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Q6

How can India achieve energy independence through clean technology by 2047? How can biotechnology play a crucial role in this endeavour?

UPSC Civil Services Mains 2025 · GS III · 10 marks · Infrastructure

Infrastructure: Energy, Ports, Roads, Airports, Railways etc.

Core demand of the question

- Define energy independence by 2047 as less import of oil, gas and coal, not a literal zero molecule
- **Show clean-tech paths:** solar, wind, storage, nuclear, green hydrogen, efficiency
- **Place biotechnology:** biofuels, biogas, bio-enzymes, carbon use, not a magic bean

Revision summary

India still imports most of its crude, so 2047 independence means much lower import intensity, not a sealed border.

Clean electricity from solar, wind, storage and nuclear, plus green hydrogen and efficiency, are the main path.

Electric mobility cuts oil only if the grid is cleaner.

Biotechnology helps through biogas, second-generation ethanol from residue, industrial enzymes and less energy-intensive farming.

Fuel-from-food is a poor version of that biotech role.

Introduction

India still **imports most of its crude oil** and a large share of gas. That is a strategic bill as well as a trade bill. **Energy independence by 2047**, the hundredth year of independence, cannot mean that no tanker docks. It can mean that **electricity, cooking and a growing slice of mobility** no longer live or die by a Gulf strait. Clean technology is the tool. **Biotechnology** is one under-sold branch of that tool.

Body

The 2047 path

Independence here is **lower import intensity** plus **secure electrons**. **Solar and wind**, already the cheapest new bulk power in many auctions, must scale with **storage** (batteries, pumped hydro). **Nuclear** gives firm power; small modular talk is still talk until steel is poured. **Green hydrogen** can enter fertiliser and refining, where India now uses grey hydrogen from gas. **Efficiency** - buildings, motors, a modal shift to rail - is the cleanest "source". **EVs** cut oil if the grid is cleaner. Coal will linger in the 2030s; independence is a **direction of travel**, not a 2047 fairy tale of zero coal overnight.

Biotechnology's role

Biotech is not a solar panel. It is **life as a factory**. **Compressed biogas** from cattle dung and crop waste (**SATAT**) replaces LPG and CNG molecules. **Second-generation ethanol** from agri-residue, if it actually works at scale, cuts petrol without eating food the way first-generation cane ethanol can. **Enzymes** make industrial processes run at lower heat. **Algal or microbial** routes to fuels and to **carbon use** are still mostly labs, but they belong in a 2047 story. **GM and gene-edited** crops that need less water or fertiliser cut the **energy hidden in agriculture** (fertiliser is gas-heavy). Biosafety and land-use ethics remain.

A biotech path that only burns food grain is a bad independence. A path that turns **waste methane** into a fuel and **cuts fertiliser energy** is a real one.

2047 will still see some oil. The test is whether India **owns the electrons and the bio-molecules** that can grow.

Flow diagram

Oil gas import -> 2047 lower intensity
Solar wind storage -> 2047 lower intensity
Nuclear hydrogen -> 2047 lower intensity
Biogas 2G ethanol enzymes -> 2047 lower intensity

Conclusion

Energy independence by 2047 means a grid and a fuel mix that lean far less on imported oil and gas. Solar, wind, storage, nuclear and hydrogen do the heavy lifting. Biotechnology adds biogas, residue ethanol and lower-energy farming, if it uses waste more than food.

Facts & figures

Crude import dependence

India has in recent years imported around eighty-five per cent of its crude oil, the core strategic vulnerability.

SATAT

A Union effort to produce compressed biogas from waste as a transport and cooking fuel.

Green hydrogen mission

A national programme to make hydrogen with renewable power for industry that now uses gas-based hydrogen.