Financing Green Ammonia in India: Blended Finance, CfDs, and Financial Modelling Approaches

Abstract

India's ambition to become a global leader in clean energy hinges on its ability to finance a large-scale transition to green ammonia, with capital requirements estimated at approximately USD 15–20 billion to achieve its target capacity by 2035. The central challenge lies in the capital-intensive nature of green ammonia projects, which renders conventional debt and equity financing insufficient to meet national targets. This study presents a first-of-its-kind application of structured project finance modelling to the Indian context, systematically comparing the bankability of green ammonia projects under commercial, blended finance, Contracts for Difference (CfD), and green bond structures. The analysis evaluates each scenario against key financial metrics—including Levelized Cost of Ammonia (LCOA), Net Present Value (NPV), Internal Rate of Return (IRR), and the Debt Service Coverage Ratio (DSCR)—to identify the most effective de-risking and cost-reduction pathways. The principal finding is that a strategic combination of concessional finance to lower the cost of capital and CfDs to ensure revenue stability is critical for making green ammonia projects bankable and cost-competitive in the current Indian market.

1. Introduction

Green ammonia, a key derivative of green hydrogen, is foundational to India’s strategy for decarbonizing its hard-to-abate sectors and establishing itself as a global clean energy hub. Its production is central to the objectives of the National Green Hydrogen Mission (NGHM), which targets 5 million metric tonnes per annum (MMTPA) of green hydrogen production by 2030. By substituting grey ammonia in critical industries like fertilizers, green ammonia not only reduces domestic emissions but also diminishes reliance on volatile imported fossil fuels, thereby enhancing national energy security. Successfully financing this transition is therefore of paramount strategic importance for India's sustainable economic future.

The Capital Intensity Challenge

The primary obstacle to scaling green ammonia production is the high capital expenditure (CAPEX) associated with greenfield projects. This capital intensity is driven by the combined costs of key technology components: high-capacity electrolyzers for hydrogen production, the Haber-Bosch synthesis loop for ammonia conversion, and the integration of these systems with round-the-clock (RTC) renewable energy (RE) sources. The scale of investment required—estimated at USD 3–4 billion per MTPA of capacity—creates a significant financing gap. Conventional financing mechanisms, structured for more mature and less capital-intensive sectors, struggle to bridge this gap, creating commercial uncertainty and hindering investment in the large-scale projects needed to achieve national targets.

Research Framework

This paper's objective is to model and evaluate different financing structures to test their effect on the bankability and cost-competitiveness of green ammonia projects in India. It addresses the central challenge of high financing costs by quantitatively assessing how targeted financial instruments can de-risk projects and attract private capital. The research is guided by the following questions:

1. *What is India's projected total financing requirement to meet its green ammonia targets by 2035?*
2. *Which financial instruments and structures are most effective in lowering the Levelized Cost of Ammonia (LCOA)?*
3. *What combination of public and private capital is required to mobilize investment at the necessary scale?*

A thorough review of existing global financing mechanisms provides the necessary context for analyzing India's specific challenges and the opportunities for tailored financial innovation.

2. Literature Review: Global Financing Mechanisms and the Indian Context

While green ammonia is a nascent sector, valuable lessons can be drawn from the global policy support mechanisms designed for green hydrogen and the established principles of project finance in the renewable energy sector. This review identifies key international instruments that have successfully catalyzed investment and highlights the analytical gap in Indian-specific research that this paper aims to fill.

International Support Frameworks

Several major economies have implemented robust policy frameworks to stimulate low-carbon hydrogen and ammonia markets. These models offer proven templates for de-risking investment and bridging the cost gap with conventional fossil-based production.

- **European Union Mechanisms:** The EU has created strong demand-side pull through its 'Fit for 55' and REPowerEU plans, which mandate the use of renewable fuels of non-biological origin (RFNBOs). This is complemented by supply-side support from the EU Hydrogen Bank, which utilizes competitive auctions to award a fixed premium for renewable hydrogen production, thereby providing long-term revenue certainty to producers.
- **Germany's H2Global:** This innovative double-sided auction mechanism employs a government-backed intermediary to bridge the gap between producer costs and market prices. The intermediary signs long-term contracts to purchase green hydrogen derivatives (like ammonia) at a fixed price and then sells them to European consumers through short-term auctions, absorbing the price difference and de-risking the transaction for both sides.
- **United States' Inflation Reduction Act (IRA):** The IRA has fundamentally altered project economics in the U.S. through its Production Tax Credit (PTC), which offers up to USD 3/kg for clean hydrogen. This direct subsidy effectively bridges the cost gap with grey hydrogen, making green alternatives immediately competitive and triggering a surge in investment announcements.
- **Japanese Subsidies:** As a major energy importer, Japan has focused on securing future supply through a strategy centered on direct subsidies and long-term offtake agreements, exemplified by competitive tenders for low-emission ammonia to co-fire its power plants.

Financing Models in Emerging Markets

Project finance is a well-established practice in mature renewable energy sectors like solar and wind, but its application to hydrogen and ammonia projects faces unique hurdles. These projects carry higher technology and market risks due to the novelty of large-scale electrolyzer integration and the volatility of ammonia as a traded commodity.

In this context, **blended capital** emerges as a critical enabler. This approach combines concessional finance from Multilateral Development Banks (MDBs) or national financial institutions with commercial private capital. The concessional debt serves to de-risk projects by offering lower interest rates, longer tenors, or risk guarantees, which in turn reduces the project's overall weighted average cost of capital (WACC). This makes the project more attractive to commercial lenders and equity investors, effectively mobilizing private finance at scale in emerging markets like India.

The Gap in Indian-Specific Empirical Analysis

While these global mechanisms and financing principles offer valuable models, there is a scarcity of empirical, model-based studies that apply these structured project finance concepts specifically to the Indian green ammonia sector. Existing analysis has largely focused on policy frameworks or high-level market potential. There is a clear need for quantitative research that models the financial performance of Indian green ammonia projects under different support schemes.

To address this gap, this paper develops a robust financial model to simulate the impact of these mechanisms on project bankability and cost-competitiveness within the unique Indian context.

3. Methodology

This section details the quantitative project finance model developed to assess the bankability and economic viability of green ammonia projects under different financing scenarios. The framework is designed to provide clear, data-driven insights for investors and policymakers.

Discounted Cash Flow (DCF) Project Finance Model

The core of the analysis is a standard Discounted Cash Flow (DCF) project finance model, which projects cash flows over the typical 20–30 year lifetime of a project and discounts them to determine its present value. This proprietary DCF model was developed for the purpose of this study, integrating cost parameters and financing structures relevant to the Indian market to provide a comparative analysis of different support mechanisms. The model evaluates project viability against four key financial metrics:

- **Levelized Cost of Ammonia (LCOA):** The discounted lifecycle cost per tonne of ammonia produced. This metric allows for a direct comparison of the cost-competitiveness of green ammonia against both grey ammonia and international benchmarks.
- **Internal Rate of Return (IRR):** The discount rate at which the net present value (NPV) of all cash flows equals zero. It is a primary indicator of profitability for equity investors.
- **Net Present Value (NPV):** The difference between the present value of cash inflows and outflows. A positive NPV indicates that the projected earnings generated by a project (in present-day currency) exceed the anticipated costs.

- **Debt Service Coverage Ratio (DSCR):** The ratio of cash flow available to pay debt obligations. Lenders use this metric to assess the project's ability to service its debt; a DSCR below a certain threshold (typically 1.2x–1.3x) renders a project unbankable.

Financing Scenarios

To test the impact of different financial instruments, four distinct scenarios were modeled. Each scenario alters the capital structure and revenue assumptions to reflect a different policy or market environment.

1. ***Base Commercial Case:*** A baseline scenario funded with conventional private equity and commercial bank debt. This case assumes no government subsidies or concessional financing and serves as a benchmark to measure the impact of interventions.
2. ***CfD Support Case:*** This scenario incorporates a Contract for Difference (CfD) mechanism. The CfD provides revenue stabilization by guaranteeing a fixed "strike price" for the ammonia produced, insulating the project from commodity price volatility and ensuring predictable cash flows.
3. ***Blended Finance Case:*** This scenario introduces concessional debt from an MDB alongside commercial debt. The lower interest rate and longer tenor of the concessional loan reduce the project's overall WACC, directly impacting its LCOA and IRR.
4. ***Green Bond Case:*** In this scenario, project debt is raised through the issuance of green bonds. This structure can potentially offer a modest reduction in financing cost compared to commercial loans and often provides a longer debt tenor, improving the project's long-term financial stability.

Model Inputs and Case Application

The model's robustness was tested through a sensitivity analysis that assessed the impact of fluctuations in key variables, including the **renewable electricity tariff, project CAPEX, WACC, and electrolyzer efficiency**.

To ground the model in real-world conditions, its inputs were calibrated using data from recent projects awarded under the Solar Energy Corporation of India (SECI) auctions. Specific case studies referenced include the **Paradeep Phosphates** project (75,000 tpa) and the **Krishna Phoschem** project (70,000 tpa). The model was also applied to a hypothetical 1 MTPA export-oriented cluster to assess the economics of projects at a globally competitive scale.

The application of this methodology to the defined scenarios yields clear, quantitative insights into the effectiveness of each financing structure in making green ammonia projects viable in India.

4. Results

The financial modeling reveals significant differences in project viability across the four financing scenarios and identifies the most influential drivers of cost and bankability. The results clearly demonstrate that without targeted financial support, green ammonia projects in India face substantial economic headwinds.

- **Base Case Analysis:** Under a purely commercial financing structure, the LCOA of green ammonia is significantly higher than prevailing grey ammonia prices. The project's IRR is low and the DSCR hovers near or below the typical 1.2x–1.3x threshold required by commercial lenders, making non-recourse debt financing challenging. This confirms that at current technology costs, standalone projects are not commercially viable.
- **Impact of Blended Finance:** The introduction of concessional debt from an MDB has a tangible positive effect. By lowering the WACC, this structure facilitates a material reduction in the LCOA. This cost reduction leads to a marked improvement in the project's IRR and NPV, making it a more attractive proposition for equity investors.
- **Impact of CfD Support:** The CfD mechanism proves highly effective in de-risking the project from a lender's perspective. By replacing volatile commodity-based revenue with a fixed, long-term contractual cash flow, the CfD significantly improves the DSCR and increases the certainty of funds available for debt service. This enhancement in credit quality allows the project to sustain a higher level of financial leverage (i.e., a greater proportion of debt in the capital structure), which reduces the requirement for more expensive equity and thereby lowers the overall cost of capital.
- **Impact of Green Bonds:** The green bond scenario reduces the overall financing cost more modestly than the blended finance case. However, its primary advantage lies in potentially offering a longer debt tenor, which can improve the project’s cash flow profile and long-term financial sustainability.

The empirically-grounded results from India’s initial SECI green ammonia auctions provide a clear price discovery benchmark. Winning bids for long-term supply contracts ranged from ₹50.00/kg (USD 567/t) to ₹64.74/kg (USD 739/t). This demonstrates that at scale, India can produce green ammonia at prices that are competitive with, and in some cases lower than, recent grey ammonia prices, which have ranged between USD 640–660/ton.

Key Cost Drivers

The sensitivity analysis confirmed that project economics are most exposed to two critical variables: the **renewable electricity price** and the **Weighted Average Cost of Capital (WACC)**. These two factors were identified as the most influential drivers of the final LCOA. This finding underscores that policy efforts must focus on both ensuring low-cost, round-the-clock renewable power and implementing financial mechanisms that lower the cost of capital.

These quantitative results provide a clear basis for a broader discussion on their strategic implications for India's policy and market development.

5. Discussion

This section moves beyond the model's quantitative outputs to analyze their strategic implications for India's policy direction, investment climate, and positioning in the emerging global green ammonia market.

India's Model in a Global Context

India's financing approach, as demonstrated by the SECI auction model, presents a compelling alternative to the strategies being pursued by other major economies. While the EU's Hydrogen

Bank and Japan's direct subsidies focus heavily on supply-side incentives, India has strategically anchored its initial efforts around demand aggregation in the domestic fertilizer sector. This focus on securing offtake provides a powerful de-risking mechanism that is particularly well-suited for an emerging market. By guaranteeing a market for early-stage projects, India creates a bankable foundation that can attract first-mover investments. This approach directly improves the Debt Service Coverage Ratio (DSCR) by ensuring predictable revenues, making projects more attractive to commercial lenders, in contrast to a pure subsidy model like the US IRA's Production Tax Credit, which primarily boosts the Internal Rate of Return (IRR) for equity investors.

Demand Aggregation as a De-risking Tool

Guaranteed offtake is the cornerstone of project bankability, and India's approach leverages this principle effectively. The fertilizer industry represents an ideal anchor for the nascent green ammonia sector, as it is a large, established market with subsidized and stable demand. The 10-year tenure of the supply contracts awarded under the SECI auctions provides the long-term revenue security that lenders require to finance capital-intensive projects. This demand-centric model creates a protected ecosystem for initial projects to achieve commercial operation, build investor confidence, and drive down costs through learning and scale.

Investment Risks and Mitigation

Despite the strengths of India's approach, investors still face several primary risks that must be actively managed:

- **Currency and Supply Chain Risk:** With significant project debt and key components like electrolyzers often sourced internationally, projects are exposed to financial risks. This reliance on imported components not only poses a supply chain risk but also directly exposes project CAPEX to foreign exchange volatility, making the development of effective and accessible currency hedging products essential for bankability.
- **Certification and Standards:** A lack of alignment between India's domestic green hydrogen standards and international criteria, such as the EU's stringent RFNBO rules, could create significant barriers to accessing export markets. A credible, internationally recognized certification system is a prerequisite for becoming a global supplier.
- **Policy Continuity:** Investor confidence is contingent on the stability and predictability of government policy. Long-term success requires a clear and consistent policy framework that extends beyond initial auction rounds, providing certainty on subsidy support, offtake mandates, and infrastructure development.

Implications for Key Stakeholders

The study's findings carry distinct implications for the primary actors in India's green ammonia ecosystem:

- **For Investors and Banks:** The unique risk profile of green ammonia projects necessitates innovation in financial structuring. Lenders and investors must develop expertise in blended finance structures, standardized offtake agreements, and technology risk assessment to effectively deploy capital into the sector.

- **For Policymakers:** The government's role is to create a durable, long-term policy framework that fosters a competitive market. This includes implementing clear offtake mandates, establishing a robust and internationally aligned certification system, and coordinating public investment in critical enabling infrastructure like storage and port facilities.

Based on this analysis of results and risks, a set of concrete policy recommendations can be formulated to accelerate the financing of India's green ammonia transition.

6. Policy Recommendations

To translate India's green ammonia potential into reality, a strategic policy roadmap is required. The following recommendations are structured chronologically to build a sustainable and competitive ecosystem: Short-term actions focus on establishing *bankability* for first-movers, medium-term actions aim to build *market depth and resilience*, and long-term actions are designed to achieve *market maturity* where direct subsidies are no longer needed.

Short-Term (1-3 Years): Catalyzing First-Mover Projects

The immediate priority is to de-risk and fund pioneer projects to build market momentum and drive initial cost reductions.

- **Scale Up Contracts for Difference (CfDs) and Viability Gap Funding (VGF):** The government should expand the use of financial instruments like CfDs and VGF to bridge the initial "green premium" for early projects. The success of the SECI auction model, which provides revenue stability through long-term contracts, should be replicated and scaled.
- **Prioritize Concessional Finance Allocation:** Policymakers should actively channel concessional loans from MDBs and Indian public financial institutions toward the first wave of green ammonia projects. Lowering the cost of capital at this critical stage is the most direct way to improve project viability and attract private co-investment.

Medium-Term (3-7 Years): Building a Sustainable Market

With initial projects underway, the focus should shift to creating deep and liquid domestic markets for both finance and technology.

- **Develop a Domestic Green Bond Ecosystem:** Establish a clear green taxonomy and create credit enhancement mechanisms (e.g., partial risk guarantees) to facilitate the issuance of green bonds for ammonia projects. This will unlock access to a wider pool of domestic institutional capital, such as pension funds and insurers.
- **Implement Domestic Manufacturing Incentives:** Leverage the Production-Linked Incentive (PLI) model to encourage the domestic manufacturing of electrolyzers, catalysts, and other critical components. This will reduce CAPEX, mitigate global supply chain risks, and foster a local value chain.
- **Establish a National Certification Registry:** Create a national registry for green hydrogen and ammonia certification that is fully aligned with leading international standards, particularly the EU's RFNBO criteria and CertifHy. This is non-negotiable

for enabling exports and ensuring Indian products command a green premium in global markets.

Long-Term (7+ Years): Transitioning to Market-Driven Growth

In the long run, direct subsidies should be phased out as the market matures and green ammonia becomes commercially competitive.

- **Introduce Carbon Pricing:** Gradually implement a carbon price or strengthen India's emissions trading scheme to level the playing field between green and grey ammonia. A meaningful carbon price will internalize the environmental cost of fossil-based production, making green alternatives competitive on a standalone basis.
- **Foster Mature Domestic Capital Markets:** Focus policy on developing deep and sophisticated domestic capital markets capable of financing large-scale infrastructure projects without the need for concessional support, ensuring the long-term sustainability of the sector.

Strengthening the Regulatory and Contractual Framework

Underpinning these efforts must be a robust and streamlined regulatory environment.

- **Standardize Project Finance Norms:** Develop standardized templates for project finance covenants, Debt Service Reserve Account (DSRA) requirements, and risk guarantee structures tailored to green ammonia. Standardization will reduce transactional complexity, lower legal costs, and accelerate financial closure.
- **Create a Nodal Agency for Offtake Agreements:** Establish a governmental nodal agency to facilitate standardized, medium-term (e.g., 10-year) offtake agreements between producers and industrial consumers. This will enhance bankability and simplify the procurement process for both buyers and sellers.

The implementation of this multi-pronged policy approach will be essential to solve the financing challenge and unlock India's full potential in the global green ammonia market.

7. Conclusion

India's ambition to decarbonize its industrial base and emerge as a leader in the global hydrogen economy faces a substantial financing gap, with investment needs for green ammonia estimated at USD 15–20 billion by 2035. This study argues that while this challenge is significant, it is solvable through the strategic and coordinated deployment of blended financing mechanisms, targeted policy support, and robust risk mitigation frameworks.

The financial modeling presented in this paper confirms that standalone commercial financing is currently insufficient to deliver bankable green ammonia projects in India. The most effective instruments for catalyzing the market in the near term are Contracts for Difference (CfDs), which provide crucial revenue certainty, and concessional finance, which directly lowers the cost of capital. Looking toward 2035, the analysis suggests that a combination of mature sustainable finance markets, significant technology cost reductions in electrolyzers and renewables, and strong, diversified demand from domestic industry and export markets can collectively mobilize the capital required to meet national targets.

This paper’s unique contribution is its synthesis of real-world auction-discovered prices with structured project finance analysis, providing the first empirically grounded evaluation of the specific blended finance and offtake structures needed to scale India's green ammonia sector. By simulating the financial impact of different support structures, it equips policymakers, investors, and developers with the data-driven insights needed to navigate the complex financing landscape of India's green ammonia transition. In doing so, this research supports the dual objectives of achieving deep industrial decarbonization and cementing the nation's role as a competitive and reliable supplier in the global clean energy economy.