by public views (Al Maawali & Masengu, 2023). Social acceptability will be key in the development of hydrogen schemes in the generation and provision of energy (Gordon et al., 2024). Socioeconomic and geopolitical impacts of green hydrogen, such as exploitation of labor and distorted economic opportunities, have to be addressed. Balanced employment practices form the backbone of sustainable development and integrating green hydrogen with Oman's long-term development aspirations (Akhtar et al., 2023).Using green hydrogen also fosters technological developments within Oman's domestic market. A study on the sustainable development of green hydrogen indicates that Oman may create a skilled workforce in new energy technologies, contributing to the country's economic diversification and improving its future sustainability (Vallejos-Romero et al., 2023). This corresponds with Oman Vision 2040 concerning establishing a knowledge-based economy and creating qualified employment for Omanis(Oman Vision 2040, 2020).

Indeed, transitioning to green hydrogen promotes economic and social change in Oman and preserves the environment. Focusing on resource-efficient approaches and encouraging people participation, Oman can develop the perspective of a green hydrogen industry consistent with the national and international climate goals. This dedication to integrating environmental and social concerns guarantees that green hydrogen can become an agent of change in Oman's future energy.

Hydrogen storage and transport are critical challenges for expanding hydrogen production in Oman. Integrating floating photovoltaic (FPV) systems with hybrid renewable models, such as a 22 MW PEM electrolyzer backed by fuel cells, offers efficient solutions, producing over 800,000 kg of hydrogen annually and ensuring stable storage despite solar power variability (Al Saadi & Ghosh, 2024). However, storage technologies like cryogenic systems, which enable high-density hydrogen storage, remain prohibitively expensive, with costs ranging from $465 to $620 million per vessel (Olabi & Jouhara, 2024). Compressed gas storage presents a cost-effective alternative but has lower capacity, creating trade-offs between cost and efficiency. Research into in-situ hydrogen production highlights the potential of Oman’s geological conditions to support cost-effective extraction, though risks like groundwater contamination necessitate stringent regulatory measures (Ikpeka et al., 2024). Addressing these technological and infrastructural challenges is essential to advancing Oman’s hydrogen economy.

Oman has established Hydrom to develop hydrogen supply chains and export routes, reinforcing its position as a hydrogen export hub within the Gulf Cooperation Council (GCC) and aligning with Vision 2040’s focus on leveraging renewable resources for domestic and international energy needs (Al-Khayari et al., 2024). Utilizing Omani platinum reserves in PEM electrolysers could further reduce costs and dependence on imports, enhancing Oman’s competitiveness in the global hydrogen market (Al-Khayari et al., 2024). However, water scarcity poses a significant challenge to scaling green hydrogen production, as electrolysis consumes large quantities of water. While desalinated water is currently used, it creates competition among industrial, agricultural, and municipal sectors, highlighting the need for integrated water-use strategies to support hydrogen production without exacerbating resource stress (Saberi, 2024).

Oman’s hydrogen economy benefits from abundant renewable resources but faces significant infrastructure and regulatory challenges, requiring government-private sector collaboration to address barriers and secure funding for large-scale projects (Khan & Al-Ghamdi, 2023). By leveraging local resources, such as platinum and geological structures, and developing export-oriented infrastructure through initiatives like Hydrom, Oman can strengthen its position in the global hydrogen market. However, sustainable and economically viable implementation will depend on increased capital investment and targeted policy measures.

3. Methods

This research examines the role of green hydrogen in Oman's energy transition and its compatibility with Vision 2040. It evaluates green hydrogen as a pioneering energy solution and its complementarity with Oman Vision 2040, emphasizing its technological, economic, and environmental advantages for sustainability.

This research applies qualitative research grounded on interpretivism to examine what stakeholders believe, plan, and perceive regarding the green hydrogen strategy of Oman. Qualitative research fits the understanding of how individuals perceive and react towards Vision 2040's sustainable energy ambitions in various sectors. In contrast to quantitative approaches, which work with measurable variables, qualitative research provides an interpretive view of Oman's policies, technology readiness, and socio-economic impacts, and produces richer insights into Vision 2040 goals compliance and the general policy landscape (Lim, 2024). Thematic and content analyses complement the approach by classifying materials to ascertain the compatibility of renewable energy goals with economic stability targets.

The interpretivist paradigmatic method captures the vision of Oman's policymakers and situational forces guiding the hydrogen strategy. As Vision 2040 sets ambitious transformational goals, the adaptability of the approach accommodates policy development and addresses numerous factors influencing the viability of green hydrogen. Through the integration of secondary data, the framework enables a comprehensive assessment of green hydrogen's current and future role in achieving Oman's national ambitions under Vision 2040.

This research employs a qualitative approach with Thematic analysis, Life Cycle Assessment (LCA), and SWOT analysis to examine the alignment of green hydrogen with Oman's objectives. Thematic analysis identifies the trends in renewable energy policy for sustainability, economic resilience, and technology (Finlay, 2021; Lim, 2024). Through comparison of Vision 2040 with industry and government reports, it examines how green hydrogen contributes to economic diversification and environmental sustainability. Strategic issues like export potential of hydrogen, water management, and socio-economic advantages are addressed.

LCA determines the environmental implications of the production of green hydrogen from raw material extraction to end use (Litardo et al., 2023). With the integration of academic and industry research, the research compares carbon emissions, water requirements, and resource utilization that aligns with the aspirations of Vision 2040's sustainability. SWOT analysis identifies Oman's strengths, including high solar radiation and geographical location, and weaknesses such as high infrastructure expenditure. It also explores opportunities, such as international collaboration, and threats such as water scarcity and international competition, offering recommendations to enhance Oman's hydrogen economy (Nygaard, 2024).

4. Results and Discussion

4.1 Results

Currently, Oman's great focus on solar and wind energy is the cornerstone that will enable the country to become one of the largest producers of green hydrogen. The government has long-term plans to increase hydrogen generation, which aligns with its vision of becoming a global exporter of renewable energy. Electrolysis in Oman is key to the country's green hydrogen strategy that seeks to produce one million tonnes of fuel yearly by 2030 (IEA, 2023). Two primary electrolysis technologies have been studied in Oman, namely the Proton exchange membrane (PEM) and the Alkaline electrolysers (AEL), both essential in the Oman vision of green hydrogen.

Green hydrogen generation is one of Oman's key approaches to developing a more sustainable energy mix and moving away from hydrocarbon resources. Electrolysis is the primary method of water splitting into hydrogen and oxygen using electrical energy, and the obtained energy is used to produce hydrogen. Thus, when powered by renewable energy, this process enables the production of zero-carbon hydrogen, which is central to Oman's journey to transition to net-zero emissions. The country has high solar potential, with some areas of Marmul and Thumrait among regions getting the highest levels of solar irradiation globally. Besides solar energy, wind energy is another essential component of renewable energy needed for hydrogen production in Oman, especially in regions like Dhofar (World Economic Forum, 2023).
This section discusses the ongoing electrolysis technologies being implemented in Oman, emphasising PEM and AEL electrolysis systems. It reflects how the two technologies will support Oman's green hydrogen plan combined with renewable energy.

Based on the data analysed, several themes are identified that play a crucial role in developing and scaling green hydrogen technologies in Oman. These themes highlight specific technological, economic, and environmental concerns paramount to Oman's feasibility of developing a hydrogen economy.

One of the unique characteristics inferred from the analysis is that electrolysis systems encompass a broad range of technologies. PEM electrolysers are known for their high efficiency and flexibility and can be used with fluctuating renewable energy sources, while the AEL system is considered the cheapest for large-scale applications (IEA, 2023). Therefore, incorporating these electrolysis systems with solar and wind power in a hybrid manner is crucial to guarantee that Oman can produce hydrogen from water continuously and in large quantities.

The analysis of electrolysis technologies reveals a complex interplay between cost and efficiency. The comparison of PEM and AEL electrolyzers is summarized in the Table 1 below:

Table 1. Comparison of PEM and AEL electrolyzers

Technology	Efficiency (%)	Capital Cost (USD per kW)	LCOH (USD per kg)
PEM Electrolyzers	60-80	1000-1500	4.2-6.5
AEL Electrolyzers	50-70	800-1200	3.8-5.5

PEM electrolyzers, with an efficiency range of 60 to 80 percent, incur capital costs between $1,000 and $1,500 per kilowatt and yield a levelized cost of hydrogen ranging from $4.2 to $6.5 per kilogram (Hermesmann & Müller, 2022; El-Shafie, 2023). In contrast, AEL systems offer efficiencies between 50 and 70 percent at lower capital costs of $800 to $1,200 per kilowatt, resulting in an LCOH of $3.8 to $5.5 per kilogram (Hermesmann & Müller, 2022; El-Shafie, 2023). While PEM systems excel with intermittent renewable inputs, such as solar and wind, AEL systems are more feasible for large-scale, stable applications. A strategic deployment of these technologies in hybrid configurations can optimize hydrogen production costs and align with Oman’s renewable energy potential.

Water scarcity remains a critical issue. The comparative analysis of water sources for electrolysis is detailed below in Table 2:

Table 2. Comparative analysis of water sources for electrolysis

Water Source	Water Consumption (Liters per kg of H2)	Energy Cost (kWh per m3)
Desalinated Water	9-12	3.5-4.5
Treated Wastewater	8-10	1.8-2.5

Desalinated water, currently the primary input for electrolysis in Oman, requires 9 to 12 liters of water per kilogram of hydrogen produced, with an associated energy cost of 3.5 to 4.5 kilowatt-hours per cubic meter (Delpisheh et al., 2021). Treated wastewater, by comparison, reduces water consumption to 8 to 10 liters per kilogram and energy costs to 1.8 to 2.5 kilowatt-hours per cubic meter (Woods et al., 2022). The adoption of wastewater recycling plants near hydrogen production sites could significantly mitigate environmental impacts while enhancing sustainability. Hydrogen storage and transport technologies also face significant hurdles. The Table 3 below provides a comparative overview:

Table 3. Hydrogen storage and transport technologies

Storage Method	Cost (USD per kg of H2)	Energy Efficiency (%)	Scalability in Oman
Cryogenic Storage	30-50	65-75	Moderate
Compressed Gas	2.5-4.0	50-60	high
LOHC	4.0-6.0	70-80	Low

Cryogenic storage systems, which cost $30 to $50 per kilogram of hydrogen, offer energy efficiencies between 65 and 75 percent but require substantial infrastructure investments (Santhanam, 2024). Compressed gas systems, with lower costs of $2.5 to $4.0 per kilogram and efficiencies of 50 to 60 percent, are more scalable for domestic applications (World Bank, n.d.). LOHC systems, while highly efficient at 70 to 80 percent, present limited scalability due to technological readiness. Oman's strategy should prioritize scalable compressed gas storage for local use and invest in cryogenic systems for export markets, leveraging international partnerships to co-develop advanced transport solutions.

Another significant trend is the cost-effectiveness of generating green hydrogen. The technological factor that can be seen as a drawback is electrolysis systems' high capital cost– particularly PEM technology. However, with the continued decline in the price of solar energy, the overall economics of PEM electrolysis are better. Oman has developed key strategies where it identifies and targets government incentives and public-private partnerships that cover most of the initial costs and bring about the large-scale transition in the production of green hydrogen (Hydrom, 2024).

Another relevant theme is the transition in economic specialisation, with green hydrogen as a possible way for Oman to expand its economy by turning away from oil and selling hydrogen to energy-intensive regions such as Europe and Asia (World Economic Forum, 2023). This theme supports the efforts made for Oman's overall economic diversification mission in concordance with Oman Vision 2040.

The evaluation also stressed the environmental advantage of green hydrogen. Hydrogen produced through electrolysis can be considered a zero-emission form of energy, fitting Oman's overall climate plan, especially regarding carbon emissions. However, the problem of water usage for electrolysis is another issue that arises as a theme. Although Oman employs desalinated water for electrolysis, this technique has environmental and cost drawbacks, especially the energy consumed in the desalination process (Prabhu, 2024). Oman is thus considering treated wastewater as an option to alleviate such an environmental cost.

4.2 Discussion

A key challenge to scaling up green hydrogen production in Oman is the cost of capital needed to adopt electrolysis technologies. New technologies such as Proton Exchange Membrane (PEM) and Alkaline Electrolyzer (AEL) for hydrogen production also have high capital investment costs for installation and integration with renewable energy sources. However, even if AEL systems are cheaper than total PEM systems, both technologies remain a substantial investment. This is especially problematic since Oman is only in the initial phase of developing its green hydrogen network (IEA, 2022).

Furthermore, these technologies' operating and sustaining costs remain relatively expensive, especially for PEM systems, which require changes in a renewable power source. As the cost of renewable energy technologies has come down and more efficient production technologies have emerged, achieving Oman's targets for utilising hydrogen will require long-term capital expenditure. The lack of financial resources poses a financial barrier, for which Oman has to rely on foreign investment and public-private partnerships (Prabhu, 2024).

Electrolysis is vital in producing green hydrogen but comes at a high cost, particularly the consumption of water, which Oman experiences a challenge with due to its climatic conditions. The country currently uses desalinated water to generate hydrogen, which is quite consuming and expensive. This will impact the green aspect of green hydrogen since utilising power for desalination may also use fossil energy-based power, thus reducing the positive environmental impact of hydrogen. One of the concerns in the use of desalinated water in large-scale hydrogen production is environmental sensitivity, especially regarding the impacts of energy consumption in the desalination process and the unsafe disposal of brine (Hydrom, 2024).

The increasing demand for water resources has led Oman to look for alternative water sources, including treated wastewater. However, the feasibility of this alternative in terms of its scalability is still questionable, and the recycling of water and treating wastewater will require additional facilities. Water shortage problems are aggravated by the increasing need for this resource in food production and manufacturing, which also uses desalinated water (Prabhu, 2024).

4.3 Proposed Improvements

1. Develop Infrastructure
• Invest in hydrogen transport and storage infrastructure, e.g., cryogenic and compressed gas terminals, to enable large-scale production and export.
• Designate special zones for renewable energy schemes, e.g., floating photovoltaic (FPV) power plants with integrated hydrogen production facilities.
2. Optimize Water Resources
• Use treated wastewater as a secondary water supply for electrolysis to alleviate water shortage problems.
• Encourage R&D of innovative water-saving electrolysis technologies.
3. Improve Policy and Regulation
• Provide incentives, in the shape of subsidies or tax refunds, for private investment in green hydrogen initiatives.
• Create regulatory environments to streamline production, storage, and export operations of hydrogen.
4. Develop Public-Private Partnerships
• Create coordination between government departments, foreign investors, and domestic firms for experience sharing and cost reduction.
• Partner with global technology leaders to localise production of advanced electrolysers and restrict dependence on imports.
5. Foster Research and Development
• Invest in research in hybrid renewable energy systems integration, i.e., integrating solar and wind power to produce hydrogen on a reliable basis.
• Set up research labs to establish cost-effective and efficient hydrogen production technology.
6. Develop Human Capital
• Prepare specialized training programs to develop human capital for the green hydrogen industry.
• Partner with educational institutions to provide course instruction in renewable energy and hydrogen technology.
7. Take Advantage of Strategic Location
• Establish Oman as a green hydrogen export hub through partnership with high-demand markets like Europe and Asia.
• Construct pipeline and shipping infrastructure specifically for hydrogen export.
8. Monitor and Measure Progress
• Create quantifiable targets for the production of green hydrogen and track progress on a regular basis against Oman Vision 2040 targets.
• Create mechanisms for receiving feedback to shift strategies based on arising opportunities and challenges.

5. Conclusion

Oman is blessed with good renewable energy resources, especially solar and wind power, to produce green hydrogen. Thumrait and Marmul have high solar irradiation, and Dhofar has good-quality wind energy. These advantages place Oman in a favorable position for the production of hydrogen at commercial scale for the local market as well as for the international market.

Two technologies, PEM and AEL electrolysis, are the main focus of Oman's green hydrogen strategy. PEM electrolysis is more effective when combined with intermittent renewables but is more expensive since platinum catalysts are utilized. AEL electrolysis is less expensive and more suited for large applications, particularly in areas where there are more dependable renewable energy resources. Both technologies play a key role in the scale-up of hydrogen production in Oman to achieve its 2030 and 2040 green hydrogen vision. From an economic perspective, embracing green hydrogen provides Oman an opportunity to reduce its dependence on fossil fuel and diversify the economy. Green hydrogen production and export can diversify Oman's economy away from oil. It will also generate employment and build a skilled labor force, creating long-term economic value and positioning Oman in its rightful position as a world leader in clean energy.

Green hydrogen consumption has beneficial environmental effects, supporting Oman's decarbonization and international carbon reduction. Transition from fossil fuels to zero-carbon hydrogen can reduce emissions in heavy industry and transportation. However, dependence on desalinated water for electrolysis is an issue. This energy-demanding process can negate the environmental benefit of hydrogen production. Oman is investigating alternatives like treated wastewater to mitigate water resource pressures and lower the environmental impact of hydrogen production.

Green hydrogen adoption offers considerable social co-benefits, especially in terms of jobs, human capital formation, and access to energy improvements. Oman's green hydrogen sector has the potential to diversify the economy, provide employment in the renewable energy industry, and enhance innovation. It also enhances energy access in rural regions, delivering clean energy to off-grid villages, enhancing energy security and equity.

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Biographies

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