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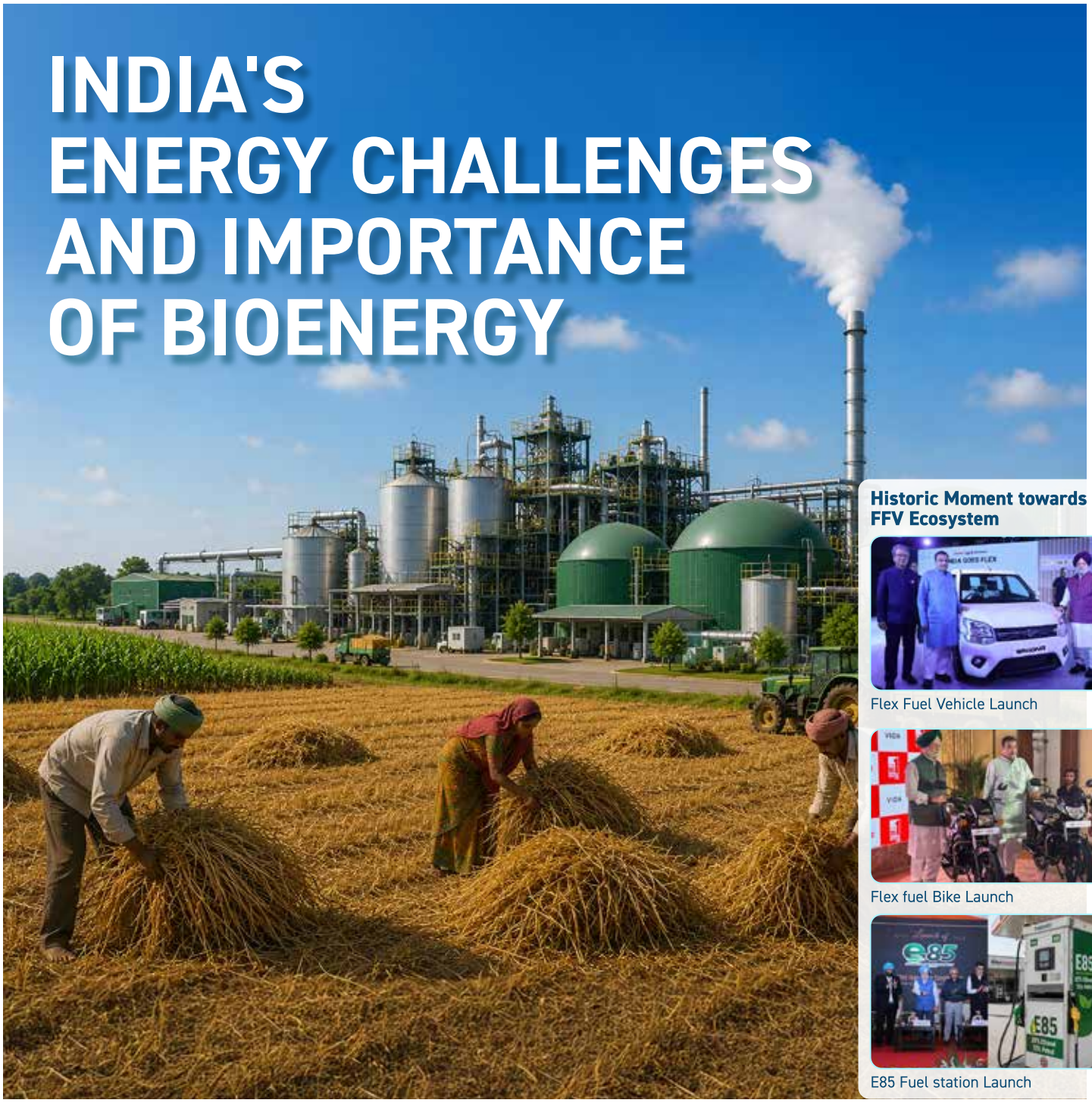
INDIA'S ENERGY CHALLENGES AND IMPORTANCE OF BIOENERGY



Historic Moment towards FFV Ecosystem

Flex Fuel Vehicle Launch

Flex fuel Bike Launch

E85 Fuel station Launch

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Energy Security in the Age of Geopolitical Uncertainty

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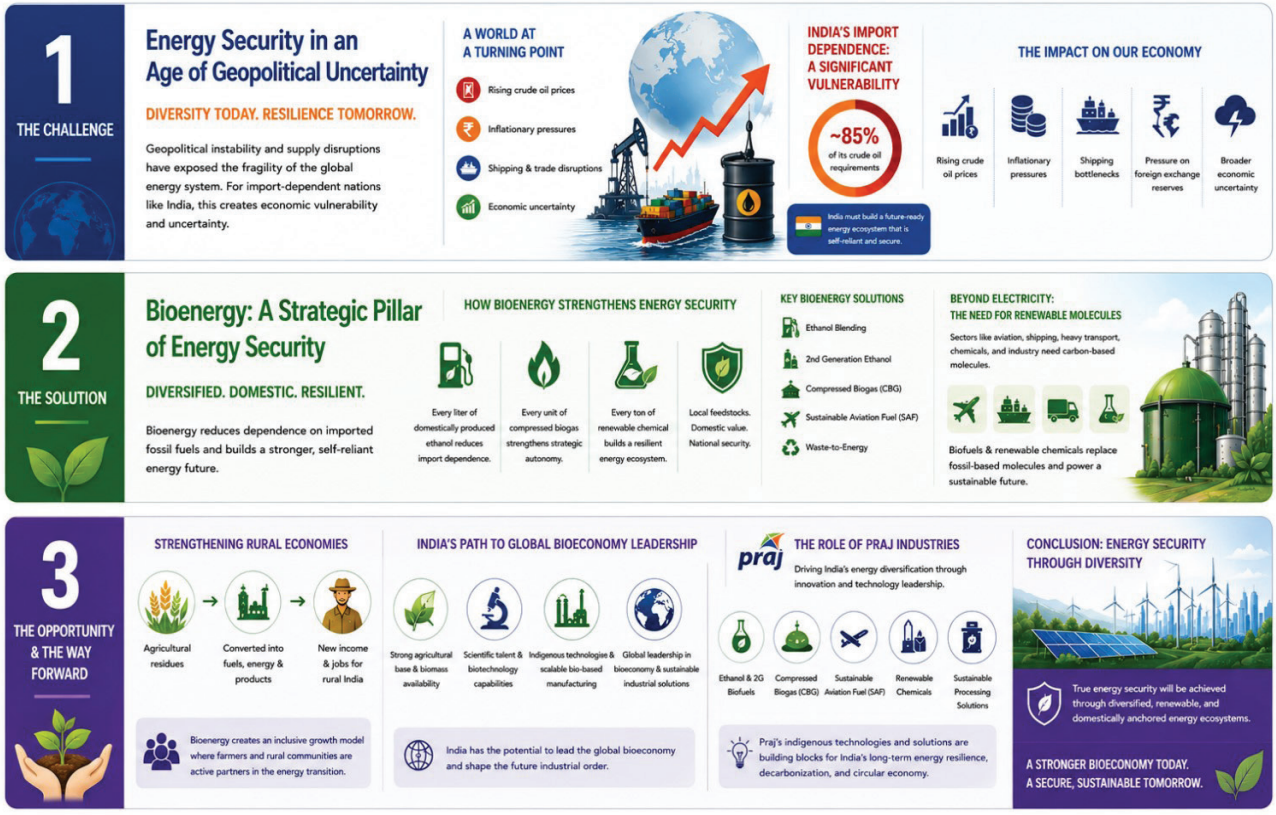
Energy security has become a strategic imperative

The world today stands at a defining moment in the global energy landscape. What was once viewed largely as an economic issue has now evolved into a matter of strategic importance and national security. The ongoing geopolitical instability in the Middle East, coupled with prolonged disruptions arising from conflicts in other parts of the world, has once again exposed the fragility of the global energy system and the risks associated with excessive dependence on fossil fuel imports.

For decades, the global economy has been built around centralized fossil fuel supply chains. However, recent events have demonstrated how quickly these supply chains can become vulnerable to geopolitical tensions, trade disruptions, shipping bottlenecks, and price volatility. The impact is immediate and widespread - rising crude oil prices, inflationary pressures, increased transportation costs, pressure on foreign exchange reserves, and broader economic uncertainty.

India's import dependence and economic vulnerability

For import-dependent nations like India, the implications are even more significant. India imports nearly 85% of its crude oil requirements, making the country highly exposed to



fluctuations in global energy markets. Every geopolitical conflict that affects oil-producing regions or critical shipping routes directly impacts the nation's economy. Energy security, therefore, can no longer be viewed merely as securing fuel supplies; it must now be understood as ensuring long-term resilience, diversification, and domestic capability.

In this context, bioenergy, biofuels, renewable chemicals, and bio-based materials are emerging not just as sustainability solutions, but as strategic instruments of energy security.

Bioenergy: A strategic solution for energy diversification

The future energy system cannot rely on a single source or geography. It must be diversified, decentralized, and increasingly domestic. Bioenergy offers precisely that advantage. Unlike conventional fossil fuels that are concentrated in specific regions of the world, bio-based energy systems can be built around locally available feedstocks, agricultural residues, industrial waste streams, and renewable biomass resources. This fundamentally changes the energy equation for countries like India.

Every liter of domestically produced ethanol, every unit of compressed biogas, and every ton of renewable chemical produced within the country reduces dependence on imported fossil resources. More importantly, it strengthens strategic autonomy while creating a more resilient energy ecosystem.

India's progress in ethanol blending over the past few years is a strong example of how policy support and indigenous technological capability can together transform the energy landscape. The country's growing focus on second-generation ethanol, compressed biogas (CBG), sustainable aviation fuel (SAF), and waste-to-energy platforms reflects a broader realization that the energy transition must go beyond electricity alone.

Energy transition needs renewable molecules, not just renewable power

While solar and wind energy will continue to play a vital role in decarbonizing power generation, many sectors of the economy, including aviation, shipping, heavy transportation, chemicals, and industrial manufacturing, still require carbon-based molecules. This is where biofuels and renewable chemicals become indispensable. The transition to a sustainable future is not only about replacing electrons; it is equally about replacing fossil-based molecules with renewable carbon alternatives.

This opens a much larger opportunity for the bioeconomy

The dependence on crude oil is not limited to fuels alone. Modern economies are deeply dependent on petrochemicals for plastics, solvents, specialty chemicals, packaging materials, textiles, and industrial intermediates. Renewable chemicals and bio-based materials, therefore, represent the next frontier in reducing fossil dependence. They offer the possibility of creating circular manufacturing systems where agricultural and industrial residues are converted into high-value sustainable products.

Strengthening rural economies through bioenergy

Equally important is the socio-economic dimension of bioenergy. Unlike many traditional energy systems, bioenergy has the unique ability to connect national energy goals with rural economic development. India generates enormous quantities of agricultural residue every year, much of which remains underutilized or contributes to environmental concerns such as stubble burning. Converting these residues into fuels, energy, and renewable products creates new revenue streams for farmers while supporting rural industrialization and employment generation.

In many ways, bioenergy transforms agriculture from being solely a food-producing sector into a dual food-and-energy ecosystem. This creates a more inclusive model of growth where farmers and rural communities become active participants in the energy transition rather than passive observers.

India's opportunity to lead the global bioeconomy

At a broader level, the global energy transition also presents India with a historic strategic opportunity. With its strong agricultural base, abundant biomass availability, large domestic market, scientific talent, and growing industrial biotechnology capabilities, India

has the potential to emerge as a global leader in bioeconomy. The countries that develop indigenous technologies and scalable bio-based manufacturing ecosystems today will shape the industrial order of the future.

Role of Praj Industries in advancing energy security

This is where Praj Industries has played a significant role over the past several decades. Through sustained innovation and technological leadership in biofuels, industrial biotechnology, renewable chemicals, and sustainable processing solutions, Praj has contributed meaningfully to advancing India's energy diversification journey.

From ethanol technologies to second-generation biofuels, compressed biogas solutions, sustainable aviation fuel initiatives, renewable chemicals, Isobutanol (IBA) blending in diesel, the company's work reflects the importance of indigenous innovation in building long-term energy resilience. More importantly, it demonstrates how Indian technology and engineering capabilities can create globally relevant solutions for decarbonization, circular economy development, and energy security.

Energy security through diversity

The conversation around energy security must, therefore, evolve beyond the traditional narrative of oil reserves and fuel imports. In the coming decades, true energy security will be defined by a nation's ability to build diversified, renewable, and domestically anchored energy ecosystems. It will depend on how effectively countries integrate agriculture, biotechnology, renewable energy, and circular manufacturing into a cohesive economic framework.

The world is entering an era where geopolitical resilience and climate resilience are becoming deeply interconnected. Nations that continue to depend excessively on finite and geographically concentrated fossil resources will remain vulnerable to recurring cycles of instability. Those that invest in renewable carbon economies, domestic innovation, and bio-based industrial ecosystems will be better positioned to navigate future uncertainties.

Energy security in the 21st century will not be achieved through dependence; it will be achieved through diversity. And bioenergy will be one of the most important pillars supporting that transition. ■