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Developing a Green Hydrogen Economy in Oman: Investment Appraisal and Economic Feasibility

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Abstract

Green hydrogen economy formation is a key element of Oman's strategy of economic diversification and decarbonisation in the context of Vision 2040. This study is a combined techno-economic and investment analysis of the green hydrogen production on a large scale in Oman through an alkaline electrolysis system that operates on solar energy within a 23-year project life. The financial model is designed in such a way that it can be used to estimate the levelized cost of hydrogen (LCOH) and determine the viability of the project based on discounted cash flow metrics, such as the net present value (NPV) and the internal rate of return (IRR). In contrast to traditional deterministic evaluations, time-based cost estimates, and an extended sensitivity model including discount rates, capital expenditure overruns, electricity, and water prices are included in the analysis as the main indicators of economic uncertainty in the Omani setting. Findings show that the LCOH will reduce significantly, with 6.37 USD/kg in 2025 decreasing to 2.85 USD/kg in 2050, which will be mainly due to the decrease in capital costs and the increase in the efficiency of operations. Financial viability is, however, very sensitive to financing assumptions and electricity prices, and IRR values are never greater than the assumed cost of capital under the base-case conditions. Commercial attractiveness would be very low without the support of policy. The findings indicate that although Oman has high potential of resource to develop green hydrogen, economic competitiveness will be attained through maximised financing regimes, variable electricity pricing systems, and supportive policy tools. This research adds to the body of literature by giving a clear, Oman-specific investment appraisal model that relates the techno-economic performance to the financial viability, providing practical implications to policymakers and investors.

Keywords: Green Hydrogen, Techno-Economic Analysis, Investment Appraisal, Levelized Cost of Hydrogen (LCOH), Oman Energy Transition

1. Introduction

Green hydrogen is being viewed more and more as a key facilitator of deep decarbonisation, especially in hard-to-abate sectors, including heavy industry and long-distance transport. It can be manufactured with the help of renewable energy by the process of electrolysis, providing a way to incorporate variable renewable sources and contributing to long-term energy storage and the industrial systems of the low-carbon nature (Bolard et al., 2023; Liu, 2023). Hydrogen is also becoming a strategic commodity in the face of the growing international demand for clean energy carriers, and it has the potential to redefine international energy trade (Oramulu & Machmudi, 2025).

MENA and Oman in particular have an excellent opportunity to join this transition because the region has a high solar irradiance, good wind sources, and good export location to Europe and Asia (International Energy Agency, 2023; Rokabi, 2024). The national plans of Oman, such as Vision 2040, and its roadmap on green hydrogen, underline hydrogen as one of their main economic diversification and sustainable development pillars (Hydrom, 2024; Oman Vision 2040, 2024).

The large-scale production of green hydrogen is not yet economically viable, even though this is possible. The literature tends to make generalised assumptions or deterministic models that fail to capture the financial risks of capital-intensive hydrogen projects, especially in the new economy (Sadighi, 2025; Sadiq, 2024). Moreover, little focus has been placed on integrated investment appraisal models to associate techno-economic performance and financial viability in the Omani context.

This study evaluates the economic feasibility of green hydrogen production in Oman through an integrated techno-economic and investment appraisal framework, aiming to identify key cost drivers and assess the conditions under which such projects can achieve financial viability.

2. Literature Review

The increasing literature on green hydrogen indicates its primary role in the global decarbonisation strategies, but there is still much variance in the assessment of its economic viability and its deployment strategies. The early diagnosis assessments were mainly based on techno-economic performance, where the emphasis was laid on cost structures and system efficiencies, and the more recent studies were making increasing inclinations on policy, market, and geopolitical aspects.

Some of the studies have concurred that electricity prices, cost of capital spending and system efficiency are the key factors that determine the cost of green hydrogen. Bolard et al. (2023) stated that there is a rapid change in the technologies of electrolysis, and reducing the cost of capital is one of the main enablers to deploy at a large scale. Similarly, Liu (2023) said that the adoption of renewable electricity coupled with the use of electrolysis systems has a considerable impact on lowering the cost of production in areas where there are great amounts of renewable resources. Nonetheless, most of these studies are based on global data and general assumptions, which restrict their credibility to a particular regional setting.

By contrast, regional-based studies have tried to put hydrogen implementation into its context in particular economic and policy contexts. In the article by Sadiq (2024), the author investigated the production pathways of hydrogen in the MENA region and decided that, despite the region possessing significant competitive advantages, the financial viability of the field is incredibly dependent on electricity tariffs and financing models. Almazeedi (2024) also added that strategic positioning in the world hydrogen markets is not only based on the costs of production, but also on investment structures and global trade forces. All these studies imply that techno-economic competitiveness is not enough to make successful implementation without favourable financial and policy mechanisms.

Research work that is policy-based has also been critical in helping to create the discourse on hydrogen economies. Alam et al. (2024) discussed the issue of accelerating hydrogen adoption by emphasising the importance of integrative policy structures, which the authors believe can obstruct investment flows in the case of fragmented or disjointed policies. Likewise, Islam and Ali (2024) studied policy interdependencies in energy changes, and they highlighted the fact that to scale hydrogen technologies, it is crucial to be able to regulate them. Although these studies offer useful information on the structure of governance, they do not have sufficient financial quantification, and thus, they do not provide much information on the viability of projects.

Strategically, there are a number of authors who have discussed the role of hydrogen in the emerging economies and the energy-exporting regions. Bacil et al. (2025) stated that green hydrogen is a rare chance that emerging economies may jump over the old system of energy and build new chains of industrial value. Krane (2025) and Hamed (2025) also reiterated the strategic value of hydrogen to GCC countries, in that it has the potential to

support the energy export revenues of the decarbonising world market. These studies are, however, inclined to take a macro-level approach, and they are not rigorous in the assessment of the financial viability of certain projects.

The work to do with infrastructure and system integration has created new dimensions of hydrogen deployment. Notteboom and Haralambides (2023) reviewed the perspective on seaports as the hydrogen hubs and proposed that infrastructure preparedness is essential in facilitating the major export-oriented hydrogen economies. Gil-Garcia et al. (2024) also touched upon hybrid renewable systems and proved that the relation of wind and solar resources could improve the efficiency of a system and decrease the costs. Although these studies are very important in considering the system level, they usually presume that operating conditions are ideal and fail to take into consideration the financial uncertainties or operational risks.

There has been an increasing body of research that has tried to combine techno-economic and financial analysis, but gaps still exist. Sadighi (2025) has applied an economic analysis of the deployment of hydrogen and highlighted the significance of financial metrics like net present value and internal rate of return in analysing the feasibility of a project. Priovolos (2024) compared the economics of hydrogen production in the European regions and emphasised the differences in the cost formation based on the regional differences in resource availability and the policy support. Nonetheless, such studies tend to be based on deterministic models, and they fail to reflect well the uncertainties regarding financing, market dynamics, or long-term cost development.

The literature in the context of Oman is relatively limited and mainly qualitative in the context of the particular country. Al-Mamari et al. (2024) discussed the future perspectives of the use of hydrogen in Oman and highlighted the high base of renewable resources and the possibilities of strategic export of the country. The International Energy Agency (2023) also pointed out that Oman has great potential to produce renewable hydrogen, as it is also competitive in terms of its solar and wind resources. Although these studies are informative on the strategic level, they do not include specific techno-economic and financial modelling according to the conditions in Oman.

Moreover, it is the current literature that usually ignores such crucial aspects as the nature of financing, variation of costs and operational risks. As an example, discount rates, capital costs, and system lifetimes assumptions are often based on the global standards and are not justified in terms of the local economy. Also, lack of sensitivity analysis in most researches restricts drawing conclusions with a lot of strength, especially in the emerging market, where the economic uncertainties are high.

Overall, the literature shows that there is an evident development of the techno-economic evaluations to the more comprehensive analyses that would include policy and strategic implications. Nevertheless, one of the missing links is the creation of open, contextual constructs that integrate the use of techno-economic models with a strict financial analysis. Specifically, the research that focuses on uncertainty, financing setups, and the dynamics of costs in a particular regional setting, like Oman, is needed.

The study attempts to fill these gaps by offering a combined techno-economic and investment appraisal model of the production of green hydrogen in Oman. It will provide a more detailed view of the viability of the project by integrating the model of costs with the financial analysis and sensitivity analysis, and help to better understand the hydrogen economics in the new energy markets.

3. Methodology

3.1 System Description

The study examines the economic viability of an alkaline water electrolysis (AWE) system operated by a renewable energy source to produce green hydrogen in Oman. Electricity supply, water input, electrolysis, hydrogen drying, compression, and storage are defined as the system boundary, and it is costed at the plant gate. The reason alkaline electrolysis is chosen is that it is technologically mature, capital-intensive is lower, and has been demonstrated to be scalable relative to other types of electrolysis (Bolard et al., 2023). Its applicability to

large-scale implementation of areas with high renewable sources has been commonly highlighted in recent techno-economic research (Liu, 2023).

This process begins with renewable electricity as an input, and electrochemical separation of water into hydrogen and oxygen is triggered. The hydrogen is then dried and pressurised to either be stored or utilised downstream. The analysis presupposes the work in the steady-state mode, where the production of hydrogen is carried out during the whole period of the project. The country of Oman has all the above, which offers an optimal location to such systems due to the solar irradiance and the developing renewable energy infrastructure, which further supports its strategic positioning in global hydrogen markets (International Energy Agency, 2023; Hydrom, 2024).

The model of the system is based on a production basis in kilograms of hydrogen, which can be directly compared to the current literature and market standards. The study provides uniformity in terms of technical performance and economic analysis, which is required in investment-based analyses by concentrating on one integrated production system (Sadighi, 2025).

The production capacity applied in the paper embodies a consolidated annual output of running the plant instead of the size of an electrolyser unit. This method permits the model to represent the large-scale industrial deployment situations that are congruent with the export-oriented hydrogen production systems. The analysis is also a representation of system-wide performance as opposed to unit capacity, which presents uniformity between economic analysis and production output.

3.2. Assumptions and Input Parameters

The techno-economic model is created on a group of standardised assumptions that demonstrate realistic operating and financial situations. The projected project life of the project is 23 years, which includes construction, ramp-up and operation periods. It uses a discount rate of 5%, which is a moderate finance rate normally used in infrastructural projects in new energy markets (Patsatsia, 2024).

Some of the major technical parameters are electrolyser energy consumption of 57.5 kWh/kg H₂, 15 L/kg H₂ water consumption and an annual continuous operation of 8000 hours. These values agree with reported ranges of performance in alkaline electrolysis systems in the industrial environment (Bolard et al., 2023). It is assumed that the electricity is acquired through renewable generation, which highlights the strategic orientation of Oman towards the development of solar and wind energy (International Energy Agency, 2024).

Table 1: Key Input Parameters

Parameter	Value	Unit
Project lifetime	23	years
Discount rate	5	%
Electricity consumption	57.5	kWh/kg H ₂
Water consumption	15	L/kg H ₂

Constant production of hydrogen per annum and performance of the system being constant with time are some of the operating assumptions. The cost is expressed in terms of a functional unit, namely, 1 kg of hydrogen, which guarantees the comparability of the cost in different situations and its alignment with the existing techno-economic models (Priovolos, 2024). The financial parameters, such as the capital cost factors and operating cost structures, are obtained with the combination of the project-specific data and literature benchmarks.

These assumptions give a systematic basis in which to assess the cost competitiveness and investment feasibility, as well as remain in line with the operating conditions in the real world of the emerging hydrogen sector in Oman.

3.3 Capital Cost Estimation (CAPEX)

The estimation of capital expenditure (CAPEX) is done by a scaling method, which is based on the reference plant data, and this provides the ability to adjust the cost to other levels of production. The relationship between scaling is determined to be:

$$C_2 = C_1 \left(\frac{Q_2}{Q_1} \right)^n$$

where C_1 and C_2 represent the capital cost of the scaled and reference systems, Q_1 and Q_2 designate their respective abilities, and n represents the scaling exponent. This technique is commonly used in the process engineering field, as well as in hydrogen project analysis, to approximate the capital cost of large systems (Junnila, 2024).

$$C_{\text{adjusted}} = C_{\text{base}} \times \frac{\text{CEPCI}_{\text{current}}}{\text{CEPCI}_{\text{base}}}$$

The total CAPEX is considered, including the direct costs (electrolyser system and balance of plant) and the indirect costs (installation, engineering, and contingency). Installation and EPC aspects are also included to show the actual project development realities.

Studies pointed out that the capital costs continue to be one of the most important factors of hydrogen economics, especially when it comes to the initial deployment phases (Sadighi, 2025; Sadiq, 2024). Thus, proper estimation of CAPEX is necessary to determine the viability of the project and the cost effectiveness in the long-term.

3.4 Operating cost estimation (OPEX)

Operation expenditure (OPEX) is further subdivided into variable and fixed costs to cover the operational costs, as well as the maintenance costs. Variable operating costs consist of electricity, water and consumables like potassium hydroxide and catalysts. Of these, the most significant cost factor is electricity because the process of electrolysis is energy-intensive, and this observation has also been confirmed in the literature of techno-economic studies (Liu, 2023).

The sum of the variable costs is obtained as:

$$C_{\text{variable}} = \sum(\text{Consumption}_i \times \text{Price}_i)$$

where every element is calculated with regard to unit consumption and the market prices. Electricity consumption in this study is directly related to the production of hydrogen; thus, it is a major cause of cost fluctuation.

There are fixed operating costs that comprise the labour, maintenance, and administrative costs. These have been estimated as a percentage of capital investment:

$$C_{\text{fixed}} = 0.04 \times \text{CAPEX}$$

This assumption is in line with the hydrogen cost models that have been applied in recent studies (Sadighi, 2025).

The overall OPEX is calculated on the basis of per kilogram hydrogen to make a direct comparison with LCOH outcomes. It has been stressed in the previous research that CAPEX prevails in the early stages of the expenses, but OPEX, especially electricity, plays a larger role in the long-term competitiveness (Priovolos, 2024).

3.5 Levelised Cost of Hydrogen (LCOH)

The levelised cost of hydrogen (LCOH) is the most common measure of the cost of production. It is the average unit cost of the hydrogen generated over the life of the project that includes both capital and operating costs. The LCOH is determined as:

$$\text{LCOH} = \frac{\text{CAPEX} \times \text{CRF} + \text{OPEX}}{H_2}$$

where *CRF* is the factor of capital recovery, which is defined as:

$$\text{CRF} = \frac{r(1+r)^n}{(1+r)^n - 1}$$

Here, *r* is the discount rate, and *n* represents the lifetime of the project. This formulation will make sure that there is an annualisation of capital costs in proportion to the period of operation.

LCOH has found extensive application in hydrogen research because it allows one to combine technical and economic variables into a single measure (Liu, 2023). In this study, LCOH is considered over various time horizons (20252050) in order to capture the cost reductions related to the technological advancement and economies of scale.

3.6 Financial Evaluation

In order to determine the feasibility of the investments to be made, the research uses discounted cash flow analysis based on Net Present Value (NPV) and Internal Rate of Return (IRR). The NPV can be computed as follows:

$$\text{NPV} = \sum_{t=0}^N \frac{CF_t}{(1+r)^t}$$

where *CF_t* represents the net cash flow during the year. *t*, *r* is the discount rate, and *N* is the time at which the project is going to be undertaken.

The IRR is the rate at which the discount rate is given NPV = 0, which is the break-even payment of the investment. They are commonly applied indicators when assessing energy projects and investment decisions of large scale (Patsatsia, 2024).

The calculation of revenue is also done on the basis of hydrogen sales, whereas CAPEX and OPEX are the elements of costs. This combined financial model allows measuring not only the profitability but also the risk, which is crucial when determining the feasibility of hydrogen projects that are capital-intensive (Almazeedi, 2024).

3.7 Sensitivity Analysis

The sensitivity analysis is carried out to determine how the major parameters influence the economics of the project. It uses a single-variable methodology, in which one of the variables is changed, and the rest remain constant. The approach allows for determining the key cost drivers and assessing economic resiliency in the presence of uncertainty.

The parameters under analysis are:

- Discount rate
- Capital expenditure (CAPEX)
- Operation and maintenance expenses (OPEX).
- Water price
- Electricity tariff

All the parameters are manipulated within a specific range to depict realistic market movements. As an illustration, the discount rates will be tested between 0 and 15% with the base rate of 5%, and cost parameters will be tested within a range between ±10%.

Sensitivity analysis plays a critical role in hydrogen projects evaluation because the costs of technologies, energy prices and the terms of financing can be highly uncertain (Sadiq, 2024). The research offers a thorough evaluation

of financial risk and sensitivity of investment in the green hydrogen industry of Oman by measuring the effects of these variables on NPV and IRR.

3.8 Financing Assumptions and Limitations

The financial analysis of the case study is anchored on a simplistic discount rate methodology, according to which a fixed 5% discount shall be used throughout the project lifetime. Although this assumption is consistent enough to make comparative analysis, it does not explicitly represent the capital structure generally observed in large-scale hydrogen projects, which tend to be a mix of debt capital financing and equity capital financing. Practically, the funding of projects is established using a weighted average cost of capital (WACC), which integrates financing risk, market conditions and expectations of the investor (Patsatsia, 2024).

The financing framework is a sensitive area of hydrogen projects in emerging economies, especially because it is very capital-intensive and has a long payback period. In other past analyses, it has been highlighted that concessional finance, blended finance systems, and public-private financiers can greatly enhance the viability of projects by lowering the true cost of capital (Almazeedi, 2024). Thus, the consideration of a unified discount rate in the study can be seen as the simplification of the model and not the true financing operation.

This limitation is mitigated partially by sensitivity analysis concerning the discount rate, but in future research, the dynamic nature of the financing structure and scenario modelling of the WACC would be employed to more effectively reflect the reality of the conditions of investment in a real-life hydrogen project.

4. Results and discussion

4.1 Cost Structure Analysis

The green hydrogen production cost structure in Oman is distinguished by a clear segregation between components, which are capital-intensive and those which are energy-intensive. The findings show that capital expenditure (CAPEX) and electricity-based operating expenditure (OPEX) represent the highest costs of hydrogen production, and this is in line with research results available in the world and regional techno-economic literature (Bolard et al., 2023; Sadiq, 2024). Table 2 shows the capital costs divided into normalised forms.

Table 2: Capital Cost Structure

Component	Value (USD/kW)	Contribution (%)
Direct cost (installed system)	862.25	89.7
Indirect cost (EPC)	99.02	10.3
Total CAPEX	961.28	100

The findings indicate that direct costs, especially costs on electrolyser systems and balance-of-plant cost predominate in the investment of capital. This is consistent with the earlier research that has stressed the initial high price of the electrolysis technologies, particularly in the initial stages of implementation (Sadighi, 2025). Indirect costs that would be comparatively less still are crucial because of the engineering, procurement, and construction (EPC) needs.

On the contrary, electricity consumption has a significant effect on operating costs. Table 3 shows the breakdown of operating expenditure on a per-kilogram basis of hydrogen.

Table 3: Operating Cost Breakdown

Component	Value (USD/kg H ₂)	Contribution (%)
Electricity	1.3225	99.1
Water	0.00645	0.48
Chemicals & catalyst	0.00559	0.42
Fixed O&M	0.19367	—
Total OPEX	1.52821	100

More than 99% of variable operating costs are covered by electricity, which substantiates the fact that electricity is the major cost driver in the production of hydrogen using electrolysis. This result is aligned with the earlier report that has suggested that the variability of electricity prices is the most influential factor of hydrogen price competitiveness (Liu, 2023; Priovolos, 2024).

In economic terms, the electricity cost hegemony will mean that the competitiveness of Oman in the production of hydrogen will be largely dependent on its capacity to produce renewable electricity at low prices. On the one hand, Oman is characterised by a high level of solar irradiance, and the outcomes imply that with the lack of competitiveness of pricing mechanisms in the electricity sector, a reduction in cost in CAPEX might be insufficient to ensure hydrogen costs are competitive.

4.2 Levelised Cost of Hydrogen (LCOH)

Levelised cost of hydrogen (LCOH) gives a holistic measure of the cost of production as it combines capital recovery as well as operating costs throughout the duration of the project. Its findings indicate that LCOH decreases significantly between 2025 and 2050, which is a positive sign of technological advancement, reduction in costs, and economies of scale. Table 4 is a summary of the LCOH values and the cost components.

Table 4: LCOH and Cost Composition (USD/kg H₂)

Year	LCOH	CAPEX	Variable OPEX	Fixed OPEX
2025	6.37	4.84	1.33	0.19
2030	5.22	3.87	1.19	0.15
2040	3.36	2.32	0.95	0.09
2050	2.85	2.01	0.75	0.08

These findings suggest that the LCOH has decreased by 55% during the course of study, mainly this has been as a result of reduced capital costs and higher system efficiencies. This follow-up is in line with the estimates observed in the world hydrogen literature, indicating cost savings as a factor of technological learning and scale effect (Bolard et al., 2023; Liu, 2023).

The noticeable observation is that CAPEX is predominant in the initial years(2025), with about 76% contribution to the total cost. It declines with time, however, in the proportion of its contribution to capital costs. On the other hand, the proportion of operating expenses, especially electricity, increases with advancing age, which represents the transition towards the energy-based cost structure rather than the capital-based.

Although the costs are observed to be reduced, the estimated values of LCOH still stand above the low-cost range that highly optimised hydrogen systems have been reported to possess throughout the world. Comparative studies indicate that the low cost of electricity is not the only factor needed to achieve LCOH at an amount lower than 2 USD/kg, but also specific conditions of financing and the encouragement of policies (Priovolos, 2024; Sadighi, 2025). Oman thus has a good potential, but coordinated technological, financial, and policy interventions are needed to be able to achieve global competitiveness.

In order to confirm the strength of the findings, the calculated values of LCOH are determined in accordance with the existing literature. The past research demonstrated that the cost of producing green hydrogen is generally 2-6 USD/kg according to the price of electricity, the level of technology development, and the investment terms (Priovolos, 2024; Sadighi, 2025). The findings of this study are not outside this bracket, where it is seen that early years are characterised by high costs and towards 2050, the rates approach competitive levels. Such an agreement with published standards contributes to the reliability of the model and ensures that the cost assumptions employed in it are consistent with international trends in techno-economics.

4.3 Financial Feasibility Analysis

Net Present Value (NPV) and Internal Rate of Return (IRR) are used to determine the financial feasibility of the green hydrogen project. The findings indicate that financial assumptions, specifically discount rates and capital costs, are very sensitive to the project's feasibility. With the discount rate of 5% (base case), the project will produce a positive NPV, but as the discount rate increases in value, the profitability decreases drastically.

Table 5: Financial Performance under Discount Rate Variation

Discount Rate	NPV (USD)	IRR (%)
0%	533,892,975	9.75
5% (base)	172,875,746	9.75
10%	-6,422,573	9.75
15%	-103,827,862	9.75

The outcomes in Table 5 reveal that the project is no longer a viable economic project at a discount rate exceeding 10%, which makes the financing conditions vital. This is consistent with the past studies that highlight the fact that hydrogen projects are massively capital-intensive and marginal to the cost of capital (Almazeedi, 2024).

As IRR does not change in this analysis because of model assumptions, it is still lower than the expected IRR by average investors when dealing with high-risk energy projects. This implies that, given the prevailing circumstances, policy support mechanisms to attract private investment in Oman through green hydrogen investments may include subsidies or concessional funding.

Relatively, research in the other parts of the world has revealed that positive financing setups may greatly enhance project feasibility even when production expenses are relatively elevated (Sadighi, 2025). Accordingly, the reduction of costs is not the only factor of financial viability, but the overall investment climate.

4.4 Sensitivity Analysis

Table 6: Sensitivity Analysis

Parameter	Base Value	Range Tested	NPV Range (USD)	IRR Range (%)
Discount Rate	5%	0–15%	533,892,975.52 → (103,827,862.76)	9.75 (constant)

CAPEX Overrun	0%	-10% to +10%	205,116,499.21 → 147,601,897.19	5.91 → 3.76
O&M Overrun	0%	Limited data	176,359,198.20 (at base)	4.76
Water Price (USD/L)	0.00043	0.00039–0.00047	176,356,880.25 → 176,361,516.15	4.76 (constant)
Electricity Tariff	0.02799	±10%	3,633,870.00 → 1,270,446.00	14 → 11

As shown in Table 6, the results of the sensitivity analysis indicate the relative impact of the essential economic parameters on the viability of the project. Discount rate stands out as such a factor when among the variables discussed and therefore seen to be the most critical in financial performance. When the discount rate is set at the base case of 5, the project can lead to a positive NPV of 172,875,746.57 USD; however, the NPV becomes negative with the increase of the discount rate to 10% and 15%, which shows that the project undergoes a transition to financial infeasibility. This validates the fact that hydrogen projects are extremely sensitive to the financing environment, as it is also highlighted in hydrogen investment studies (Almazeedi, 2024).

Capital expenditure is the other area of high impact on the returns of the project. Any fluctuation of CAPEX that is approximately -10% will cause large changes in both the NPV and the IRR, where an increase in costs will lead to a reduction of 5.91 per cent. to 3.76 per cent. This is symptomatic of how capital-intensive electrolysis systems are, and it coincides with conclusions that CAPEX is a major impediment to the widespread implementation of hydrogen (Sadighi, 2025). These findings imply that it is important to control the cost of the development process in a project to ensure an attractive investment.

Conversely, the water price changes do not affect the financial performance significantly, and there is a slight change in the NPV, but no change in the IRR. It means that the water expenditure is not a decisive factor in the hydrogen manufacturing economics, which aligns with the existing studies (Liu, 2023). Likewise, the data on the sensitivity of operating and maintenance costs is not extensive; however, the data given in the case of the base-case indicates that it has a medium influence in comparison with other values.

The fact that electricity tariffs change considerably proves the impact of electricity tariffs on the economics of projects validates this fact since it is the primary cost of operation. Electricity pricing changes cause observable changes in both NPV and IRR, which makes access to renewable, low-cost electricity important. This result can be aligned with comparative techno-economic analyses, which found electricity cost as the most significant variable to produce hydrogen (Priovolos, 2024).

Overall, the sensitivity analysis shows that a combination of the appropriate financing conditions, managed capital costs, and competitive price of electricity has to be achieved to provide economic viability. The findings emphasise the role of a combined policy and investment approach to help in the evolution of a green hydrogen economy in Oman (Al-Mamari et al., 2024; Hydrom, 2024).

5. Discussion and Policy Implications

Data presented in this paper proves that although Oman has good techno-economic potential to produce green hydrogen, the economic viability of such an endeavour can only materialise under the influence of financial and market forces instead of just reducing the costs. The future decreasing value of LCOH is an indicator of expected technological learning and cost of scale, but the financial analysis has shown that lower costs of production are not directly equated to investment feasibility. This difference is critical because various researches have also expressed the same claim where they state that the techno-economic competitiveness should be judged together with financing structures and market conditions to make real-life judgments (Sadighi, 2025).

One of the key conclusions of this research is the prevalence of the financing conditions on project viability. The elasticity of NPV to changes in the discount rate implies that the cost of capital is a decisive factor in the evaluation of the outcome of an investment. Moderate hikes in the discount rate also lead to a shift from positive to negative

NPV, which indicates how risky hydrogen projects are to be financed. This phenomenon can be aligned with the larger body of literature on energy investments, as it highlights that capital-intensive projects are very much reliant on the availability of low-cost financing mechanisms (Patsatsia, 2024). Here, assuming a homogeneous discount rate makes the real world of financing much simpler, as blended finance models, concessional financing, and state-owned ventures are frequently needed to minimise the risk of an investment (Almazeedi, 2024).

The second most important factor that defines economic performance is electricity pricing. Since electricity represents most of the operating costs, changes in tariff structures have a tremendous impact on both LCOH and financial indicators. Even though Oman is advantaged by the abundance of solar irradiance, the outcomes indicate that such a natural resource would not suffice without the underpinning measures. The results correspond with the regional studies, which state the cost of electricity as the key factor in defining the competitiveness of hydrogen (Sadiq, 2024). Moreover, hydrogen in the future cannot be run on fixed tariffs since the growth in the use of renewable energy will probably create dynamic pricing and power purchase agreements (PPAs). These mechanisms can be used to enhance efficiency in costs and decrease the price fluctuations, especially in combination with the hybrid renewable systems (Gil-García et al., 2024).

Capital expenditure is also a major limitation, especially at the initial stages of deployment. The sensitivity analysis outcomes indicate that any small improvement in CAPEX causes significant decreases in IRR, thus the capital intensity of electrolysis technology. This result is in agreement with international forecasts that the prices of electrolyzers will fall as mass use and mass production rise (Bolard et al., 2023). Nonetheless, the findings also indicate that early-stage projects might be exposed to additional financial risk prior to these cost reductions, true to reality, whereby there exists a disconnect between technological potential and commercial viability.

The costs and financing issues are not the only essential aspects in the study, as it implicates operational and technological uncertainties. The existing model presupposes stable work of the system, but in reality, degradation of the electrolyser, the intermittency of the renewable energy, and downtime of the system can determine the efficiency of the production process and the cost-efficiency. These are the aspects that are often disregarded in deterministic techno-economic models but have been found to be important factors to consider when assessing hydrogen systems (Priovolos, 2024). Due to the unpredictability of these and other uncertainties, introducing them into the future modelling structures would enhance the validity of investment analyses and offer a better representation of project performance.

Strategically, the geographic positioning of Oman and the base of renewable sources make it a potential exporter of green hydrogen. The geographic closeness to major markets in Europe and Asia is what gives it a competitive advantage in the area of logistics and trade integration (International Energy Agency, 2023). Nevertheless, the findings indicate that this may be limited by competition with other areas which have equally good renewable potential but have much better financing facilities or are policy-favourable. This implies that the availability of resources is not enough to guarantee competitiveness and that it will be necessary to have a coordinated development of the infrastructure, supply chains and export strategies.

Policy frameworks, thus, are important in bridging the gap between technical and economic feasibility. Although the national plans of Oman have a solid basis on which to develop hydrogen, the findings of this research have shown that more policy tools would be needed to facilitate investment. These are concessional financing, carbon pricing mechanism, and long term offtake or commitment, and regulatory mechanisms that minimise uncertainty of the investor. As experience on the global level suggests, this type of policy backing is needed to scale up to hydrogen economies, especially at the first stage of market building (Alam et al., 2024).

Even though the economic feasibility is the main theme of this research, the environmental effects of the production of green hydrogen give one more reason why it should be developed. Hydrogen, which is generated using renewable energy, can play a huge role in the carbon emissions of hard-to-abate sectors, which can help in the decarbonisation efforts of the world. Earlier studies have revealed that renewable hydrogen systems are capable of being instrumental when it comes to emissions reduction pathways, especially in places where fossil fuel has been extremely important (Oyewo et al., 2024). The benefit of this transition within the framework of Oman is

that it can coordinate with the national sustainability goals and provide a chance to decrease the intensity of carbon content of energy exports.

Overall, the results indicate that the green hydrogen economy development in Oman needs to be a multidimensional process incorporating technical progress, financial optimisation, and policy assistance. As much as the nation has definite resource strengths, economic feasibility will revolve around its capacity to deal with financing limitations, dealing with uncertainties about costs, and supportive policy frameworks. In the absence of these enablers, there is only a slight possibility that large scale roll out would be commercially viable in the short run.

6. Conclusion

The study has analysed the economic viability of the production of green hydrogen in Oman using a combined techno-economic as well as investment appraisal model. The study offers a full review of the costs of production as well as the viability of the investment under real conditions by using the cost modelling, the financial analysis and sensitivity analysis covering the 23-year project life.

The findings reveal that green hydrogen generation in Oman has a good potential regarding the cost aspect because the levelised cost of hydrogen in Oman will reduce considerably in the year 2025 to 6.37 USD/kg and by 2050 to 2.85 USD/kg. The main contributors to this decrease include lowering the costs of capital and increased efficiency of the system, which align with the tendencies in the development of electrolysis technology in the world (Bolard et al., 2023). Nevertheless, even with this cost reduction, the financial analysis shows that the viability of investments is difficult to produce under the present assumptions.

The first outstanding aspect that this study has uncovered is that financial feasibility is very sensitive to the discount rate, capital expenditure and electricity tariff. Sensitivity analysis proves that despite the reduction in the cost of production, an increase in the cost of capital can make the project economically non-viable. On the same note, capital cost overruns have a substantial impact on decreasing the internal rates of return and electricity pricing has a strong impact on operating costs. Conversely, the effects of water price changes on total project economics are insignificant. These results prove that economic feasibility cannot be calculated alone based on technological performance, but rather combined with financing conditions and energy pricing structure.

Strategically, Oman has numerous strengths, such as a great diversity of renewable energy and a favourable geographical location in which to export hydrogen. Nevertheless, the current potential should be translated into a competitive hydrogen economy through combined efforts to mitigate the financial and market hindrances. These findings indicate that the policy support mechanisms, including concessional financing, stable regulatory systems, and long-term offtake schemes, will play an important role in investment attraction and risk minimisation of projects.

Overall, this research study helps in the literature by presenting a clear and Oman-specific framework of investment appraisal that connects the techno-economic performance with financial reasonableness. The results help to note that even though green hydrogen may be cost-competitive in the long run, its extensive implementation in Oman will require the coordination of technological advances, financing opportunities, and policy measures. Further studies are recommended on this analysis through the integration of marketing dynamics, export logistical and policy scenarios, to further narrow the evaluation of the development of the hydrogen economy in Oman. In Oman, due to the absence of specific financial and policy modifications, the implementation of green hydrogen is not likely to realise large-scale commercial viability in the near future.

7. Limitations and Future Research

The study is a structured techno-economic and financial assessment of the green hydrogen production in Oman, but a number of limitations must be mentioned. First, the analysis is carried out in a deterministic modelling framework, in which important parameters are supposed not to vary with time unless within the specified ranges

of sensitivity. Although sensitivity analysis is used as a method to deal with uncertainty, it does not exhaust stochastic changes in market conditions, financing structures and technology performance.

Second, the financial model uses a simplified rate of discount as compared to a more detailed financing structure using the weighted average cost of capital(WACC). Since hydrogen projects are often characterised by complicated financing schemes, blended finance models, and investment structures that are based on scenarios should be used in future research.

Third, the impact of the environment, e.g., the carbon emissions of the lifecycle, or the water sustainability, is not explicitly mentioned in the research. Whereas green hydrogen is generally well known as a low-carbon solution, including environmental metrics would give a more detailed analysis of the benefits of projects.

Finally, the analysis is based on production economics and fails to look at downstream issues like hydrogen transport, hydrogen storage systems, or export logistics. These aspects should be incorporated in future research to come up with a more detailed evaluation of the development of the hydrogen economy in Oman.

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