India's Quest for Solar Dominance

This editorial is based on "Solar strategies" which was published in The Hindu Business Line on 20/09/2024. The article highlights India's solar ambitions to achieve 570 GW capacity by 2030, surpassing global commitments, with significant investment and domestic manufacturing initiatives. To meet its full potential, India must accelerate solar capacity additions while reducing reliance on Chinese imports.

For Prelims: Current Status of India's Solar Sector, **Clean Energy**, **Production Linked Incentive (PLI) scheme**, **Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan** , **India's Carbon Credit Trading Scheme**.

For Mains: Significance of Solar Energy Dominance for India,Major Issues Related to the Solar Sector in India.

India's solar ambitions have reached new heights with the recent **REINVEST meet in Gandhinagar,** which garnered **renewable energy** investment proposals totaling **USD 386 billion** and aims to create 570 GW of solar power capacity by **2030**. This ambitious goal puts India on track to surpass its global commitment of **500 GW non-fossil fuel capacity by 2030.** However, to realize India's estimated solar potential of **749 GW**, the country must significantly accelerate its current annual capacity additions of **10-15 GW**.

The push for solar dominance is **not just about clean energy;** it's a strategic move with **geopolitical implications**. India's recent policy shifts, including production-linked incentives for solar cells and modules and the introduction of the **Approved List of Models and Manufacturers (ALMM),** aim to reduce dependency on Chinese imports and bolster domestic manufacturing. While this protectionist approach may lead to higher domestic power costs in the short term, it positions **India as a potential global hub for solar technology production**.

What is the Current Status of India's Solar Sector?

- **About**: India is the 3rd largest energy-consuming country in the world. And, India stands **5th in solar power capacity (REN21 Renewables 2024 Global Status Report).**
  - At COP26, India pledged to achieve 500 GW of non-fossil fuel-based energy by 2030, **part of the Panchamrit initiative**—the world's largest renewable energy expansion plan.
- **Solar Energy Growth:**
  - Installed solar energy capacity has increased **30-fold in the last 9 years, reaching 89.4 GW in August 2024.**
  - India's solar potential is estimated to be **748 GWp (National Institute of Solar Energy, NISE).**
- **Investment and FDI:**

- **100% Foreign Direct Investment (FDI)** is allowed under the automatic route for renewable energy generation and distribution projects, subject to **The Electricity Act 2003.**

What is the Significance of Solar Energy Dominance for India?

- **Energy Independence**: India's push for solar energy is a cornerstone of its quest for energy independence.
  - With the country importing over **80% of its oil needs**, solar power offers a path to reduce this dependency.
  - The ambitious target of **500 GW non-fossil fuel capacity by 2030,** with solar playing a major role.
  - The recent **REINVEST meet in Gandhinagar,** which attracted **USD 386 billion in investment proposals**, underscores the scale of this transition.
  - This shift not only bolsters energy security but also **insulates the economy from global oil price volatility,** as evidenced by the **relative stability of renewable energy prices** during recent **global energy crises**.
- **Economic Catalyst:** The solar sector is emerging as a significant economic multiplier for India.
  - Solar energy sector is projected to generate **3.26 million jobs by 2050**. As of 2021-22, over 29,000 people were employed in the solar sector.
  - The government's **Production Linked Incentive (PLI) scheme** for solar manufacturing, with an outlay of ₹24,000 crore, is expected to add significant manufacturing capacity for fully and **partially integrated solar PV modules.**
  - This not only creates jobs but also positions **India as a potential global manufacturing hub.**
- **Climate Change Mitigation:** Solar energy is at the forefront of India's climate change mitigation efforts.
  - Solar power installed capacity has increased from 2820 MW in March 2014 to **72002 MW in Oct 2023**, i.e. an increase of around 25.54 times, making it the **fifth-largest solar power producer globally.**
  - The recent introduction of **India's Carbon Credit Trading Scheme** further **incentivizes solar adoption,** potentially accelerating the transition and positioning India as a leader in climate action among developing nations.
- **Rural Electrification**: Solar power is revolutionizing rural electrification in India, bringing light to the country's most remote corners.
  - The **Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme** aims to add 30.8 GW of solar capacity by **2026**.
  - Moreover, initiatives like the **Solar Charkha Mission** are empowering rural artisans. These programs n**ot only provide clean energy** but also boost rural economies, **demonstrating solar's potential to bridge the urban-rural divide.**
- **Technological Innovation**: India's solar ambitions are driving significant technological innovations.
  - Indian scientists have indigenously developed **highly stable, low-cost Carbon-based perovskite solar cells** with superior thermal and moisture stability.
  - The **establishment of the National Institute of Solar Energy (NISE)** as an autonomous R&D institution further underscores this commitment.
  - These innovations not **only enhance efficiency** but **also drive down costs**.
    - Solar cells and modules have witnessed price drops of **65% and 50% respectively in 2022,** making solar increasingly competitive with conventional power sources.

What are the Major Issues Related to the Solar Sector in India?

- **Land Acquisition Challenges**: Land scarcity poses a significant hurdle for large-scale solar projects in India.
  - Solar Power Plants occupy at least **5 acres of land per 1 MW output; the** country's 500 GW renewable energy target by 2030 could necessitate over **1.5 million acres for solar**

alone.
        - This demand often **conflicts with agricultural and habitation needs,** leading to social tensions and project delays.
    - For instance, **the 5000 MW Dholera Solar Park in Gujarat faced protests from local farmers,** delaying its implementation.
        - The land issue is further complicated by **India's complex land ownership laws**.
- **Grid Integration and Infrastructure Bottlenecks:** The **intermittent nature of solar power** poses significant challenges for grid stability and management.
    - India's **grid infrastructure**, designed primarily for **conventional power sources**, struggles to accommodate the variability of solar generation.
        - The country's transmission losses stand at about 16.4% as of 2021-22, significantly higher than the global average.
        - Recent **grid failures, like the one in Mumbai in October 2020**, highlight the vulnerability of the system.
- **Financing and Investment Hurdles:** Despite the recent influx of investment proposals, securing consistent financing for solar projects remains challenging.
    - The outstanding dues of electricity discoms dropped by one-third to **₹93,000 crore by May,2023** following the implementation of the Late Payment Surcharge (LPS) Rules in June 2022, but still it is significant creating liquidity pressures and increasing investor risk perception.
    - While green bonds and specialized financial instruments are emerging, with India's first sovereign green bonds raising **₹16,000 crore in 2023**, scaling up these funding mechanisms to meet the sector's needs remains a crucial challenge.
- **Technological Dependence and Manufacturing Gaps**: India's solar sector heavily relies on **imported technology, particularly from China.**
    - Despite recent policy pushes like increased import duties and the **Production Linked Incentive (PLI) scheme**, domestic manufacturing capacity remains limited.
    - The **lack of a robust domestic supply chain** for critical components like wafers and ingots increases vulnerability to global supply disruptions.
        - Post July 2020, **polysilicon price** in the global markets increased from USD 6.8/Kg to USD 43/Kg in November 2021(~6 times increment).
- **Storage and Round-the-Clock Power:** The lack of cost-effective energy storage solutions hinders the full potential of solar power in India.
    - With **solar generation limited to daylight hours**, meeting evening peak demand remains a challenge.
    - The current battery storage capacity in India is **merely 20 MWh,** against a projected requirement of 74 gigawatts by 2032.
    - The high cost of battery storage makes round-the-clock solar power economically viable for many applications.
- **Environmental and Social Impacts:** While solar energy is clean, its large-scale deployment is not without environmental concerns.
    - Solar parks can lead to **habitat destruction and biodiversity loss**.
    - The **Bhadla Solar Park in Rajasthan**, one of the world's largest at **2245 MW,** has raised concerns about its **impact on local flora and fauna**.
    - Moreover, the end-of-life management of solar panels poses a significant challenge.
    - India is expected to generate **34,600 tonnes of solar panel waste by 2030,** yet lacks a comprehensive recycling policy.

What Steps can India Take to Enhance the Viability and Efficiency of Solar Energy?

- **Streamlined Land Acquisition and Innovative Land Use Policies:** Implement a centralized land bank system for solar projects**, identifying and pre-clearing suitable non-agricultural lands.**
    - Introduce a **national policy on agrivoltaics,** incentivizing dual use of land for agriculture and solar generation.
    - Simplify land leasing regulations for solar projects, **allowing for longer lease periods of up to 40 years.**
    - Encourage the use of **brownfield sites,** such as **closed landfills and abandoned**

mines, for solar installations.

- **Grid Modernization and Smart Integration Technologies:** Invest heavily in **smart grid technologies** and energy management systems to handle the variability of solar power.
    - Implement **advanced forecasting tools and artificial intelligence** for better prediction and management of solar generation.
    - Upgrade transmission infrastructure, focusing on **high-capacity interstate transmission** lines dedicated to renewable energy.
    - Incentivize the deployment of **distributed energy resources (DERs)** and microgrids to reduce transmission losses and improve grid resilience.
- **Innovative Financing Mechanisms and Risk Mitigation Tools:** Establish a dedicated **Green Bank for renewable energy projects**, offering low-interest loans and credit enhancement tools.
    - Introduce **solar-specific green bonds** and **climate bond**s to tap into global sustainable finance markets.
    - Implement a **national payment security mechanism** to address the risk of delayed payments from DISCOMs.
    - Create a standardized **solar asset-backed securities** market to improve liquidity for developers.
- **Domestic Manufacturing through Technology Transfer and R&D:** Implement a phased manufacturing program for the **entire solar value chain, from polysilicon to modules.**
    - Establish joint ventures with global technology leaders for knowledge transfer and capacity building.
    - Increase **R&D funding for next-generation solar technologies** like **perovskite cells and tandem modules**.
    - The recent success of the **Indian Institute of Technology (IIT) Bombay** in developing **4T- silicon-perovskite tandem solar cells** with more than **26% efficiency** demonstrates the potential for indigenous innovation, which could be scaled up with targeted support.
- **Comprehensive Energy Storage Policy and Infrastructure:** Develop a **national energy storage mission** with clear targets and incentives for various storage technologies.
    - Implement a regulatory framework that **recognizes and compensates the value of storage in grid stabilization.**
    - Incentivize the co-location of storage facilities with solar plants through additional tariffs or capacity payments.
    - Promote **pumped hydro storage** in suitable geographical locations as a cost-effective large-scale storage solution.
- **Skill Development and Workforce Training Programs:** Establish a **network of solar skill development centers across the country,** focusing on rural areas where large solar projects are typically located.
    - Integrate solar technology courses into ITI and p**olytechnic curricula** to create a pipeline of skilled technicians.
    - Implement a **national certification program for solar installers and maintenance** personnel to ensure quality standards.
    - Introduce apprenticeship programs in collaboration with solar companies to provide hands-on training.
    - The **Suryamitra Skill Development Programme** could be expanded and modernized to include advanced technologies and soft skills training.
- **Water-Efficient Cleaning Technologies and Practices:** Mandate the use of robotic dry-cleaning systems for large-scale solar installations in water-stressed areas.
    - Invest in research and development of **hydrophobic coatings for solar panels** to reduce dust accumulation.
    - Implement **rainwater harvesting systems at solar parks** for cleaning purposes.
    - Promote the use of treated wastewater for panel cleaning in areas near urban centers.
- **Accelerating Rooftop Solar Adoption**: Revamp the rooftop solar ecosystem by implementing a unified, **nationwide net metering policy with consistent regulations across states.**
    - Introduce innovative financing models like **solar leasing and on-bill financing** to reduce upfront costs for consumers.
    - The **Pradhanmantri Suryoday Yojana** seeks to outfit 10 million households with rooftop solar panels.

- For this, simplifying the approval and installation process through a single-window clearance system and standardized equipment ratings is necessary.

Conclusion

India's ambitious solar goals are not only key to achieving energy independence but also critical for **driving economic growth, climate action, and technological innovation.** By focusing on grid modernization, innovative financing, domestic manufacturing, and sustainable practices, India can unlock the full potential of its solar energy sector and become a global leader in renewable energy production. A **comprehensive and balanced approach is necessary** to ensure long-term viability and efficiency in the solar domain.

Drishti Mains Question:

Discuss the role of solar energy in India’s journey towards energy independence. How can India effectively optimize its solar energy potential?

UPSC Civil Services Examination Previous Year Question (PYQ)

Prelims

Q. Consider the following statements: (2016)

1. The International Solar Alliance was launched at the United Nations Climate Change Conference in 2015.
2. The Alliance includes all the member countries of the United Nations.

Which of the statements given above is/are correct?

(a) 1 only

(b) 2 only

(c) Both 1 and 2

(d) Neither 1 nor 2

Ans: (a)

Mains

Q. India has immense potential for solar energy though there are regional variations in its developments. Elaborate. **(2020)**