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EDITORIAL ANALYSIS

Ethanol Beyond E20: Strategic Choices for India's Energy Transition

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CURATED & WRITTEN BY

Bharat Choudhary

UPSC Educator & Content Creator

linkedin.com/in/epicbharat

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INTERVIEW ANGLE

"India has achieved E20 ethanol blending five years ahead of schedule. Should the next target be E25/E30 via expanded sugarcane + grain feedstocks, or should policy instead pivot to 2G cellulosic ethanol to avoid food-vs-fuel and water-use conflicts?"

Source: Original editorial ↗ The Hindu

EDITORIAL SUMMARY

India has achieved E20 ethanol blending ahead of the 2030 target. Amid the 2026 West Asia crude spike, the case for E25/E30 looks compelling — but sustainability, feedstock choice, and technology lock-in require careful calibration. The next phase of ethanol policy must integrate with EV transition and green hydrogen, not compete with them.

THE E20 ACHIEVEMENT — WHAT IT ACTUALLY DELIVERED

India's **Ethanol Blending Programme (EBP)** — formally launched in 2003 but accelerated post-2014 — crossed its major milestone in **April 2025**: nationwide **E20 availability** (20% ethanol by volume in petrol). The key milestones:

YEAR	TARGET / ACHIEVEMENT
2014	Policy target: E10 by 2022, E20 by 2030
2018	Roadmap revision: E20 by 2025
2019	E10 achieved nationally
2023	E12 average achieved
April 2025	**E20 nationally available** — 5 years ahead of original schedule

Savings Delivered

- **Crude import reduction:** ~6-8 MMT (million metric tonnes) annually
- **Foreign exchange saved:** ~$3-4 billion/year at 2024 crude prices
- **CO_2 reductions:** ~15-18 million tonnes annually (ethanol combustion is not carbon-neutral but lifecycle emissions are lower than fossil petrol)
- **Farmer income:** ~₹70,000 crore disbursed to farmers (cane growers + grain-based ethanol producers) over 2014-2025

Institutional Architecture

- **Department of Food & Public Distribution** — oversees policy
- **Ethanol Blending Programme** — procurement system via OMCs (Oil Marketing Companies: IOCL, BPCL, HPCL)
- **Ethanol Purchase Policy** — annual procurement prices set by inter-ministerial committee
- **PM JI-VAN Yojana (2019)** — promotion of 2G (second-generation) ethanol plants

THE FEEDSTOCK QUESTION — WHERE ETHANOL COMES FROM

Indian ethanol is produced from several feedstocks. The 2024-25 breakdown:

	SHARE	LOCATION
Sugarcane molasses (C-heavy, B-heavy)	~35%	Maharashtra, UP, Karnataka, Tamil Nadu
Direct sugarcane juice / syrup	~25%	Same states
Damaged food grain (rice, maize)	~30%	FCI surplus; Punjab, Haryana, AP
Other (jowar, millets, agri-residue, molasses from distilleries)	~10%	Diversified

The 2022 policy pivot: When sugar prices were globally weak, the government began diverting cane juice directly to ethanol, bypassing sugar production. This gave distilleries guaranteed feedstock and farmers stable cane prices — but deepened the water-intensity problem.

The Water Footprint

Sugarcane is one of the most water-intensive crops in India:

- **1 litre of sugarcane ethanol needs ~3,000 litres of water** (well-to-wheel, including irrigation)
- Maharashtra, where ~40% of national cane is grown, faces recurring drought
- Groundwater depletion in cane belts (Marathwada, Western UP, Karnataka) is among the worst in India

Scaling ethanol from E20 to E30 on existing feedstock would mean **an additional ~4-6 MMT of ethanol production annually** — roughly **equivalent to doubling the water footprint** of the current programme.

The Food-vs-Fuel Concern

The decision to use **damaged food grain** (rice, wheat, maize from FCI's buffer stocks that have deteriorated beyond human consumption grade) is defensible — it uses waste that would otherwise be destroyed.

But increasingly, **fit-for-consumption grain** is being diverted to ethanol:

- **Maize ethanol** is now promoted under NMFP (National Mission for Food Processing) — maize production expanded from ~25 MMT (2014) to ~38 MMT (2024), a portion of the growth directed to ethanol
- **Rice diversion** during surplus years has drawn criticism from food-security advocates

In a country where **~15% of population remains food-insecure** (FAO, 2023) and where PDS reform is a continuing political priority, food-to-fuel conversion carries moral and political risk.

2G ETHANOL — THE SUSTAINABILITY PATHWAY

Second-generation (2G) ethanol is produced from **cellulosic feedstocks**:

- Agricultural residue (rice straw, wheat straw, bagasse, corn stover)
- Forestry waste
- Lignocellulosic industrial by-products

Why 2G Matters

1. **No food-fuel conflict** — uses agricultural waste, not food crops
2. **No incremental water demand** — waste is already being produced
3. **Reduces stubble burning** — Punjab and Haryana burn ~20 MMT of paddy straw annually, causing North India's winter air pollution. 2G plants could absorb this waste at premium prices

4. **Higher CO_2 reduction** — lifecycle emissions 60-80% below fossil petrol (1G ethanol achieves 30-40%)

The 2G Gap

METRIC	INDIA (2026)	BRAZIL (COMPARABLE)	USA (COMPARABLE)
1G plants	~200	~400	~200
2G plants (commercial)	**~5**	~15	~10
2G share of ethanol production	<5%	~12%	~8%

India's five commercial 2G plants:

1. **Panipat (Haryana)** — IOCL's plant using paddy straw (commissioned 2022; ~100 kL/day)
2. **Bathinda (Punjab)** — HPCL (commissioned 2023)
3. **Numaligarh (Assam)** — NRL
4. **Bargarh (Odisha)** — BPCL
5. **Gorakhpur (UP)** — IOCL

Scaling Challenges

- **Capital cost:** 2G plants are ~3x more expensive than 1G (₹1,000-1,500 cr vs ₹300-500 cr)
- **Feedstock aggregation:** Straw from ~10,000 farmers per plant needs organised collection — currently fragmented
- **Enzyme costs:** Cellulase enzymes for 2G conversion are ~30% of production cost; licensed primarily from Novozymes, DuPont
- **Policy ambivalence:** Capital subsidy under PM JI-VAN Yojana (2019) covers ~30-40% of project cost — not sufficient to close cost gap with 1G

ENGINE COMPATIBILITY — THE TECHNICAL LAYER

BLEND	ENGINE IMPACT	STATUS
E10	No modification needed; compatible with all post-1990 petrol engines	Achieved 2019
E20	Minor tuning (injector calibration, compatible fuel lines)	Achieved 2025
E25	Additional tuning; seal and hose material upgrades	Technically feasible in existing fleet
E30	Manufacturer certification needed; older vehicles may face warranty issues	Requires 2-3 year transition
E85 / Flex-fuel	Redesigned fuel system; **Flex-Fuel Vehicle (FFV) required**	Mandatory in Brazil since 1997; under study in India

BS6 (Bharat Stage 6) emission norms, effective April 2020, already anticipate ethanol blending. The auto industry (SIAM) has broadly endorsed E25 as achievable by 2028 with coordination.

The Flex-Fuel Option

Brazil mandated FFVs (Flex-Fuel Vehicles) by 1997 — vehicles that run on any blend from E25 to E100. This decoupled ethanol blending from fleet turnover.

India's route forward:

- **Mandatory E20 compatibility** from 2025 (achieved)
- **FFV pilot** announced 2023; under study by auto industry
- **Full FFV mandate** — not yet decided; likely post-2028

THE TRANSITION STRATEGY — BEYOND ETHANOL

Ethanol alone cannot solve India's energy transition. The broader architecture:

Parallel Tracks

TRACK	PURPOSE	TIMELINE
Ethanol (E20 → E25 → E30)	Short-term crude hedge	2025-2032
EVs — 2W/3W	Urban personal transport	2020-2030
EVs — 4W	Personal and fleet	2025-2035
Public transport EVs	City buses, Metro	2020-2030
Hydrogen for heavy transport	Trucks, long-haul	2028-2040
Green Hydrogen — refinery feedstock	Replace grey hydrogen in refineries	2025-2035
Sustainable Aviation Fuel (SAF)	Aviation carbon reduction	2030-2045

The **National Green Hydrogen Mission (January 2023, ₹19,744 crore)** targets 5 MMT annual green hydrogen production by 2030. A significant portion would substitute grey hydrogen in refineries — reducing crude dependence via a different pathway.

Integrated Rationale

Ethanol, EVs, and green hydrogen are complementary:

- **Ethanol** handles the installed ICE fleet transition (~200 million vehicles today)
- **EVs** handle new urban personal transport
- **Hydrogen** handles heavy transport + industrial use

Pushing ethanol beyond E30 without sustainability guardrails could lock India into ICE vehicles for too long. Pushing EVs without transition fuel for existing fleet creates affordability strain for middle-income consumers.

POLICY RECOMMENDATIONS

Immediate (2026-2028)

- **E25 target by 2028** (not E30 in a rush)
- **Mandatory 2G feedstock share** — rising from 5% to 30% by 2030
- **Water-use caps** on ethanol-focused sugarcane areas
- **End food-grain diversion** beyond damaged/surplus stocks

Medium-term (2028-2035)

- **FFV pilot** — phased introduction starting with government fleet, transitioning to retail
- **Green hydrogen refinery integration** — OMCs to use green H_2 for refining

- **Stubble-burning-linked 2G** — 15+ new 2G plants in Punjab-Haryana-UP corridor

Long-term (2035-2045)

- EV majority share in new vehicle sales (>60%)
- Ethanol transitions to aviation (SAF) and marine fuel markets
- Hydrogen dominates heavy transport

UPSC RELEVANCE

PAPER	ANGLE
GS2 — Governance	PM JI-VAN Yojana; National Green Hydrogen Mission; EBP coordination; inter-ministerial policy
GS3 — Economy	Ethanol economy; farmer income; crude substitution; CAD management; PLI for ACC batteries
GS3 — Environment	Water footprint; food-vs-fuel; stubble burning; agricultural residue use; lifecycle emissions
GS3 — S&T	2G technology; enzyme engineering; FFV technology; green hydrogen production
Mains Keywords	E20 blending, 2G ethanol, PM JI-VAN Yojana, flex-fuel vehicles, food-vs-fuel, water footprint, stubble burning, National Green Hydrogen Mission, energy transition

KEY ARGUMENTS AT A GLANCE

E20 ethanol blending is a real but limited hedge against West Asia crude dependence — higher blending (E25/E30) makes strategic sense only if India simultaneously transitions feedstocks from water-intensive sugarcane to 2G cellulosic sources, and integrates ethanol within a broader EV-plus-hydrogen transition strategy.

✓ **SUPPORTING**

- E20 achievement (April 2025) saved India an estimated 6-8 MMT of crude imports annually (~$3-4 billion at 2024 prices); E30 could double that to 12-15 MMT.
- Current ethanol feedstock mix (~60% sugarcane molasses/juice, ~35% damaged food grain, ~5% others) has a high water footprint — 1 litre of sugarcane ethanol needs ~3,000 litres of water, concentrated in water-stressed Maharashtra, Karnataka, UP.

- 2G ethanol from agricultural residue (rice straw, wheat straw, bagasse) could simultaneously address stubble burning (Punjab-Haryana crisis) and reduce food-vs-fuel pressure — but India has only 5 commercial 2G plants vs 200+ 1G plants.
- E25/E30 requires engine modifications — petrol engine compatibility studies show E25 viable with minor tuning; E85 flex-fuel vehicles require fundamentally different fuel systems, already mandated in Brazil since 1997.

⚠ COUNTER

The ethanol bridge has limits — transport electrification (EVs) is the structural pathway, not a feedstock change. Pushing E30 could lock India into prolonged ICE-vehicle dependence precisely when the global pivot is toward battery EVs and fuel-cell trucks.

→ WAY FORWARD

Phased, sustainability-conditioned expansion: E25 by 2028 (not E30 in a rush); feedstock diversification mandate (2G share >30% by 2030); parallel EV acceleration (public transport first); integrate ethanol strategy with National Green Hydrogen Mission for refinery-feedstock substitution; and rationalise sugarcane cultivation subsidies that currently distort the feedstock economy.

🧠 **PRACTICE TODAY'S QUIZ**

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📣 MAINS ANSWER FRAMEWORK

QUESTION

India has rolled out E20 ethanol blending ahead of its 2030 target. Evaluate the costs and benefits of pursuing higher blending (E25/E30) as a hedge against West Asia supply shocks, and analyse the sustainability trade-offs involved. (250 words)

INTRODUCTION

India's ethanol programme has delivered a rare policy success: achieving E20 (20% ethanol blending in petrol) nationally by April 2025, five years ahead of the original 2030 target. Amid the 2026 West Asia crude price spike, policymakers are naturally asking: should E25/E30 be the next target? The answer

requires separating the short-term crude-savings calculus from the deeper sustainability and transition questions.

BODY

The case for higher blending is straightforward. E20 saves an estimated 6-8 MMT of crude imports annually — roughly $3-4 billion at 2024 prices; E30 could double that to 12-15 MMT, a meaningful CAD hedge in a $120/bbl world. But three structural constraints matter. **First, feedstock sustainability**: India's ethanol production is ~60% from sugarcane (molasses and direct juice), ~35% from damaged food grain (rice, maize from FCI surplus), and ~5% from other sources. One litre of sugarcane ethanol requires ~3,000 litres of water — a staggering footprint in Maharashtra, Karnataka, and UP, already water-stressed. Expanding to E30 on this feedstock base would deepen the water crisis. **Second, food-vs-fuel**: direct diversion of rice and maize from PDS surplus to ethanol raises ethical questions in a country where ~15% of population remains food-insecure (FAO). **Third, technology lock-in**: pushing harder on ethanol risks locking India into prolonged ICE-vehicle dependence at precisely the moment when the global auto industry is pivoting to battery EVs. The deeper strategic answer is to transition ethanol feedstocks to 2G cellulosic sources — agricultural residue like rice straw (solving Punjab-Haryana stubble burning), wheat straw, and bagasse. India has only 5 commercial 2G plants versus 200+ 1G plants; scaling 2G requires capital subsidy reforms, assured feedstock aggregation, and enzyme technology licensing.

CONCLUSION

A phased, sustainability-conditioned expansion — E25 by 2028 with a binding 2G feedstock minimum — captures the crude-savings benefit while avoiding water and food-security harms. Simultaneously, India must accelerate EV adoption in public transport and fleet vehicles, and integrate ethanol with the National Green Hydrogen Mission for refinery feedstock substitution. Ethanol is a bridge, not a destination.

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CURATED & WRITTEN BY

Bharat Choudhary

UPSC Educator & Content Creator

linkedin.com/in/epicbharat

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