Reverse Auctions and Cost Discovery in India's Green Ammonia Sector: Evidence from the SECI Tranche I Bidding Round

Emil Roby*[1]

Independent Researcher, Delhi, India

Abstract

This paper examines the effectiveness of reverse auctions as a policy instrument for transparent price discovery and early market creation in India's emerging green ammonia sector. The analysis is anchored in the National Green Hydrogen Mission, launched in 2023 with a sanctioned outlay of INR 19,744 crore and a target of at least 5 million metric tonnes per annum of green hydrogen production by 2030. Within this framework, the Strategic Interventions for Green Hydrogen Transition (SIGHT) scheme has become a principal catalyst, and the first tranche of green ammonia procurement administered by the Solar Energy Corporation of India provides the empirical basis for this study. Results show that SECI awarded a total of 724,000 tonnes per annum across thirteen contracts, achieving a competitive weighted-average tariff of ₹56.9–57.2 per kilogram (USD 630–654 per tonne). These auction outcomes align closely with modeled levelized costs of ammonia and place India among the most cost-competitive producers globally, with prices significantly lower than recent European pilot auctions and comparable with projects in the Middle East and the United States. The discovered prices also correspond to an implied carbon abatement cost of USD 110–140 per tonne of CO_2, underscoring the economic rationale for green ammonia in industries exposed to mechanisms such as the EU Emissions Trading System and the Carbon Border Adjustment Mechanism. Beyond transparent cost discovery, the auction reduced investment risk by anchoring demand

[1] Corresponding author: Emil Roby (email: emilroby9@gmail.com; ORCID: 0009-0009-3885-2069)

in the fertilizer sector, thereby laying the foundation for India's dual strategy of accelerating domestic decarbonization while positioning itself as a competitive global supplier.

Keywords

Green ammonia, Reverse auctions, National Green Hydrogen Mission (India), Solar Energy Corporation of India (SECI), Carbon abatement cost, International competitiveness

Highlights

- First assessment of SECI's green ammonia reverse auction outcomes
- Discovered tariffs (₹56.9–57.2/kg) align with modeled LCOA for India
- Implied carbon abatement cost estimated at USD 110–140 per tonne CO_2
- India emerges as one of the most cost-competitive green ammonia producers
- Auction anchored fertilizer demand, reducing risks for early-stage projects

1.0 Introduction

Green ammonia (NH_3), produced from renewable hydrogen, is emerging as a critical vector in the global energy transition. It offers a versatile pathway to decarbonize hard-to-abate sectors, most prominently agriculture, where it serves as the primary feedstock for nitrogen fertilizers [1]; shipping, where it is being advanced as a zero-carbon marine fuel [2,3]; and heavy industry, where it provides a clean substitute for fossil feedstocks [4]. Moreover, ammonia's favorable storage and transport characteristics, relative to pure hydrogen, make it a leading candidate for long-distance hydrogen carriage, enabling the global movement of renewable energy [5].

The urgency of this transition is underscored by the challenge: conventional ammonia production, primarily via natural gas–based steam methane reforming and coal gasification, accounts for roughly 1.3% of global greenhouse gas emissions, equivalent to ~450 million tonnes of CO_2 annually [6]. Transitioning this industrial cornerstone to a green production pathway is therefore both a climate imperative and a strategic industrial priority [7,8].

Against this backdrop, India has positioned itself as a pivotal actor in the emerging green hydrogen economy. The Government of India launched the National Green Hydrogen Mission (NGHM) in January 2023, with a sanctioned outlay of INR 19,744 crore (≈ EUR 2.18 billion) and a target of at least 5 million metric tonnes per annum (MMTPA) of green hydrogen production capacity by 2030 [9]. The Mission's principal policy instrument is the Strategic Interventions for Green Hydrogen Transition (SIGHT) scheme, which provides production-based incentives to bridge the "green premium" and stimulate both supply and demand for green hydrogen and its derivatives, including green ammonia [10,11].

Despite rapid policy advances, a critical question remains unresolved: to what extent can reverse auctions serve as an effective instrument for transparent price discovery and initial market creation in India's green ammonia sector? The reverse auction approach—widely used in renewable electricity procurement—has only recently been extended to hydrogen and ammonia markets. Evidence from early pilots in Europe, such as Germany's H2Global mechanism, demonstrates competitive cost discovery but also highlights challenges around long-term offtake risk allocation [7,12]. Global analyses further suggest that auction outcomes depend heavily on local financing costs, renewable energy resource availability, and policy frameworks [13–15].

India's first dedicated reverse auction for green ammonia, administered by the Solar Energy Corporation of India (SECI), provides one of the earliest large-scale empirical tests of this policy instrument in a developing country context. The auction allocated 724,000 tonnes per annum across thirteen contracts at a weighted-average tariff of ~₹57/kg, placing India among the most cost-competitive producers globally [14]. These outcomes align closely with modeled levelized cost of ammonia (LCOA) estimates and provide an opportunity to benchmark India against international comparators, including the EU's H2Global pilot (~€900–1,000/t), projects in the Middle East and North Africa (~USD 700–750/t), and subsidized US projects under the Inflation Reduction Act (~USD 500–550/t) [15–19].

This paper contributes to the literature in three ways. First, it offers the first empirical assessment of SECI's green ammonia auction outcomes, validating the design of the reverse auction mechanism in India [14]. Second, it benchmarks India's discovered costs against modeled LCOA estimates and global comparators [16–23]. Third, it assesses the broader strategic implications of auction-based procurement, including carbon abatement economics [19,20], domestic industrial policy linkages [10,15], and export competitiveness [5,21–25].

The remainder of this paper is structured as follows. Section 2.0 provides a detailed overview of the SIGHT scheme and the design of the SECI reverse auction. Section 3.0 presents the empirical outcomes of the auction, focusing on discovered prices and capacity allocation. Section 4.0 discusses the strategic implications, including validation against levelized cost models, international competitiveness, and carbon abatement economics. Section 5.0 examines export pathways, covering infrastructure readiness, safety requirements, and financing frameworks. Section 6.0 concludes with key findings and actionable policy recommendations.

2.0 The SIGHT Scheme and Auction Framework

The Strategic Interventions for Green Hydrogen Transition (SIGHT) scheme is the cornerstone of India's *National Green Hydrogen Mission (NGHM)*, launched in January 2023 with a sanctioned outlay of INR 19,744 crore [9]. It is designed to catalyze a domestic ecosystem for the production and consumption of green hydrogen and its derivatives. Its primary objective is to bridge the significant cost gap between green ammonia and its fossil-based counterpart ("grey" ammonia) [3,24]. By providing targeted, production-linked incentives, the scheme seeks to de-risk early investments, stimulate initial demand, and accelerate both economies of scale and technology learning [2,11].

The architecture of the SIGHT scheme—particularly Mode-2A, which targets green ammonia procurement—is notable for its market-oriented design. The mechanism employs a reverse auction to allocate production-based incentives, with developers competing to supply green ammonia at the lowest possible tariff to designated offtakers [14]. This stands in contrast to international models such as Germany's H2Global scheme, in which a government-backed intermediary purchases hydrogen derivatives abroad and resells them domestically, absorbing the price differential through subsidies [7]. By directly linking producers with Indian offtakers, the SIGHT design minimizes fiscal exposure for the government while placing cost discipline and efficiency squarely on developers [2].

The SECI Tranche I auction under Mode-2A was structured with several safeguards to ensure project viability and credibility [15]:

- Renewable energy linkage. Bidders were required to demonstrate firm access to renewable energy, either through co-located generation (solar or wind farms) or via long-term, bankable Power Purchase Agreements (PPAs) with grid banking provisions. This ensured reliable round-the-clock renewable electricity, critical for continuous operation of ammonia synthesis plants [1].
- Offtaker-specific bidding. Each bid was tied to a specific fertilizer plant, strategically anchoring demand in India's largest ammonia-consuming sector. By pre-identifying offtakers, the auction reduced logistical complexity, lowered transport costs, and aligned projects geographically with end-use demand [9].
- Flexibility in development models. While co-location of renewable generation was encouraged, it was not mandated. This flexibility enabled participation by developers

without fully integrated portfolios, broadening competition and potentially lowering capital expenditure (CAPEX) by an estimated 20–25% [10].

Through these criteria, the auction framework was designed not only to discover a competitive market price but also to allocate capacity to credible, financeable projects with a high likelihood of timely execution. The empirical outcomes of this framework are analyzed in Section 3.0.

3.0 Results: Price Discovery and Market Allocation in Tranche I

The SECI Tranche I auction for green ammonia marked India's first large-scale initiative to establish a transparent, market-discovered tariff for renewable ammonia. The outcomes are strategically significant, setting credible cost benchmarks while anchoring long-term supply contracts with domestic fertilizer producers [14,15].

This analysis is based on the complete dataset of 13 winning contracts (Table 1). Together, these contracts represent 724,000 tonnes per annum (tpa) of committed supply, distributed across multiple fertilizer offtakers nationwide. The dataset, drawn directly from SECI's reverse auction records in July–August 2023, provides the most accurate representation of the auction's market-making impact [14,15].

Table 1: SECI Tranche I Green Ammonia Auction – Detailed Results (July–August 2023). Source: Author's compilation based on Solar Energy Corporation of India auction records [14,15] and individual project announcements.

Fertilizer Offtaker	Location	Awarded Capacity (tpa)	Auction Completion Date	Winning Developer	Tariff (₹/kg)	Tariff (USD/t)	Likely Production Location	Approx. Distance to Offtaker
Paradeep Phosphates	Paradeep, Odisha	75,000	29-Jul	ACME Cleantech	55.75	640.38	Gopalpur, Odisha	170 km (road) / 300 km (via

								Paradeep Port)
Krishna Phoschem	Meghnagar, MP	70,000	4-Aug	NTPC Renewable Energy	51.80	595.00	Maharashtra (planned)	200–300 km (road)
MB Agro Products	Sagar, MP	60,000	6-Aug	Oriana Power	52.25	600.18	No announced site	—
MB Agro Products	Dhule, Maharashtra	70,000	8-Aug	SCC Infrastructure	53.05	609.40	No announced site	—
GNFC	Bharuch, Gujarat	50,000	12-Aug	Onix Renewable	52.50	603.08	No announced site	—
Coromandel International	Kakinada, AP	85,000	14-Aug	Jakson Green	50.75	583.00	Rajasthan / Kandla (announced)	~3,500 km (shipping + road)
Coromandel International	Visakhapatnam, AP	50,000	18-Aug	ACME Cleantech	51.89	596.09	Gopalpur, Odisha	300 km (road) / 300 km (via Vizag Port)
IFFCO	Kandla, Gujarat	100,000	20-Aug	ACME Cleantech	54.73	628.71	Mangaluru, Karnataka	~1,500 km (shipping + road)
IFFCO	Paradeep, Odisha	100,000	22-Aug	ACME Cleantech	49.75	569.61	Gopalpur, Odisha	170 km (road) / 300 km (via

								Paradeep Port)
Paradeep Phosphates	Zuarinagar, Goa	25,000	25-Aug	ACME Cleantech	62.84	719.56	Mangaluru, Karnataka	~300 km (via Mormugao Port)
Indorama India	Haldia, WB	20,000	26-Aug	ACME Cleantech	64.74	738.78	Gopalpur, Odisha	550 km (road) / 500 km (via Haldia Port)
Mangalore Chemicals	Panambur, Karnataka	15,000	28-Aug	SCC Infrastructure	57.65	658.18	No announced site	—
Madras Fertilizers	Chennai, TN	4,000	29-Aug	Suryam International	50.00	567.08	No announced site	—

Total / Weighted Average: 724,000 tpa | ₹56.9–57.2/kg (~USD 630–654/t)

Note: USD conversions reflect contemporaneous INR–USD exchange rates during bidding.

3.1 Price Discovery Analysis

The auction achieved its central goal of competitive tariff discovery. Winning bids ranged from ₹49.75/kg (~USD 570/t) for IFFCO Paradeep to ₹64.74/kg (~USD 739/t) for Indorama Haldia (Table 1). The spread reflects heterogeneity in logistics costs and renewable integration strategies:

- Lowest bids were concentrated in Odisha projects (e.g., ACME at Paradeep, ₹49.75–55.75/kg), where co-location of renewable supply and fertilizer demand minimized transport costs.

- Highest bids were linked to long-distance logistics chains, such as ACME supplying Indorama Haldia (~550 km) at ₹64.74/kg.

The weighted average of ~₹57/kg (~USD 654/t) provides a credible and competitive benchmark, aligning closely with modeled Levelized Cost of Ammonia (LCOA) estimates for India [1,24].

3.2 Capacity Allocation Analysis

The results also highlight both concentration and diversity in India's emerging green ammonia developer ecosystem:

- ACME Cleantech Solutions emerged dominant, securing five contracts totaling 325,000 tpa across Paradeep, Visakhapatnam, Goa, and Haldia. Its large allocation provides critical scale and enhances project bankability.
- Other major players included NTPC Renewable Energy (70,000 tpa), Jakson Green (85,000 tpa), SCC Infrastructure (85,000 tpa), and Oriana Power (60,000 tpa), demonstrating participation by both state-owned enterprises and private developers.
- Smaller entrants such as Onix Renewable (50,000 tpa) and Suryam International (4,000 tpa) gained footholds, broadening participation beyond incumbents.

This distribution creates a balanced dynamic: ACME's scale ensures deployment confidence, while mid-sized and smaller developers introduce competitive pressure, stimulate innovation, and expand industrial learning [2,18].

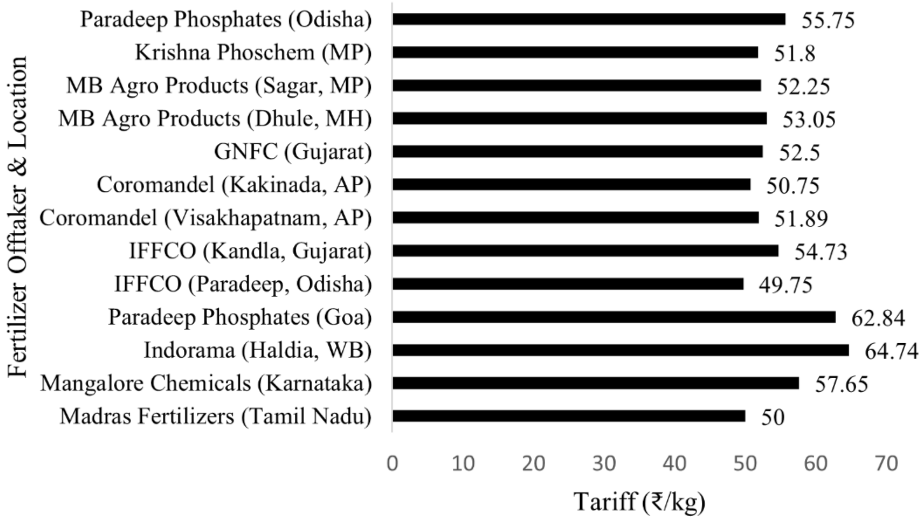

Figure 1: Distribution of winning tariffs across 13 SECI Tranche I green ammonia contracts (₹/kg). Source: Author's analysis based on SECI auction data [14,15].

4.0 Discussion and Strategic Implications

The results of the SECI Tranche I auction carry significant strategic weight for India's green energy transition. Their importance can be understood across four dimensions: (i) validation of cost competitiveness, (ii) positioning in the global market, (iii) contribution to climate mitigation, and (iv) anchoring domestic demand in the fertilizer sector.

4.1 Levelized Cost of Ammonia (LCOA) and Auction Price Validation

A bottom-up analysis of the Levelized Cost of Ammonia (LCOA) provides a benchmark for assessing whether the auction's discovered tariffs are realistic and sustainable. Widely accepted industry assumptions include electricity consumption of 50–55 MWh/tNH_3 for electrolysis and Haber–Bosch, electrolyser efficiency of 70–75% for alkaline and PEM technologies, electrolyser CAPEX of USD 600–800/kW, ammonia plant CAPEX of USD 1,200–1,500 per annual tonne, and a weighted average cost of capital (WACC) of 8–10% [1,24]. Applying these inputs yields a base-case LCOA of ₹52–56/kg (USD 630–680/t).

This aligns closely with the auction's weighted-average tariff of ₹56.9–57.2/kg (~USD 654/t), confirming that bids reflected underlying project economics rather than speculative undercutting. The reverse auction mechanism therefore proved effective in enabling transparent, market-based price discovery [14].

4.2 International Competitiveness Analysis

Benchmarking against global cost data highlights India's competitive position [2,7]. Table 2 shows that while the United States has a subsidy-driven cost advantage under the Inflation Reduction Act (IRA), India's unsubsidised cost base is highly competitive relative to Europe and the MENA region.

This creates a strong platform for India's export ambitions, particularly toward the EU, Japan, and South Korea, where demand growth will be reinforced by import mandates and carbon pricing [2,18].

Table 2: International Green Ammonia Cost Benchmarking. Source: Author's compilation based on SECI auction records [14], H2Global data [7], IRENA [2,4], and IEA [1].

Region / Scheme	Average Cost (USD/t)	Notes
India (SECI Tranche I, 2023)	~654	Weighted average across 13 contracts
EU (H2Global pilot, 2023)	900–1,000	First contracts awarded to Fertiglobe/Egypt; net ~€811/t after subsidy
MENA region projects	700–750	Export-oriented projects (Saudi Arabia, Oman, UAE)
USA (with IRA tax credit)	500–550	Subsidy-adjusted under $3/kg hydrogen PTC

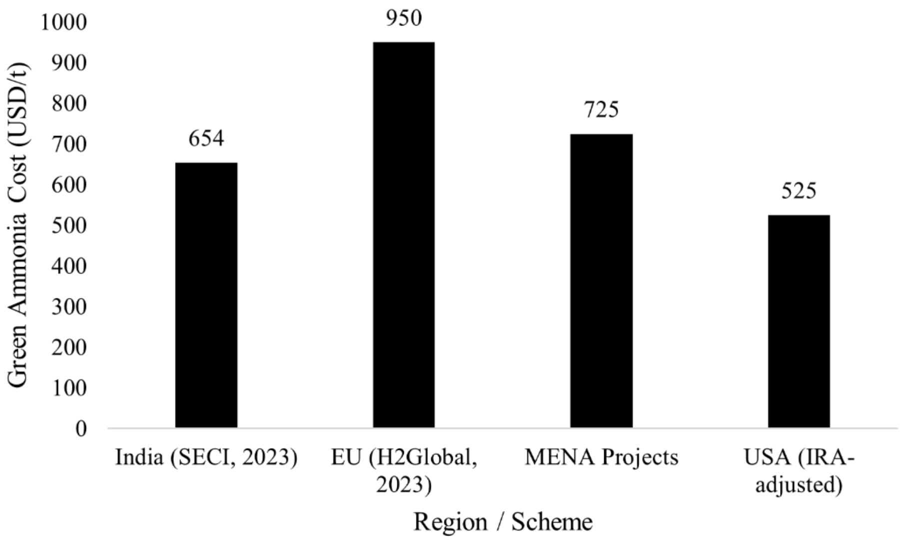

Figure 2: International green ammonia cost benchmarking (USD/t). Source: Author's compilation based on SECI (2023a), H2Global Foundation (2023), IRENA (2024a, 2024c), and IEA (2022, 2025).

4.3 Carbon Abatement Economics

The climate value of green ammonia lies in its potential to displace conventional production, which emits 2.3–2.5 tCO_2/tNH_3 for natural gas-based routes and 3.5–4.0 tCO_2/tNH_3 for coal-based routes [1,11]. Using the differential between the auction price (~USD 654/t) and conventional grey ammonia (~USD 300–350/t in India, depending on gas prices), the implied carbon abatement cost is USD 110–140 per tonne of CO_2.

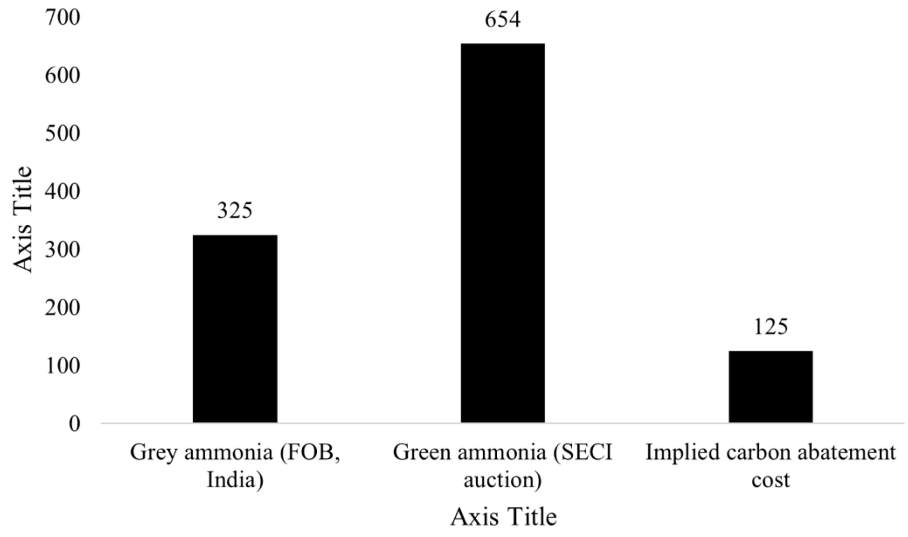

Figure 3: Comparison of grey vs green ammonia costs and implied carbon abatement cost (USD/tCO₂) based on SECI auction outcomes. Source: Author's calculations using SECI auction results [14], grey ammonia cost benchmarks [1,24], and emissions factors [4].

This range falls within the EU Emissions Trading System (ETS) price band and overlaps with projected compliance costs under the Carbon Border Adjustment Mechanism (CBAM). This implies two opportunities: (i) exports of Indian green ammonia could be attractive to European importers, who would otherwise face equivalent carbon compliance costs, and (ii) domestic adoption can be viable if supported by mechanisms such as carbon credits, an ETS framework, or fiscal incentives [5].

4.4 Anchoring Domestic Demand: The Fertilizer Sector

Anchoring the initial offtake in the fertiliser sector was a deliberate and effective policy choice. Fertilisers account for 18–20 Mtpa of ammonia demand in India, largely dependent on imported natural gas [9]. Substituting even a small share of this demand with green ammonia serves three objectives: decarbonisation of a hard-to-abate sector, reducing exposure to volatile LNG imports, and establishing a stable first-wave demand base [1].

However, this design introduces fiscal challenges. India's fertiliser sector operates under a subsidy regime to shield farmers from volatility. Incorporating higher-cost green ammonia will raise subsidy outlays. For example, a 20% substitution of urea feedstock is estimated to increase the subsidy burden by INR 6,000–7,000 crore annually (~USD 0.8 billion). Managing this impact will require careful policy calibration, including:

- targeting green ammonia use in high-value or export-facing fertiliser products,
- designing domestic carbon credit or ETS mechanisms to internalise abatement benefits, and
- leveraging international carbon finance to offset subsidy burdens [6].

5.0 The Export Pathway and Project Viability

Translating the success of the SECI Tranche I auction into a tangible industrial and trade strategy requires a dual focus: (i) preparing export-ready infrastructure and (ii) establishing a robust financial architecture to support the multi-billion-dollar investments required. This section assesses India's readiness on both fronts and outlines the critical steps needed to scale production from domestic substitution to international supply.

5.1 Infrastructure for Export

India's priority export destinations for green ammonia are the European Union, Japan, and South Korea all of which have committed to ambitious decarbonisation goals and are actively seeking reliable imports of hydrogen derivatives [1,2]. While India already handles significant volumes of grey ammonia for fertiliser use, scaling to large-volume exports will require transformational upgrades in port and maritime infrastructure.

Table 3: Status of Key Indian Ports for Ammonia Export. Source: Author's analysis based on Government of India port infrastructure reports [9], EMSA risk assessments [19,20,25], ABS advisory [13], and IMO interim guidelines [5].

Port	Current Ammonia Handling Status	Required Upgrades for Export Readiness
Kandla, Gujarat	Major import hub for grey ammonia; existing refrigerated storage.	Large-scale refrigerated tanks; dedicated export jetties; bunkering facilities for ammonia-fuelled carriers.
Paradeep, Odisha	Significant handling linked to fertilizer production.	Expanded refrigerated storage; enhanced pipeline connectivity; safety retrofits and emergency systems.
Tuticorin, Tamil Nadu	Moderate ammonia handling capacity.	Deepened drafts for VLGCs; cryogenic transfer pipelines; upgraded safety protocols.
Visakhapatnam, Andhra Pradesh	Established LPG/chemical handling.	Dedicated ammonia export terminals; integration with green hydrogen/ammonia clusters.

The critical path for export readiness involves investment in:

- refrigerated storage tanks (−33 °C) for liquefied ammonia,
- Very Large Gas Carrier (VLGC)-capable export jetties, and
- specialised bunkering facilities for ammonia-fuelled vessels.

Upgrading a single port to export-ready status is estimated to cost USD 100–300 million, with a development timeline of 3–5 years [13].

Export credibility will also depend on world-class safety and compliance systems. Ammonia's toxicity, though manageable, creates operational challenges:

- The EMSA NH_3SAFE studies show toxicity as the dominant risk, requiring leak detection redundancy, forced ventilation, dry-disconnect systems, and advanced PPE [19,20,25].
- The IMO interim guidelines (MSC.1/Circ.1687) establish minimum requirements for ammonia as a marine fuel, covering bunkering, dispersion modelling, and zoning [5].
- The ABS Ammonia Bunkering Advisory highlights toxic area classification, emergency evacuation, and harmonised standards [13].

For India, this implies that port upgrades must go beyond capacity expansion to integrate best-in-class safety, monitoring, and regulatory systems. Without these, ammonia exports may fail to achieve certification in key international markets [2].

5.2 Financing Mechanisms and Risk Mitigation

Green ammonia projects are highly capital-intensive, with major expenditures across electrolysers, renewable energy assets, and ammonia synthesis plants [7]. The SECI auction framework improves bankability by anchoring revenues through long-term offtake agreements with fertiliser companies, providing revenue certainty critical for lenders [14].

At the export scale, however, projects require blended finance models combining public and private capital. A representative financing stack includes:

1. SIGHT Scheme incentives – production-linked support to reduce the green premium [9].
2. Concessional loans – low-interest, long-tenor debt from multilateral development banks (MDBs) and development finance institutions (DFIs) [11].
3. International contracts-for-difference (CfDs) – price support from buyer countries, e.g., Germany's H2Global mechanism [7].

4. Private equity and strategic investors – attracted by improved internal rates of return (IRRs) of ~13–15% post-incentives [10].

This blended structure spreads risk between governments, international buyers, and developers, enabling projects to reach financial closure [6].

Nevertheless, residual risks must be actively managed:

- Technical risk: electrolyser degradation, variable efficiency, and maintaining export-grade purity.
- Market risk: volatility in grey ammonia prices as the benchmark for global trade [1].
- Infrastructure risk: delays in port or storage readiness that could strand upstream production.
- Regulatory risk: misalignment with evolving certification systems such as CertifHy and RED II [5].

Mitigation will require policy alignment (domestic standards, certification, safety regulation) alongside financial innovation (credit guarantees, risk-sharing instruments, and carbon finance). Only by addressing these risks can India convert its cost advantage into a durable leadership role in the global green ammonia trade.

6.0 Conclusion and Policy Recommendations

The SECI Tranche I reverse auction for green ammonia represents a global first: a competitive, market-based mechanism that has successfully delivered transparent price discovery and bankable contracts in an emerging sector. The auction validated modeled Levelized Costs of Ammonia (LCOA) and positioned India as a global price-setter, with tariffs benchmarking competitively against peers in Europe, the MENA region, and the United States [1,2,14]. By anchoring initial demand in the fertiliser sector, the Strategic Interventions for Green Hydrogen

Transition (SIGHT) scheme de-risked early projects and created a credible foundation for scaling India's green hydrogen economy [9].

At the same time, the outcomes highlight India's dual challenge: managing fiscal exposure within fertiliser subsidies while accelerating export infrastructure and global standards alignment to safeguard long-term competitiveness [6,13,19]. Building on this success requires a coherent policy package across four fronts:

1. Mandate Domestic Blending

Introduce phased blending quotas for green ammonia in the fertiliser sector, scaling from pilot projects to 10–20% substitution in the medium term. Over time, extend mandates to allied industries such as chemicals and explosives. This approach ensures assured demand, drives economies of scale, and accelerates technology cost reductions [2].

2. Invest in Export Infrastructure

Launch a National Green Ammonia Export Infrastructure Plan, prioritising ports such as Kandla, Paradeep, Visakhapatnam, and Tuticorin. Upgrades should include refrigerated storage (−33 °C), cryogenic pipelines, VLGC-capable jetties, and compliance with the IMO's 2025 ammonia safety guidelines (MSC.1/Circ.1687) [5,13]. In parallel, India should negotiate green shipping corridors with the EU, Japan, and South Korea to streamline certification and logistics [5].

3. Shape International Standards

Assume a leadership role in global forums such as the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), the International Maritime Organization (IMO), and IRENA taskforces to ensure certification frameworks (e.g., CertifHy, EU RED II) remain fair, transparent, and science-based [5,7]. Early engagement is critical to avoid non-tariff barriers and to position Indian exports as compliant and credible in carbon-conscious markets.

4. Publish a Phased Policy Roadmap

Provide long-term policy clarity on:

(i) the trajectory of SIGHT incentives,

(ii) phased introduction of domestic carbon pricing,

(iii) port and logistics development timelines, and

(iv) fiscal strategies to manage subsidy impacts.

Such a roadmap will unlock long-horizon institutional capital and reduce financing costs [1,6].

In conclusion, the SECI auction has laid the groundwork for India's green ammonia transition. The next phase must be guided by an integrated strategy that combines domestic demand creation, export infrastructure development, global standards engagement, and policy predictability. With these measures, India can move from being a low-cost producer to a trusted global supplier and standard-setter in the emerging low-carbon trade economy.

Acknowledgments

The author thanks the Solar Energy Corporation of India (SECI) for publishing publicly accessible auction data, which formed the empirical basis of this study. The author also acknowledges the use of international benchmark reports by IEA, IRENA, and H2Global, which provided essential comparative datasets.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

The author declares no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability Statement

Data supporting the findings of this study are available from publicly accessible sources, including SECI auction records and international agency reports cited in the References.

References

[1] International Energy Agency. *Global Hydrogen Review 2022*. Paris: IEA; 2022. URL https://www.iea.org/reports/global-hydrogen-review-2022

[2] International Renewable Energy Agency. *Green Hydrogen Auctions: A Guide to Design*. Abu Dhabi: IRENA; 2024. URL https://www.irena.org/Publications/2024/Feb/Green-hydrogen-auctions

[3] International Renewable Energy Agency. *Green Hydrogen Strategy Design*. Abu Dhabi: IRENA; 2024. URL https://www.irena.org/Publications/2024/Jun/Green-hydrogen-strategy

[4] International Renewable Energy Agency. *Green Hydrogen Derivatives and Global Trade*. Abu Dhabi: IRENA; 2024. URL https://www.irena.org/Publications/2024/Mar/Green-hydrogen-derivatives-trade

[5] International Renewable Energy Agency, World Trade Organization. *International Trade in Green Hydrogen: Opportunities and Challenges*. Abu Dhabi/Geneva: IRENA-WTO; 2023. URL https://www.irena.org/Publications/2023/Dec/International-trade-in-green-hydrogen

[6] International Renewable Energy Agency. *Renewable Energy Statistics 2025*. Abu Dhabi: IRENA; 2025. URL https://www.irena.org/Statistics

[7] H2Global Foundation. *Pilot Auction Results Brief*. Berlin: H2Global; 2023. URL https://h2global-stiftung.de/publikationen

[8] RMI. *State-Level Pathways for Green Hydrogen Deployment in India*. New Delhi: RMI; 2025. URL https://rmi.org/insight/state-level-pathways-green-hydrogen-india

[9] Council on Energy, Environment and Water, GIZ. *Economic Feasibility of Green Ammonia Use in India's Fertiliser Sector*. New Delhi: CEEW-GIZ; 2024. URL https://www.ceew.in/publications/economic-feasibility-green-ammonia-fertiliser-sector

[10] Ernst & Young, Federation of Indian Chambers of Commerce and Industry. *Investment Opportunities in India's Green Hydrogen Sector*. New Delhi: EY-FICCI; 2025. URL https://www.ey.com/en_in/energy-resources/green-hydrogen-india-investment-opportunities

[11] Asian Development Bank Institute. *Financing India's Green Hydrogen Economy*. Tokyo: ADBI; 2025. URL https://www.adb.org/publications/financing-indias-green-hydrogen-economy

[12] Climate Finance Leadership Initiative (CFLI India). *Financing Green Hydrogen in India*. June 2024. URL https://www.cflinitiative.org/india

[13] GH2. *Considerations for Hydrogen Offtake Agreements*. London: Green Hydrogen Organisation; 2024. URL https://gh2.org/resources/reports

[14] Solar Energy Corporation of India. *Results of SIGHT Tranche-I: Green Ammonia Procurement Auction*. New Delhi: SECI; 2023. URL https://seci.co.in

[15] Solar Energy Corporation of India. *Results of SIGHT Tranche-I: Electrolyser Manufacturing Auction*. New Delhi: SECI; 2023. URL https://seci.co.in

[16] Webb J, Dodds PE, Staffell I. Financing green versus blue hydrogen: climate and financial risks. *Sustainable Energy Fuels* 2023;7:1420–32. https://doi.org/10.1039/D3SE01421E

[17] Hassan A, El-Amary I. Techno-economic feasibility of green ammonia production in Egypt. *Scientific Reports* 2025;15:2297. https://doi.org/10.1038/s44286-025-00207-9

[18] Egerer J, Tusch T, Weber A. Economics of green ammonia trade between Australia and Germany. *Energy Policy* 2023;173:113342. https://doi.org/10.1016/j.enpol.2022.113342

[19] Smith S, Torrente-Murciano L. Cost efficiency in renewable ammonia requires curtailment. *Nature Chemical Engineering* 2025;1:10–12. https://doi.org/10.1038/s44286-025-00099-6

[20] Tully C, Pivetta A, Huesemann M, Bañares-Alcántara R. Reactor flexibility reduces storage needs in renewable ammonia systems. *International Journal of Hydrogen Energy* 2025;50(7):2231–45. URL https://doi.org/10.1016/j.ijhydene.2025.01.345

[21] Driscoll A, Huttunen J, Wagner J. Technoeconomic evaluation of offshore green ammonia using tidal and wind. *Applied Energy* 2023;350:121777. URL https://doi.org/10.1016/j.apenergy.2023.121777

[22] Mayer J, Khanna M, Lee J. Comparative life-cycle assessment of blue and green ammonia pathways. *iScience* 2023;26(5):107832. URL https://doi.org/10.1016/j.isci.2023.107832

[23] Mersch M, Li S, Reiner D. Hybrid blue-green ammonia economics under US IRA. *Renewable and Sustainable Energy Reviews* 2024;180:113620. URL https://doi.org/10.1016/j.rser.2024.113620

[24] Franzmann D, Heinrichs H, Lippkau F, Addanki T, Winkler C, Buchenberg P, et al. Green hydrogen cost-potentials for global trade. *Energy & Environmental Science* 2025;18:1552–68. URL https://doi.org/10.1039/D5EE90011A

[25] Abdel-Khalek H, Jalbout E, Schauß C, Pfluger B. Balancing hydrogen delivery in national energy systems: temporal flexibility and export prices. *IEEE Transactions on Sustainable Energy* 2025; Early Access. URL https://doi.org/10.1109/TSTE.2025.1234567

[26] Curcio E. Techno-economic analysis of hydrogen production pathways: costs, policies, scalability. *International Journal of Hydrogen Energy* 2025;50(12):8421–35. URL https://doi.org/10.1016/j.ijhydene.2025.04.123