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BIOREFINERY
A Way Forward towards Energy Transition

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We are at a critical juncture of an energy transition as we celebrate World Biofuel Day. As the world grapples with the challenges of climate change and the need to transition towards sustainable energy sources, biorefineries have emerged as a promising solution. These innovative complexes integrate various technologies to efficiently convert renewable biomass into a wide array of valuable products, including biofuels, bioplastics, and renewable chemicals. In the Indian context, a biorefinery complex holds enormous potential, owing to the country's rich feedstock availability, rapidly advancing technology, and supportive policies.

Feedstock Perspective

As an agriculturally rich nation, India has an abundance of available biomass resources. India boasts of a diverse range of feedstock sources, making it an ideal platform for biofuel production. From feedstocks like sugarcane, corn, and vegetable oils to agricultural residues, forest waste, algae, and organic municipal solid waste, the country's agricultural and industrial sectors offer abundant raw materials for biorefinery operations.

Current biomass availability in India is estimated at 750 MMT per year, with surplus biomass availability estimated at around 170 MMT per year.1 With an abundant and varied supply of feedstock, India has all the resources needed to meet its biofuel requirements sustainably and independently.

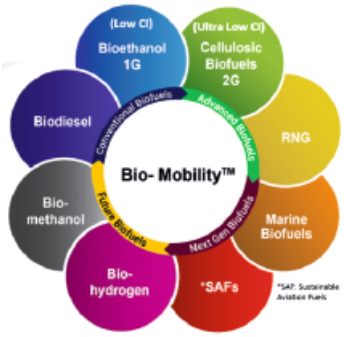
A harmonious blend of nature's wealth and advanced technology, biorefinery can produce an array of value-added products and chemicals. Embracing the single feedstock-multiproduct model, this complex offers a formal and sustainable path towards a promising future.

Technology Perspective

Praj is India's leading industrial biotech firm, driven by innovation, integration, and delivery capabilities. Praj's key contributions to the worldwide Bioeconomy are the Bio-MobilityTM and Bio-PrismTM technologies. With the help of these advanced technology portfolio, fossil fuel and chemicals are replaced with the biobased renewable fuels and chemicals.

A. Bio-mobilityTM

In the Bio-economy space, Praj has pioneered a basket of innovative technology solutions in the form of Bio-MobilityTM. True to its vision



of making the world a better place, Praj continues to pursue sustainable decarbonization mobility sector through circular bio-economy by deploying its proprietary bio-fuel technology solutions.

The Bio-MobilityTM platform promotes the use of renewable resources to produce low carbon intensity transportation fuel across all modes of mobility (surface, air, and water). This platform comprises:

I. Conventional Bio-fuels

• Low carbon bio-ethanol is produced from sugar and starch-based feedstock like B & C molasses, sugarcane juice, cassava, grain, sugar beet, among others.

• EcodiezelTM – Bio-diesel is produced from used cooking oil, palm fatty acid, palm stearin, tallow, etc. using enzymatic technology.

II. Advanced Bio-fuels

• Ultra-low carbon bio-ethanol produced through Praj's proprietary enfinity® technology using lignocellulosic residue such as bagasse, corn cob, rice straw, wheat straw, etc. This technology is deployed on a commercial scale. Praj is setting up three commercial scale plants with Fortune 500 companies, Indian Oil Corporation Limited (IOCL), Hindustan Petroleum Corporation Limited (HPCL) and Bharat Petroleum Corporation Limited (BPCL). Out of which IOCL plant is already commissioned and other two facilities will be commissioned within the next 6-9 months.

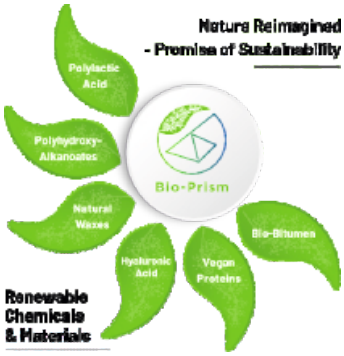
• Renewable Natural Gas (RNG)

Through RenGasTM technology RNG or compressed biogas (CBG) is produced from press mud and Agri-feedstock. This process also produced nutrient-rich manure as a by-product.

III. Next-gen Biofuels

• Sustainable aviation fuel, Marine Bio-fuels; and Future fuels including Bio-methanol and Bio-Hydrogen.

Sustainable aviation fuel (SAF) derived from bio-based feedstocks, significantly reduces carbon emissions in the aviation industry, thereby contributing to a greener future. Together with Gevo Inc., Praj Industries has developed an innovative Alcohol-to-Jet (ATJ) technology for the production of SAF using bio-based feedstock.



B. BioPrismTM

BioPrismTM portfolio encloses a cluster of technologies to produce renewable chemicals & materials that promise sustainability. Successful technologies have been developed such as Furfural technology, leveraging lignin to obtain lignosulfonates and bio-bitumen. Lignosulfonates and Bio-bitumen are the only bio-based alternative for Asphalt/Bitumen

used in cement and road construction.

Bioplastics, like polylactic acid (PLA) and polyhydroxyalkanoates (PHA), derived from plant-based sources, present a sustainable solution to the plastic pollution crisis, reducing reliance on fossil fuel-based plastics. PHA is biodegradable and bio compostable bioplastic providing green alternative.

We also present an additional segment of bio-based products including Hyaluronic acid, natural waxes, and antimicrobial peptides.

Socio-economic Benefits

• Energy Security: Energy security is improved by lessening reliance on imported fossil fuels. Supply risks and geopolitical vulnerabilities can be reduced by using energy from many sources.

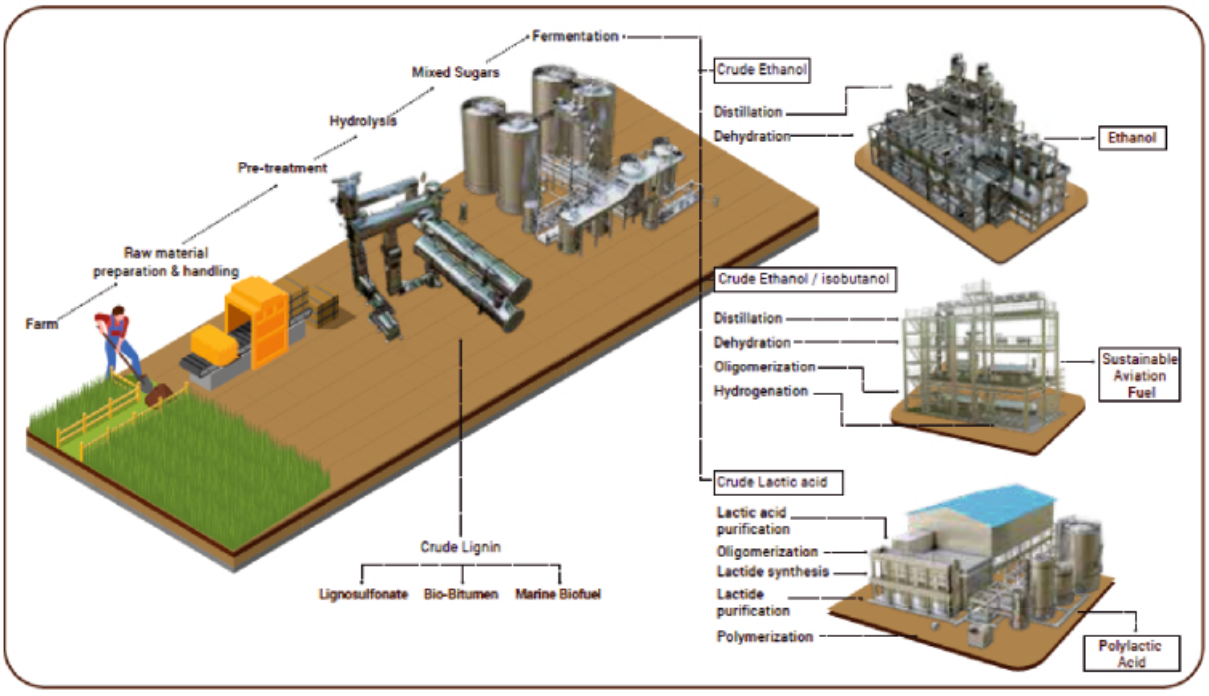
• Forex Savings: The indigenous development of biofuels reduces the demand for expensive imported oil.

• Job Creation: The biofuels industry generates employment opportunities in multiple sectors, including agriculture, biomass production, biofuel refining, and distribution. This leads to an increase in employment, particularly in rural areas, which stimulates local economies and sustains livelihoods.

Case Study

enfinity® is Praj Industries' proprietary technology to produce sustainable, carbon-neutral advanced bioethanol and high-valuable co-products. The technology can process various lignocellulosic feedstocks such as Agri residues, energy crops, and hardwood.

Praj Industries in collaboration with Indian Oil Corporation Limited has set up an advanced bio-ethanol plant in Panipat, India based on its enfinity® technology. The plant will process 200,000 MT of rice straw annually to produce 3 crore litres of ultra-low carbon



ethanol. The plant will have several socio-economic and environmental benefits,

• ~ 1,00,000 farmers to benefit

• ~1,500 jobs in rural areas

• ~ 3,20,000 MT of CO2 elimination/year which is equivalent to replace ~ 63,000 cars/ year

• Prevention of stubble burning

Bio-refinery Complex
Policy Perspective

For the bio-refinery complex to flourish, a supportive policy environment is crucial. India has been proactive in formulating policies and initiatives to drive the growth of the bioenergy sector:

• Infrastructure and Biomass Supply: Developing infrastructure and a strong biomass supply chain for efficient feedstock movement.

• Pricing Incentives: Stable pricing and incentives for biofuels to reduce fossil fuel dependence.

• Supportive Measures: Blending mandates, tax incentives, and favourable regulations to strengthen the market for biofuels and renewable chemicals.

Conclusion

In conclusion, the biorefinery emerges as a transformative force, paving the way for a greener and self-reliant India. By replacing fossil fuels and chemicals with sustainable biofuels, renewable chemicals, and materials, it serves as a catalyst for environmental preservation and mitigates the impact of climate change. The availability and deployment of advanced technologies at a commercial scale position the biorefinery as a viable and practical solution to address our pressing energy and resource challenges.

Most importantly, the biorefinery aligns seamlessly with India's vision of 'Atmanirbhar Bharat' (self-reliant India) by fostering indigenous technology development. By harnessing our rich feedstock availability and embracing homegrown innovation, the biorefinery complex empowers the nation to chart a path of economic growth and energy independence.

Reference:

https://mnre.gov.in/bio-energy/current-status

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