India’s Renewable Energy Revolution

For Prelims: **PLI Scheme for Solar Manufacturing**, **PM Surya Ghar: Muft Bijli Yojana**, **PM-KUSUM** , **National Green Hydrogen Mission (NGHM)**, **Ethanol Blended Petrol (EBP) Programme**, **Sustainable Alternative Towards Affordable Transportation (SATAT)**,**International Solar Alliance**, **Green Bonds**, **Critical Minerals**, **Special Economic Zones**, **Waste-to-Energy**, **Loss and Damage Fund**, **Global Environment Facility (GEF)**, **Green Climate Fund**.

For Mains: Factors driving India's renewable energy transition, Major challenges to India’s renewable energy transition and suggested measures to overcome them.

Source: HT

Why in News?

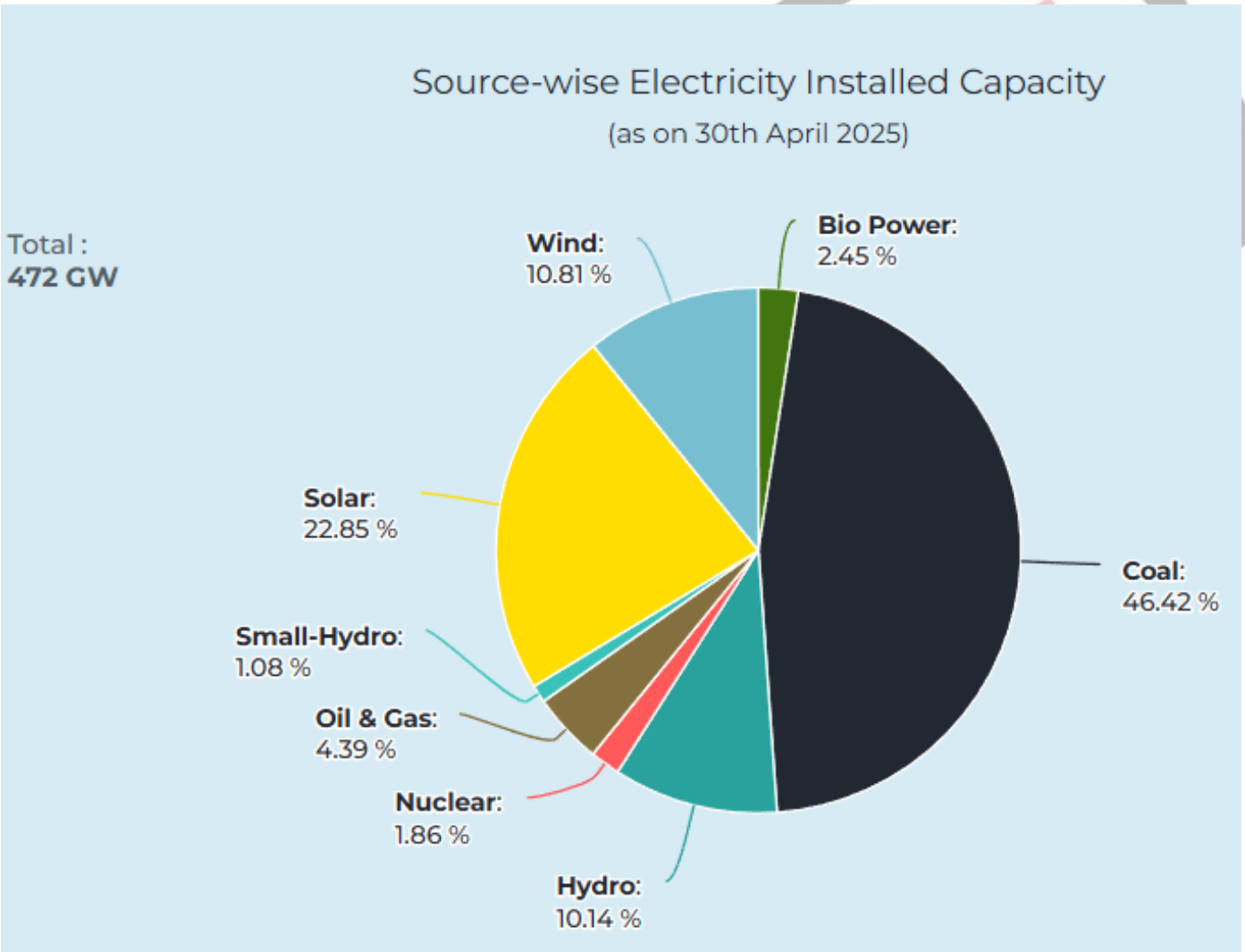
India has emerged as a **global clean energy leader**, adding a **record 29 GW of renewable energy** in the year 2024 alone.

- With **232 GW installed capacity** and **176 GW under construction**, India’s energy transition is driving **global sustainability efforts**, powered by **bold reforms** and **visionary leadership.**

What Is the Current State of Renewable Energy Development in India?

- **Status:** India ranks **3rd in solar**, **4th in wind**, and **4th in total renewable energy capacity** globally. **Solar capacity** surged from **2.63 GW in 2014 to 108 GW in 2025** (a **41-fold increase**), while **wind capacity** has crossed **51 GW.**
  - It aims to achieve **500 GW of non-fossil** capacity by **2030** and **1,800 GW by 2047**.
- **Reforms Undertaken:**
  - **Market-Driven Bidding:** India **replaced feed-in tariffs with transparent bidding**, leading to a sharp decline in solar tariffs from **Rs 10.95/unit in 2010** to **Rs 1.99/unit in 2021.**
  - **Waiver of ISTS Charges: Waiver of inter-state transmission system (ISTS) charges** has removed geographical barriers, enabling **nationwide renewable energy flow**.
  - **Flagship Programs and Initiatives:**
    - Due to **PLI Scheme for Solar Manufacturing**, India's **solar module manufacturing** capacity nearly doubled from **38 GW in March 2024 to 74 GW in March 2025.**
    - **PM Surya Ghar: Muft Bijli Yojana** targets **30 GW decentralized capacity** across **1 crore households**, with **more than 10 lakh houses** already onboarded.
    - Under **PM-KUSUM**, Farmers get up to **60% subsidy** on **solar pumps** under PM Kusum Yojana, ensuring **daytime power and extra income**.

        - The **National Green Hydrogen Mission (NGHM)** aims to produce **5 MMT of green hydrogen annually by 2030**, backed by investments in **Green Energy Corridors** and a robust **2030 transmission roadmap** to ensure efficient grid integration.
        - Under the **Ethanol Blended Petrol (EBP) Programme**, ethanol blending in petrol rose from **1.5% (2013)** to **15% (2024)**.
            - This saved **Rs 1.26 lakh crore in foreign exchange**.
        - The **Sustainable Alternative Towards Affordable Transportation (SATAT)** initiative has commissioned over **100 compressed biogas (CBG) plants** and aims for a **5% CBG blending mandate by 2028.**
- **Emerging Energy Frontiers: Offshore wind initiatives** plan **37 GW of tenders by 2030**, supported by **viability gap funding,** with pilot projects underway in **Gujarat and Tamil Nadu.**
    - **Hybrid and round-the-clock power policy** promotes **wind-solar hybrids** and **firm & dispatchable renewable energy (FDRE)** to develop **24/7 clean energy solutions.**
- **Investment and Global Leadership:** The **International Solar Alliance**, launched by **India**, unites over **100 countries** under the vision of **One Sun, One World, One Grid**.
    - India's renewable energy sector accounted for nearly **8%** of total **foreign direct investment** inflows in the financial year **2024-25**, up from about **1% in FY21**.
    - At RE-Invest 2024, global investors committed **Rs 32.45 lakh crore by 2030** to India's clean energy future.



What are the Key Issues Associated with India's Renewable Energy Sector?

- **Roadblocks in Shifting from Coal to Renewables:** India's transition from **coal to renewable**

energy faces major hurdles, including **heavy dependence on coal for employment and local economies** in states like **Jharkhand and Chhattisgarh**, and an **infrastructure** tailored to **coal-based power**.
    - Further, **policy inconsistency**, such as continued coal plant approvals, **undermines investor confidence in renewables.**
- **Financing Gaps:** To build its targeted **500 GW** of renewable energy capacity by 2030, India needs **Rs 2 trillion in funding annually**—that is **half its entire 2023-24 Union budget.**
    - Additionally, the **high capital costs** for renewable energy infrastructure, coupled with the **relatively slow return on investment**, create a barrier for many investors.
- **Grid Integration & Storage Challenges:** The **intermittent nature** of **renewable energy**, especially **solar** and **wind**, challenges **grid stability**, demanding robust **energy storage** and improved **infrastructure**.
    - As of March 2024, the cumulative **installed energy storage capacity** stood at **219.1 MWh** versus a requirement of **411 gigawatt-hours (GWh)** of energy storage capacity by 2032, while renewable-rich states like **Maharashtra** and **Rajasthan** face high **AT&C losses** of **18.9%** and **18%**, respectively.
- **Supply Chain Vulnerabilities:** China remains India's largest solar cell supplier, accounting for nearly 56% share in FY2024, which also dominates **wind turbine** supplies.
    - India is **heavily dependent on China for critical minerals**, importing **majority** of its **lithium and cobalt requirement**, with **over 70% of lithium sourced from China**, which are essential for manufacturing **renewable energy components**.
- **Land & Environmental Constraints:** The rising **demand for solar and wind farms** brings significant **land challenges**, with **solar power needing 4–5 acres/MW** and **wind energy requiring 2–40 acres/MW**, based on location and infrastructure.
    - The need for large tracts of land often leads to **competition with agricultural use, urban development, and natural habitats,** causing potential conflicts with local communities and ecosystems.
    - E.g., the **Sillahalla Hydro Project (Tamil Nadu)** highlights concerns over **biodiversity loss** and **resettlement**, underscoring the challenge of balancing **clean energy goals** with **social and environmental sustainability.**
- **E-waste and End-of-Life Management Issues:** The growing volume of **e-waste**, particularly from solar panels, poses a significant challenge for **sustainable development**, as improper disposal can release **toxic materials like cadmium and lead** into the environment.
    - As per the **International Renewable Energy Agency**, **India may become the 4th-largest producer of solar panel waste by 2050**.
    - There is **no comprehensive solar recycling policy**, and the **lack of large-scale recycling facilities** poses serious **environmental risks.**

How can India Accelerate Renewable Energy Adoption to Meet Rising Energy Demand?

- **Optimize Land and Water Resources:** Leverage **reservoirs, lakes, and coastal areas** to implement the **floating solar revolution** by installing **floating solar panels** (e.g., **Omkareshwar Floating Solar Park** in MP), which **conserve land**, **reduce water evaporation**, and **improve energy efficiency**.
    - Simultaneously, promote **land leasing** and **agrivoltaics** to enable **dual land use** for **clean energy generation** and **agriculture** through **long-term solar farming leases.**
- **Develop Renewable Energy Clusters:** Establish **Renewable Energy Special Economic Zones (RE-SEZs)** with **streamlined clearances**, **fiscal incentives**, and **integrated value chains** from **R&D to manufacturing** to boost clean energy growth.
    - Promote **Renewable Energy Parks** on **degraded or non-agricultural land** with **integrated transmission access** to optimize land use without impacting agriculture.
- **Leverage Digital and Emerging Technologies:** Adopt **blockchain-enabled peer-to-peer renewable energy trading** to decentralize markets and empower **prosumers**.
    - Concurrently, **invest in smart grids, pumped hydro, and battery storage** to effectively manage the **variability** of renewable energy supply.

- **Expand Renewable Infrastructure:** India can boost renewable energy by installing **Vertical Axis Wind Turbines (VAWTs)** on rooftops to capture urban wind, alongside decentralized solutions like **rooftop solar**, **microgrids**, and **solar irrigation pumps**.
    - These systems enhance **rural electrification**, reduce **carbon footprints**, and provide reliable energy to **off-grid areas**.
- **Promote Waste-to-Energy and Bioenergy:** Develop **Circular Waste-to-Energy Parks** (e.g., **Jamnagar Waste-to-Energy Park**) using anaerobic digestion, gasification, and pyrolysis to convert waste into energy and valuable byproducts.
    - Scale up **biofuels** and **compressed biogas (CBG)** through ethanol blending and SATAT to boost rural income and diversify energy sources.
- **Expand Global Engagement:** India can tap into **global financing tools** like the **Loss and Damage Fund** and **Green Climate Fund** to **secure financial resources** for large-scale renewable projects.
    - Strengthen **technology transfer** through partnerships with **G20**, **International Solar Alliance (ISA)**, and other international institutions to boost renewable energy deployment and technology adoption.
    - India can collaborate with international bodies like **IRENA** to establish global standards for renewable energy, including shared frameworks for **financing**, **technology adoption**, and **capacity building.**

Conclusion

India's **renewable energy push** positions it as a **global clean energy leader**. Despite challenges like **financing gaps** and **grid integration**, innovations such as **floating solar**, **RE-SEZs**, and **green hydrogen** can drive progress toward the **500 GW target by 2030**. This transition supports **SDG 7 (Affordable and Clean Energy)**, **SDG 13 (Climate Action)**, and **SDG 9 (Industry, Innovation, and Infrastructure)**, ensuring **energy security**, promoting **sustainable growth**, and advancing **climate action**.

Drishti Mains Question:

Discuss the key reforms that have enabled India’s rapid renewable energy expansion and their impact on global sustainability efforts.

UPSC Civil Services Examination, Previous Year Question (PYQ)

Prelims

Q. With reference to the Indian Renewable Energy Development Agency Limited (IREDA), which of the following statements is/are correct? (2015)

1. It is a Public Limited Government Company.
2. It is a Non-Banking Financial Company.

Select the correct answer using the code given below:

(a) 1 only

(b) 2 only

(c) Both 1 and 2

(d) Neither 1 nor 2

Ans: (c)

Mains

Q. “Access to affordable, reliable, sustainable and modern energy is the sine qua non to achieve Sustainable Development Goals (SDGs)”.Comment on the progress made in India in this regard. (2018)

Q. Write a note on India’s green energy corridor to alleviate the problem of conventional energy.(2013).