India now requires comprehensive National Biomass Allocation and Aggregation Policy

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In an exclusive interview with AgroSpectrum, Dr SSV Ramakumar, FNAE, Executive Vice President â?? SPG & Chief Technology Officer, AM Green, and Former Director (R&D), Indian Oil Corporation Ltd, lays out a pragmatic roadmap for scaling ethanol, compressed biogas and sustainable aviation fuel while strengthening India's circular bioeconomy.

This interview presents a forward-looking roadmap for strengthening India’s biofuel ecosystem beyond the successful achievement of the E20 blending target. It examines the scientific, economic and policy considerations surrounding higher ethanol blends, flex-fuel vehicles and the need for sustained feedstock availability. The discussion also highlights why CBG project execution continues to lag despite strong policy support, identifying feedstock security, digestate management and technology selection as critical challenges. A key recommendation is the creation of a National Biomass Allocation and Aggregation Policy supported by district-level mapping, organised collection infrastructure and digital traceability. The interview further explores how technological maturity, lower capital costs and carbon markets can help the sector transition from policy dependence towards commercially sustainable growth. It also assesses India’s opportunities in SAF, green methanol and other advanced biofuels as global demand for low-carbon fuels and sustainability certification intensifies. Looking towards 2035, the conversation outlines a vision of India emerging as a leading integrated biofuel economy built on secure biomass supply, efficient resource allocation and stronger circular-economy linkages.

India achieved its E20 blending target ahead of schedule and discussions have already begun around E22 and higher blends. What should be the next phase of India's ethanol roadmap, and how can policymakers ensure that higher blending ambitions remain economically and environmentally sustainable?

India's successful achievement of the E20 blending target ahead of schedule demonstrates that the country has built a robust ethanol ecosystem. The next phase of the roadmap should focus on scientifically validated higher ethanol blends while simultaneously expanding ethanol production capacity and creating an enabling ecosystem for flex-fuel vehicles.

There has been considerable debate in the country regarding India's preparedness for ethanol blends beyond E20. However, this discussion should be guided by evidence rather than perception. Indian Oil, in collaboration with Automotive Research Association of India (ARAI) and Society of Indian Automobile Manufacturers (SIAM), has been at the forefront of evaluating ethanol-gasoline blends across both two-wheelers and four-wheelers. Extensive testing has already been completed for E5-E10 and E10-E20 blends under highly structured laboratory and field conditions. These validation exercises included endurance trials exceeding one lakh kilometres, making them among the most comprehensive studies undertaken in India.

The findings clearly establish that E20 blends are fully compatible with modern engines from a metallic component perspective. Contrary to widespread misconceptions, E20 does not corrode engine metals or damage critical engine components. In fact, one of the biggest advantages of higher ethanol blending is the significant reduction in emissions. Compared to conventional gasoline, E20 delivers nearly 30 percent lower emissions and around 20 percent lower emissions compared to E10.

Another major advantage lies in the higher octane rating of ethanol. Blending ethanol increases the octane number of gasoline to around 95-97, improving combustion efficiency and engine performance. However, one challenge associated with higher ethanol blends is reduced calorific value. Since ethanol contains oxygen, increasing ethanol content lowers the overall energy density of the fuel. On paper, E20 results in approximately a six percent reduction in fuel economy. But improved combustion efficiency resulting from higher octane ratings compensates for nearly half of this loss, bringing the effective mileage reduction closer to three percent.

The only significant technical issue identified during testing relates to certain polymeric materials used in fuel system components. Some rubber and polymer parts may experience premature ageing under continuous E20 usage. For instance, a component designed to last approximately 60,000 kilometres on pure gasoline may require replacement after around 20,000 kilometres under E20 usage. Importantly, the replacement cost remains relatively small—typically below Rs 1,000 per vehicle—and policymakers are already evaluating mechanisms to compensate consumers for this additional maintenance expense.

Moving beyond E20 requires a phased approach. Before adopting E25 or E30 nationally, extensive compatibility testing must continue to determine how higher ethanol concentrations affect different engine materials and vehicle platforms. Indian Oil has already initiated testing of E25 blends. The country also possesses sufficient production potential to support higher blending. Achieving E20 requires roughly 1,000 crore litres of ethanol annually against India's gasoline consumption of approximately 29.5 million metric tonnes. Current production projections indicate that India could produce nearly 2,000 crore litres of ethanol, creating a comfortable surplus.

This expansion has largely been enabled by the National Biofuel Policy, 2018, which fundamentally transformed India's ethanol economy. Traditionally, ethanol production depended almost entirely on sugar industry by-products such as B-heavy and C-heavy molasses. The revised policy introduced assured procurement prices linked to feedstock type, providing investors with long-term confidence. Equally important, the government gradually permitted surplus food grains to be diverted toward ethanol production. Earlier, this was not allowed due to food security concerns. Improved agricultural productivity and favourable monsoons have now generated sufficient grain surpluses, enabling damaged grains, broken rice and other low-value produce—which previously offered poor returns to farmers—to become valuable ethanol feedstocks. Maize has also emerged as an important alternative raw material.

Looking ahead, ethanol production alone should not determine blending targets. The next milestone depends equally on expanding India's flex-fuel vehicle ecosystem. Indian Oil is already prepared to supply E85 fuel, but E85 can only be used in specially designed flex-fuel engines capable of operating on fuels ranging from E0 to E85. Several automobile manufacturers, including Maruti Suzuki and Hero MotoCorp, have already introduced flex-fuel vehicles. By 2030, India should aim for a sizeable population of flex-fuel vehicles. Once such a vehicle base exists, higher ethanol blends like E85 become commercially viable. Importantly, E85 could be nearly 25 percent cheaper than conventional gasoline, creating economic incentives alongside environmental benefits.

Compressed biogas (CBG) has been positioned as a cornerstone of the circular bioeconomy, yet project execution remains slower than expected. What are the biggest policy bottlenecks holding back the sector, and what immediate interventions are needed to make CBG commercially viable at scale?

India's CBG programme has one of the strongest policy frameworks globally, yet implementation has significantly lagged behind targets.

Under the SATAT initiative, the government envisioned establishing approximately 5,000 CBG plants capable of producing nearly 15,000 metric tonnes of compressed biogas by 2025. While the policy architecture is attractive, only around 400 plants

are currently operational.

Several enabling measures have already been introduced. The government established BIS specifications for CBG quality, ensuring standardized gas production. Initially, an assured procurement price of approximately Rs 48 per kilogram was announced. However, policymakers soon recognised that this price was insufficient to ensure project viability. Consequently, procurement prices have now been revised to nearly Rs 70 per kilogram, along with transportation support within a 50-kilometre radius.

The government has also classified CBG projects under priority sector lending, allowing entrepreneurs to access affordable financing through public sector banks. Furthermore, developers are not required to independently market their gas. Once a Detailed Project Report is approved under SATAT, public sector oil marketing companies provide Letters of Intent guaranteeing 100 percent offtake for ten years, including logistics support.

Despite these strong incentives, project execution remains weak because two critical operational challenges continue to undermine viability.

The first is feedstock security. Every successful CBG plant requires not only land for the plant itself but also sufficient storage facilities for maintaining feedstock inventories. More importantly, entrepreneurs must independently secure consistent feedstock supply throughout the year. Without assured biomass availability, plant utilisation declines significantly.

The second challenge relates to by-product management. From every kilogram of feedstock, only around 18 percent is converted into methane. The remaining material consists largely of carbon dioxide and digestate. Unless this digestate is evacuated regularly, plant operations become increasingly difficult.

Fortunately, digestate represents a valuable resource because it can be converted into high-quality organic manure. Therefore, one of the most important policy interventions required today is mandatory integration of organic manure into India's fertiliser ecosystem. If policymakers mandate that a certain percentage of fertiliser application must consist of certified organic manure, it would immediately create a large market for digestate generated by CBG plants. This additional revenue stream could substantially improve project economics and accelerate sectoral growth.

Technology selection also remains a major concern. Many projects continue to adopt technologies that are poorly suited to Indian feedstocks, resulting in lower gas yields and operational inefficiencies. Greater emphasis on technology evaluation and standardisation is therefore essential. Another equally important intervention involves feedstock allocation. If multiple CBG plants compete within the same geographical area, biomass shortages inevitably arise. A rational feedstock allocation mechanism should therefore accompany future project approvals.

Feedstock security is emerging as the defining challenge for both ethanol and CBG. Should India move towards a national biomass strategy with dedicated feedstock mapping, pricing mechanisms and logistics infrastructure? What would such a framework look like?

Absolutely. Feedstock security will determine the long-term success of India's biofuel programme. India now requires a comprehensive National Biomass Allocation and Aggregation Policy.

The first pillar should be biomass mapping. Every district must have scientifically validated estimates of available agricultural residues, crop waste and other biomass resources.

Second, biomass allocation must accompany project approvals. Ideally, only one ethanol or CBG plant should be permitted within approximately a 100-kilometre radius so that feedstock availability remains commercially sustainable.

Third, India urgently needs an organised biomass collection ecosystem.

Today, most biomass consists of agricultural residues generated during harvest. Farmers often have less than fifteen days before preparing land for the next crop, leaving little time for organised residue collection. Consequently, stubble burning remains the easiest option.

Mechanised biomass aggregation systems can eliminate this problem. However, these systems require significant capital investment. Entrepreneurs therefore seek government assistance for biomass collection infrastructure. Existing platforms such as the Dharani portal also require significant modernisation. India should establish a real-time national biomass repository incorporating GIS-based mapping, traceability systems and digital inventory management. Such a repository would guide optimal plant locations, reduce transportation costs and improve feedstock availability. Ultimately, biomass allocation policies, aggregation infrastructure and digital traceability should function together as a single integrated ecosystem.

India's biofuel ecosystem still depends heavily on policy support, including assured offtake and administered pricing. How can the sector transition from a subsidy-driven model to a market-led one without jeopardising investor confidence and future capacity additions?

The transition towards a market-led ecosystem will primarily depend on technological maturity rather than subsidy withdrawal. Many biofuel technologies currently remain at Technology Readiness Levels (TRL) 3 to 5. Scientific proof exists, but commercial-scale deployment remains limited. India therefore requires stronger public-private partnerships in research and development to accelerate technology maturation.

Another major challenge is capital expenditure.

For example, second-generation ethanol plants require substantial upfront investment. Indian Oil's 2G ethanol facility in Assam illustrates how high capital costs can delay breakeven even after successful commissioning. Future projects therefore require innovative engineering, value engineering and improved EPC execution models capable of reducing capital costs without compromising efficiency. Carbon markets represent another critical missing component.

The government has recently permitted qualifying second-generation ethanol with verified carbon footprints to access export markets. However, domestic carbon trading mechanisms remain under development. Entrepreneurs investing in biofuel projects should be able to monetise carbon credits generated through emissions reductions. A robust carbon credit market would provide an entirely new revenue stream, improving project economics and attracting private investment. The faster India operationalises carbon trading, the sooner private capital will accelerate biofuel investments.

As global markets increasingly demand low-carbon fuels with traceable sustainability credentials, how important are carbon accounting, lifecycle emissions standards and sustainability certification for India's biofuel ambitions? Is India moving fast enough on this front?

Carbon accounting and lifecycle assessment are rapidly becoming prerequisites for participating in international biofuel markets. Europe, particularly under CBAM-related sustainability frameworks, is likely to become India's largest export opportunity for green fuels. Meeting these requirements will demand rigorous lifecycle emissions assessments and internationally recognised sustainability certification.

India has already begun moving in this direction.

Projects such as AM Green's upcoming green ammonia facility in Kakinada have already obtained internationally accepted sustainability certifications and lifecycle assessments, positioning them to serve European markets. Nearly five million metric tonnes of green biorefinery capacity are also under planning. While North America's momentum for green fuels has moderated following recent policy changes, Europe continues strengthening sustainability standards. India therefore needs to accelerate development of transparent carbon accounting systems capable of satisfying increasingly stringent international certification requirements.

The conversation around biofuels is increasingly expanding beyond ethanol and biogas to include sustainable aviation fuel (SAF), green methanol and advanced biofuels. Where should India place its strategic bets over the next decade, and which technologies are closest to commercial scale?

Sustainable Aviation Fuel represents India's next major biofuel opportunity. Under ICAO's CORSIA framework, emissions reductions for international aviation become mandatory beginning in 2027. Our recommendations propose initiating SAF blending at one percent in 2027 and gradually increasing to five percent by 2030.

Several ASTM-approved pathways exist for SAF production. Currently, the HEFA pathway remains the most commercially mature. Feedstocks include used cooking oil, vegetable fatty acids and non-edible vegetable oils. This route requires minimal additional capital expenditure and could comfortably meet India's initial one percent blending requirement. However, India currently lacks sufficient domestic feedstock and may initially depend on imports.

Another promising pathway is Alcohol-to-Jet (ATJ), which converts ethanol into aviation fuel. This route offers tremendous long-term sustainability benefits because India possesses growing ethanol production capacity. However, ATJ technology has not yet reached commercial maturity, and no commercial-scale facilities currently exist. Another emerging pathway combines captured biogenic carbon dioxide with green hydrogen to produce green methanol, which can subsequently be upgraded into SAF. Although scientifically promising, these technologies remain at demonstration stage. Regardless of production pathway, SAF will initially cost nearly twice as much as conventional aviation fuel. Nevertheless, regulatory mandates beginning next year will drive gradual market adoption.

Looking ahead to 2035, what is your vision for India's biofuel sector? What are the three policy decisions that India must take in the next five years if biofuels are to become a durable pillar of the country's energy transition and a meaningful contributor to net-zero ambitions?

By 2035, India has the opportunity to become one of the world's leading integrated biofuel economies.

Achieving this vision will depend on three transformative policy decisions.

First, India must establish a comprehensive National Biomass Repository supported by digital biomass mapping, traceability systems and biomass allocation mechanisms. Feedstock security will remain the single biggest determinant of long-term industry sustainability.

Second, policymakers should create an organised biomass allocation framework ensuring optimal geographic distribution of ethanol and CBG plants, preventing unhealthy competition for limited agricultural residues.

Third, India should mandate greater integration of organic manure into mainstream agriculture. Requiring a defined proportion of nutrient application to come from certified organic manure would create a stable market for digestate generated by CBG plants, improving project economics while simultaneously reducing dependence on chemical fertilisers.

Collectively, these measures would transform biofuels from a policy-supported sector into a commercially self-sustaining pillar of India's energy transition, rural economy and net-zero strategy.

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