Techno-Economic Feasibility Assessment: A 10 KLPD 2G Ethanol Plant in Ballari, Karnataka

1.0 Introduction and Project Overview

This comprehensive report presents a techno-economic and environmental feasibility assessment of the proposed 10 KLPD (kilo liters per day) second-generation (2G) ethanol production facility by Ark Bio Energies Pvt. Ltd. The project is strategically positioned in Ballari, Karnataka, a region with a significant surplus of agricultural residues, to convert rice straw and husk into high-purity (99.9%) ethanol.[1] This initiative is a direct response to India's National Biofuel Policy, supporting the ambitious and now-achieved Ethanol Blended Petrol (EBP) Programme blending target of 20% by the end of 2025.[2]

The project has been meticulously de-risked on multiple fronts, making it a viable and timely investment. Technical risk is mitigated through the adoption of a proven, commercial-scale enzymatic hydrolysis and fermentation process licensed from Praj Industries, a technology already successfully deployed at the large-scale 100 KLPD Indian Oil Corporation (IOCL) plant in Panipat.[3] Financially, the project's viability is underpinned by a favorable policy environment that includes government-mandated off-take agreements, fixed pricing for ethanol [1], and a suite of financial incentives and subsidies.[4] The project's ESG impact is a core component of its value proposition, with a strong focus on rural economic development and climate change mitigation.[1]

Key Project Parameters and Findings

- **Project Capacity:** A 10 KLPD facility, scalable to 20 KLPD in a planned Phase 2.[1]
- **Location:** Ballari, Karnataka, leveraging an estimated 80% surplus of local rice straw.[1]
- **Investment:** A capital expenditure (CAPEX) of ₹50 Crore, with a funding ask of ₹20 Crore in equity for a 40% stake.[1]
- **Financial Performance:** A projected Internal Rate of Return (IRR) of 23-25% and a short payback period of 3.5-4 years.[1]
- **Technology Partner:** Praj Industries, with enzyme blends from Novozymes, a global leader in industrial enzymes.[5]
- **ESG Outcomes:** The plant is projected to reduce carbon emissions by 30,000 tons annually and directly benefit 5,000 local farmers through agricultural waste valorization.[1]

2.0 Market and Policy Landscape

2.1 The National Biofuel Imperative

India's biofuel sector is a cornerstone of its national energy strategy, driven by the twin objectives of enhancing energy security and meeting climate goals. As the world's third-largest energy consumer, India's economic growth has historically been tied to a heavy reliance on imported crude oil [7], a dependence that the Ethanol Blended Petrol (EBP) Programme is designed to reduce. The program has proven highly effective, with ethanol blending in petrol surging from 1.5% in 2014 to 20% in 2025, a significant achievement accomplished five years ahead of the original 2030 target.[2] This success has led to substantial foreign exchange savings and a reduction in carbon dioxide emissions. The shift towards 2G ethanol from non-food agricultural waste, such as rice straw, is a strategic pivot that addresses the food-versus-fuel debate that has historically constrained first-generation (1G) ethanol production.[1]

2.2 Policy Framework and Incentives

The policy landscape supporting the 2G ethanol sector has been continuously refined to de-risk investments and spur growth.[1] The National Policy on Biofuels (2022) is the key regulatory driver, introducing and bolstering several critical mechanisms.[8] As of September 18, 2025, the EBP Programme has successfully achieved its 20% blending target [2], with recent data from the Petroleum Planning & Analysis Cell (PPAC) indicating that the average blending rate for the Ethanol Supply Year (ESY) 2024-25 reached 19.1%.[9]

A crucial de-risking element is the government's administered pricing and the use of Long-Term Off-take Agreements (LTOAs).[8] These legally binding agreements with Oil Marketing Companies (OMCs) provide a guaranteed market and a fixed price for 2G ethanol [10], ensuring revenue stability for producers.[8] To date, 131 LTOAs have been signed, securing a total off-take assurance of 4.3 billion liters per annum.[11]

A comprehensive suite of financial incentives is in place to support new projects [8]:

- **Pradhan Mantri JI-VAN Yojana:** This scheme provides financial assistance for advanced

biofuel projects, with Ark Bio Energies' project eligible for a viability gap funding grant of up to ₹10 Crore.[1] The deadline for RFS-V submissions was recently extended to August 6, 2025, underscoring the ongoing nature of the scheme.[12]

- **Interest Subvention Schemes:** These programs provide a 6% interest subvention on loans for new ethanol plants, effectively reducing the cost of capital for developers.[13]
- **Tax Benefits:** The GST rate on ethanol for the EBP program has been lowered to 5%, and carbon credits are available under the Clean Development Mechanism (CDM), further enhancing project economics.[4]

2.3 Market Dynamics and the 2G Sector

The Indian ethanol market is in a phase of hyper-growth, with a significant demand-supply gap that provides a clear entry opportunity for new producers.[1] The total ethanol market is estimated to be valued at ₹27,224 Crore in 2025, with projections showing it will reach ₹77,273 Crore by 2032, representing a compound annual growth rate (CAGR) of 16.1%.[14] This growth is fueled by a demand for over 10.16 billion liters of ethanol in 2025 against an available supply of only 8 billion liters, leaving a gap of over 2 billion liters.[1]

The 2G ethanol segment, in particular, is poised for rapid expansion.[1] It is a ₹4,399 Crore market in 2025, exhibiting a higher CAGR of 20.1%.[5] This sub-sector is graduating from a demonstration phase to a commercialization phase, as evidenced by a growing number of large-scale projects, including the 100 KLPD Indian Oil Corporation (IOCL) plant in Panipat, Haryana, which uses rice straw as a feedstock.[3] The recent inauguration of India's first bamboo-based 2G ethanol plant by Numaligarh Refinery Limited (NRL) in Assam in September 2025, is another indicator of the government's and corporate sector's commitment to scaling advanced biofuel production.[15]

3.0 Technical and Operational Feasibility

3.1 Location and Feedstock Analysis

The selection of Ballari, Karnataka, as the project site is a critical strategic advantage that

addresses the single largest operational challenge for 2G ethanol production: consistent feedstock supply.[1] Known as the "Rice Bowl" of Karnataka, the district produces 2.36 lakh hectares of paddy annually, with a corresponding generation of 4.72 lakh tons of rice straw.[1] A significant portion of this biomass, estimated to be an 80% surplus post-farm use, is available for conversion.[1] The Ark plant's annual requirement of 50,000 tons represents only a small fraction of this local surplus, ensuring a robust and reliable supply chain within a 50-kilometer radius.[1]

The project's approach to feedstock acquisition directly mitigates the common industry risk of an unreliable supply chain.[17] Ark Bio Energies' strategy counters these issues by establishing partnerships with 10 local farmer cooperatives and executing MoUs for long-term supply, providing a strong economic incentive for farmers through a premium of ₹1,000 per ton for straw buy-back.[1]

3.2 Process Technology and Yield

The technological foundation of the Ark Bio Energies plant is a commercial-scale, enzymatic hydrolysis process licensed from Praj Industries, with key enzyme blends sourced from Novozymes.[5] This partnership combines a leading engineering and technology provider with a global leader in enzyme solutions.[5] The process is specifically engineered to overcome the unique challenges associated with rice straw as a feedstock, such as its fibrous nature and high gelatinization temperature.[18]

The conversion process involves a proprietary pre-treatment step (steam explosion) to break down the complex lignin barrier, followed by enzymatic hydrolysis using Novozymes' Cellic® blends, which are designed for robust and efficient conversion of cellulose to simple sugars.[19] This methodical approach ensures a high yield of 300 liters of ethanol per ton of rice straw [1], significantly higher than earlier pilot-scale projects.[1] The project's claim of proprietary pre-treatment tweaks for rice straw further highlights its focus on optimizing the process for this specific feedstock.[1]

3.3 Products and Co-Product Valorization

The project's revenue model is designed for resilience by leveraging a multi-product approach.[1] While ethanol sales constitute the primary revenue stream, the value of

co-products significantly enhances the project's overall economics and financial stability.

- **Ethanol:** This is the core product, with 100% of the plant's output guaranteed for off-take by OMCs at a fixed price of ₹65 per liter through a 5-year LTOA.[1] Ethanol is projected to account for approximately 70% of total revenue.[1]
- **By-products:** The production process generates valuable co-products. Lignin will be utilized as boiler fuel, enabling the plant to achieve 20% energy self-sufficiency and lowering its operational expenditure.[1] Additionally, the process yields high-purity (99%) carbon dioxide (CO_2), which can be sold to industrial users, providing a secondary revenue stream projected to contribute 25% of total revenue.[1]
- **Carbon and ESG Credits:** The project's significant environmental impact in reducing CO_2 emissions by 30,000 tons annually allows it to generate carbon credits and other ESG-related incentives, creating a third revenue stream that further bolsters profitability.[1]

4.0 Financial Feasibility and Projections

The financial model for Ark Bio Energies is built on realistic projections that account for the specific dynamics of the 2G ethanol market.[1] The total capital expenditure (CAPEX) is estimated at ₹50 Crore, which includes the cost of the plant, land, construction, and working capital.[1] This higher CAPEX, compared to a first-generation corn-based plant, is a known characteristic of advanced biofuel projects due to the need for complex pre-treatment and hydrolysis equipment.[20] This increased initial investment is effectively mitigated by the availability of government grants and subsidies.[13]

4.1 Capital and Operational Expenditure

The total project cost of ₹50 Crore is structured for efficient allocation. Post-subsidies, the net CAPEX is expected to be ₹40 Crore.[1] The investment ask of ₹20 Crore in equity is earmarked for the project's most critical components: 60% for plant construction and equipment, 30% for feedstock and working capital, and 10% for initial operations and other expenses.[1] The operational expenditure (OPEX) is projected at ₹15 Crore in Year 1, with feedstock accounting for a significant portion.[1]

4.2 Revenue and Profitability Projections

Based on a phased ramp-up and a conservative pricing model, the project's profitability is projected to be robust.[1] Revenue is expected to reach ₹20 Crore in Year 1, growing to ₹27 Crore in Year 3 and ₹50 Crore by Year 10.[1] The EBITDA margin is projected to stabilize at approximately 44%, a strong indicator of the project's operational efficiency.[1] The following table provides a detailed overview of the projected financial performance over the first decade.

Year	Revenue (₹ Cr)	OPEX (₹ Cr)	EBITDA (₹ Cr)	PAT (₹ Cr)
1	20	12	8	2.25
3	27	15	12	5.25
5	35	19	16	8.25
10	50	26.5	23.5	13.875

4.3 Returns and Sensitivity Analysis

The project's financial returns are attractive, with a base case IRR of 23% and a rapid payback period of 3.5 years.[1] A comprehensive sensitivity analysis has been performed to demonstrate the project's resilience to external market fluctuations, a key concern for investors.[1] The analysis shows that even under a conservative scenario, with a 15% reduction in ethanol price and a 50% increase in feedstock cost, the project maintains a viable 15% IRR and a payback period of 4.5 years.[1] This level of resilience underscores the project's fundamental strength and its ability to withstand market pressures.

Case	Ethanol Price	Feedstock Cost	IRR	Payback
Base	₹65/L	₹8/kg	23%	3.5 years

Conservative	₹55/L	₹12/kg	15%	4.5 years
Aggressive	₹75/L	₹6/kg	28%	2.5 years

5.0 ESG Impact Assessment

The Ark Bio Energies project is a prime example of a business model that creates both financial value and significant, measurable ESG returns. The project's alignment with national and global sustainability goals is a core part of its investment thesis.[1]

5.1 Environmental

The plant's primary environmental benefit is its contribution to climate action.[1] By utilizing agricultural waste for biofuel production, it directly displaces fossil fuels, leading to a projected reduction of 30,000 tons of carbon dioxide (

CO2) emissions annually.[1] This figure is highly credible, as cellulosic ethanol has the potential to cut greenhouse gas emissions by up to 86% compared to gasoline.[21] Furthermore, the project directly addresses the widespread issue of agricultural waste burning, which is a major source of air pollution. By creating a commercial use for rice straw, the plant provides a sustainable alternative to stubble burning, contributing to a 70% reduction in PM2.5 particulate matter.[1]

5.2 Social

The project is designed to have a transformative social impact on the local community.[1] It provides a reliable source of income for approximately 5,000 farmers by purchasing their agricultural waste, a resource that would otherwise have little to no economic value.[1] The guaranteed income stream through straw buy-back at a premium provides a significant financial boost to rural livelihoods.[1] In addition to farmer empowerment, the project is a major job creator, providing 100 direct jobs with a focus on local hiring and an estimated 500

indirect jobs throughout the supply chain.[1]

6.0 Comprehensive Risk Assessment and Mitigation

A thorough assessment of potential risks and corresponding mitigation strategies has been conducted to ensure the project's long-term viability.[1] The following matrix summarizes the key risks and the specific measures in place to address them.

Risk	Likelihood	Impact	Mitigation Strategy
Feedstock Shortage	Medium	High	**Structured Sourcing:** 3-year MoUs with farmer co-ops at a premium; strategic location in a region with an 80% surplus of rice straw; feedstock diversification to include other agri-residues like cotton stalk; maintenance of a 6-month buffer stock.[1]
Technology Underperformance	Medium	Medium	**Proven Technology:** Licensed from Praj Industries, whose technology is a cornerstone of India's 2G push and is commercially operational at the IOCL Panipat plant;

			proprietary pre-treatment tweaks for rice straw; and a 10% CAPEX contingency fund.[3]
Regulatory Delay	Low	High	**Streamlined Process:** Utilization of a single-window clearance portal and pre-consultation for environmental and other approvals; alignment with central and state government policies.[1]
Price Volatility	Medium	Medium	**Market & Product Hedging:** Guaranteed off-take via fixed-price contracts with OMCs; diversified revenue streams from co-products like lignin and CO2; ability to earn and sell carbon credits.[1]
Environmental Non-Compliance	Low	High	**Sustainable Operations:** Implementation of a Zero Liquid Discharge (ZLD) system for water management; commitment to

			annual third-party audits and compliance with all environmental regulations.[1]

7.0 Conclusion and Implementation Roadmap

This feasibility assessment concludes that the Ark Bio Energies project is technically sound, financially robust, and environmentally and socially beneficial.[1] The project's alignment with national energy policy, coupled with guaranteed market off-take and a de-risked operational model, positions it for sustainable and profitable growth.[1] The favorable economic returns and the resilience demonstrated in the sensitivity analysis further validate the project's viability.[1]

The following is the detailed execution roadmap to guide the project from funding to full commercial operation:

- **Q4 2025:** Finalize the Detailed Project Report (DPR), secure equity funding, and acquire land in the designated Special Economic Zone (SEZ).[1]
- **Q1 2026:** Obtain all necessary regulatory approvals, including environmental clearance (EC) and excise permissions.[1]
- **Q2-Q3 2026:** Initiate construction with a robust Engineering, Procurement, and Construction (EPC) tender process.[1]
- **Q1 2027:** Commence trial runs and plant commissioning.[1]
- **Q2 2027:** Achieve full Commercial Operation Date (COD) and ramp up to 90% utilization.[1]

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