Science & Technology · GS - III

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

EXAM YEAR	PAPER	SUBJECT
2025	GS - III	Science & Technology

MARKS	WORD LIMIT
10	~150 words

Answer Hint

Energy independence, renewables, green hydrogen, storage, biofuels, ethanol, biogas, algae, waste-to-energy, synthetic biology, circular economy

Model Answer

Introduction

Energy independence by 2047 requires reducing dependence on imported fossil fuels while creating a diversified, low-carbon and technologically resilient energy system.

1. Clean-technology pathway

India should expand solar, wind, nuclear and hydropower alongside green hydrogen, battery storage and smart grids. Energy efficiency, electrification of transport and domestic manufacturing of clean-energy technologies can further reduce import dependence.

2. Role of biotechnology

Biotechnology can complement electrification through:

1. Advanced biofuels from agricultural residues and non-food biomass.
2. Second-generation ethanol that reduces competition with food crops.

3. Biogas and compressed biogas from organic waste.
4. Algal biofuels and microbial processes for energy production.
5. Biological conversion of waste into fuels and value-added products.
6. Synthetic biology for developing microorganisms capable of producing renewable fuels and chemicals.

These technologies can simultaneously address agricultural waste, pollution and rural employment.

Conclusion

India's energy transition should combine electrons from renewables with molecules from sustainable bioenergy and green hydrogen. Biotechnology can therefore convert biomass and waste into strategic energy resources while supporting a circular and low-carbon economy.

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