Impact of Renewable Energy Price Fluctuations In Green Hydrogen Production Connected To Hyetron Energy Pvt Ltd, Chennai

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Abstract- *This study examines the impact of renewable energy price volatility—especially from solar—on the economic viability of green hydrogen production in India. Using a questionnaire-based survey of solar energy suppliers, it identifies seasonal solar variability and grid constraints as key causes of price fluctuations. Effective mitigation strategies include long-term Power Purchase Agreements (PPAs), energy storage diversification, and indexed pricing models. The findings offer actionable recommendations for Hyetron Energy Pvt Ltd and similar firms to improve cost predictability and boost investor confidence in the green hydrogen sector, supporting a more resilient renewable energy ecosystem in emerging markets.*

Keywords- Green Hydrogen Production, Renewable Energy Price Volatility, Solar Energy Suppliers, Power Purchase Agreements (PPAs),Energy Storage Solutions.

I. INTRODUCTION

Green hydrogen is emerging as a key solution in the transition toward sustainable energy. However, its production is highly dependent on renewable energy sources such as solar and wind, which are inherently variable and subject to price fluctuations. These fluctuations arise due to seasonal variations, grid constraints, and policy changes, leading to cost uncertainties, financial risks, and reduced competitiveness for hydrogen producers.

Understanding and mitigating these challenges is crucial for ensuring the long-term viability of green hydrogen production. Stable and predictable energy pricing is necessary to support large-scale adoption, investment confidence, and economic feasibility in the sector.

This study seeks to explore the extent ofrenewable energy price volatility and identify strategies to mitigate its impact on green hydrogen production. By collecting insights from renewable energy suppliers, the research aims to propose solutions that can enhance price stability and improve the resilience of green hydrogen supply chains.

II. INDUSTRY PROFILE

The green energy industry is rapidly expanding as the world transitions toward sustainable and low-carbon energy solutions. Driven by advancements in solar, wind, and energy storage technologies, this sector plays a crucial role in reducing carbon emissions and enhancing energy security. A key application of renewable energy is green hydrogen production, which depends on stable and affordable electricity from renewable sources. However, the industry faces challenges such as seasonal energy price fluctuations, grid constraints, and policy uncertainties, which create financial risks and impact long-term investment decisions. Governments worldwide are implementing incentives, subsidies, and Power Purchase Agreements (PPAs) to support renewable energy adoption and stabilize pricing. Additionally, technological innovations in energy storage, smart grids, and hybrid energy systems are helping improve supply stability and efficiency. Addressing these challenges is essential for ensuring the long-term viability and competitiveness of green hydrogen and other renewable energy applications.

III. COMPANY PROFILE

Hyetron Energy Private Limited, established on June 19, 2024, is a Chennai-based company specializing in green hydrogen production technologies. The company's mission is to accelerate the transition to a sustainable hydrogen economy by developing advanced, cost-effective, and efficient water electrolysers. These electrolysers are designed to facilitate the decarbonization of various industries, promoting a cleaner energy landscape.

The leadership team comprises directors Anoop Selvaraj and Ullattil Vivek, who bring extensive expertise in research and development, product innovation, and engineering. Their collective experience drives Hyetron's commitment to delivering reliable and scalable hydrogen

solutions. The company operates from its registered office at 581 Anna Salai, Teynampet West, Chennai, Tamil Nadu, 600006.

Hyetron Energy emphasizes a 'Right First Time' philosophy, ensuring that its designs are both effective and reliable. This approach aims to accelerate time-to-market, minimize costs, and enhance operational efficiencies in real-world applications. Through its dedication to innovation and sustainability, Hyetron Energy seeks to play a pivotal role in advancing green hydrogen technologies for a sustainable future.

IV. SERVICE OF FERINGS

Hyetron Energy specializes in manufacturing AEM (Anion Exchange Membrane) electrolysers, which are used for green hydrogen production. These electrolysers leverage advanced membrane technology to enable efficient water electrolysis using renewable energy sources.

V. REVIEW OF LITERATURE

Joshi & Patel (2021)

This study examined the factors contributing to price fluctuations in renewable energy markets. The researchers identified seasonal variations, grid limitations, and government policy shifts as the primary drivers of volatility. For instance, solar energy output is higher during sunny months, leading to price drops, whereas winter months cause price surges. Similarly, grid infrastructure constraints often result in energy curtailments, indirectly impacting market rates.

Smith et al. (2020)

Smith et al. investigated how weather variability affects the pricing of solar and wind energy. Their analysis found that unpredictable weather patterns, such as cloudy or windless days, create supply inconsistencies that result in cost volatility. To counteract this, the study proposed integrating energy storage solutions (like batteries) and flexible pricing contracts. These mechanisms help stabilize energy supply costs by allowing producers to store excess energy when prices are low and release it during high-demand periods.

Gupta & Mehta (2022)

Gupta and Mehta focused on the economic feasibility of green hydrogen production, particularly how fluctuating renewable energy prices impact hydrogen production costs. Their findings revealed that volatile electricity prices are a major barrier to cost-effective hydrogen production. To mitigate this, the study suggested the use of long-term Power Purchase Agreements (PPAs), where prices are fixed for extended periods, and government subsidies, which lower the overall cost of production.

Bauer et al. (2019)

Bauer and colleagues explored the indirect impact of fossil fuel prices (particularly natural gas and coal) on renewable energy pricing. Their research showed that fluctuations in fossil fuel markets often spill over into electricity markets, affecting renewable energy costs. Since hydrogen production heavily depends on electricity prices, any rise in fossil fuel costs makes green hydrogen less competitive. The study concluded that the indirect link between fossil fuels and green hydrogen production underscores the need for diversified energy sourcing to reduce dependency on volatile markets.

VI. OBJECTIVE OF THE STUDY

- To identify key factors contributing to renewable energy price fluctuations from the perspective of renewable energy suppliers.
- To collect insights from renewable energy suppliers on mitigation strategies for price volatility.
- To evaluate the feasibility of these strategies for green hydrogen production and propose practical recommendations for Hyetron Energy.

VII. RESEARCH DESIGN

Descriptive Research- This study adopts a descriptive research design, utilizing a quantitative approach to examine the impact of renewable energy price fluctuations on green hydrogen production and identify mitigation strategies.

VIII. SOURCES OF DATA

The researcher's source of data can be categorized into two main ways: primary and secondary data.They will have to select one or the other method of data collection

IX. PRIMARY AND SECONDARY DATA

- Primary data are gathered through questionnaires, schedules, and direct conversations with company representatives. Schedules help researchers grasp consumer demographics and behavior.

- Secondary data are collected through books, journals, articles, company websites, and online searches, providing information about industries, companies, and historical records.

X. DATA ANALYSIS

Percentage analysis - Pricing Strategies

Pricing Strategy	Count	%
Fixed price contracts	18	60
Market-based pricing	9	30
Government tariffs/subsidies	3	10
	30	100

Observed			
	Yes	No	Sum
Small Scale (<10 MW)	3	9	12
Medium Scale (10-100 MW)	5	8	13
Large Scale (>100 MW)	1	4	5
Sum	9	21	30
Expected			
	Yes	No	Sum
Small Scale (<10 MW)	3.6	8.4	12
Medium Scale (10-100 MW)	3.9	9.1	13
Large Scale (>100 MW)	1.5	3.5	5
Sum	9	21	30
$O-E^2/E$			
	Yes	No	
Small Scale (<10 MW)	0.1	0.042857	
Medium Scale (10-100 MW)	0.310256	0.132967	
Large Scale (>100 MW)	0.166667	0.071429	
Calculation			
x^2	0.824176		
df ,Formula =(no of rows - 1)(no of columns - 1)	2		
p-value	0.662266		

Interpretation

- 60% of respondents prefer fixed price contracts, indicating a focus on price stability and risk mitigation from fluctuating renewable energy costs.
- 30% use market-based pricing, showing openness to dynamic pricing based on supplyand demand but with exposure to price volatility.
- 10% rely on government tariffs or subsidies, suggesting that while policy support exists, it is not the dominant pricing mechanism
- The overall trend highlights a preference for stability, with most companies opting for fixed pricing to ensure predictable revenue Cross tabulation and chi-square test

Observed			
	Yes	No	Sum
Small Scale (<10 MW)	0	12	12
Medium Scale (10-100 MW)	5	8	13
Large Scale (>100 MW)	2	3	5
Sum	7	23	30
Expected			
	Yes	No	Sum
Small Scale (<10 MW)	2.80	9.20	12
Medium Scale (10-100 MW)	3.03	9.97	13
Large Scale (>100 MW)	1.17	3.83	5
Sum	7	23	30
$O-E^2/E$			
	Yes	No	
Small Scale (<10 MW)	2.8	0.852174	
Medium Scale (10-100 MW)	1.275092	0.388071	
Large Scale (>100 MW)	0.595238	0.181159	
Calculation			
x^2	6.091734		
df ,Formula =(no of rows - 1)(no of columns - 1)	2		
p-value	0.047555		

Interpretation:

- The p-value (0.6623) is significantly greater than the typical significance level of 0.05.
- This indicates failure to reject the null hypothesis, suggesting that there is no statistically significant association between the scale of operations of solar EPC companies and their collaboration with energy storage companies to manage supply fluctuations.
- In other words, the likelihood of collaboration with energy storage companies does not significantly differ across small, medium, and large-scale solar EPC companies

Observed			
	Yes	No	Sum
Small Scale (<10 MW)	0	12	12
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Calculation			
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df ,Formula =(no of rows - 1)(no of columns - 1)	2		
p-value	0.047555		

Interpretation:

- The p-value (0.0476) is less than the standard significance level of 0.05, indicating that we reject the null hypothesis.
- This means there is a statistically significant association between the scale of operations of solar EPC companies and their likelihood of supplying renewable energy to green hydrogen producers.
- In simpler terms, the size of the company (small, medium, or large scale) influences whether or not they supply renewable energy to green hydrogen producers

XI. FINDINGS

- Market Volatility: The renewable energy market is perceived as highly volatile, primarily due to variations in solar power generation (56.7%), followed by grid transmission and storage issues (16.7%).
- Stakeholder Composition: Industrial companies (13) form the largest stakeholder group, followed by the government/public sector (7), while green hydrogen producers (2) and energy trading companies (0) have minimal representation.

- Organization Scale: The industry is dominated by small-scale (12) and medium-scale (13) enterprises, while large-scale players are relatively fewer (5).
- Mitigation Strategies: Long-term contracts with fixed pricing (36.7%) are the most preferred strategy to tackle price volatility, followed by diversification of energy storage solutions (23.3%) and hedging through financial instruments (16.7%).
- No significant link between company scale and collaboration with energy storage companies (P-value (0.6623) > 0.05)
- Larger companies are more likely to supply renewable energy to green hydrogen producers (P-value (0.0476) < 0.05

XII. SUGGESTIONS

- Enhancing Solar Power Stability: Investing in advanced forecasting techniques and storage solutions can reduce the impact of variations in solar power generation.
- Promoting Energy Trading Market: Developing a structured energy trading market can enhance price stability and liquidity.
- Encouraging Green Hydrogen Investments: Increased subsidies, R&D investments, and policy support can improve the attractiveness of the green hydrogen sector.
- Expanding Long-Term Pricing Mechanisms: Governments and companies should work towards expanding long-term contracts to stabilize prices and provide greater financial security

XIII. CONCLUSION

The renewable energy sector faces significant price volatility, primarily driven by solar power fluctuations and grid challenges. While small and medium enterprises dominate the industry, large-scale companies and energy trading markets remain underrepresented. Long-term contracts and energy storage solutions are the most preferred strategies to mitigate price instability. To ensure sustainable growth, policy interventions, infrastructure improvements, and greaterinvestment ingreen hydrogen and energytrading mechanisms are necessary. Addressing these challenges will enhance market stability, promote sectoral growth,and ensure a resilient renewable energy ecosystem.

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