



SOLAR ENERGY IN INDIA: A BRIGHT FUTURE AMID CHALLENGES: ECOLOGY: PAPER III



Solar energy has emerged as a vital pillar in India's renewable energy ambitions, reflecting the country's commitment to combating climate change and reducing dependency on fossil fuels. With abundant sunlight available for most of the year, India holds immense potential to harness solar power as a reliable and sustainable energy source. Over the past decade, the country has made significant strides in the solar energy sector, yet it still faces challenges that require urgent attention to compete with global leaders like China.

Status of Solar Energy in India

India's solar energy capacity has grown exponentially, transforming it into one of the leading solar power producers globally. From a modest 2.3 GW in 2014, India's installed solar PV capacity has skyrocketed to approximately 67 GW by 2024. This growth reflects the government's strong push for renewable energy and the increasing adoption of solar power across residential, commercial, and industrial sectors.

Projections for the coming years are even more ambitious. India's solar PV module manufacturing capacities are expected to reach 95 GW by the end of 2025, with an overall supply chain capacity, including modules, cells, wafers, and polysilicon, predicted to hit 400 GW by 2028. Such developments align with India's commitment to achieve 280 GW of installed solar capacity as part of its 500 GW renewable energy target by 2030.



Despite these advancements, India's solar manufacturing sector remains a work in progress. A significant portion of solar components, including wafers and polysilicon, is still imported, primarily from China. This reliance exposes the sector to global supply chain vulnerabilities and fluctuating prices.

Significance of Solar Energy

Solar energy plays a crucial role in India's energy transition, offering multiple benefits:

1. **Sustainability:** Solar energy is a clean, renewable source that significantly reduces greenhouse gas emissions, making it an essential tool in combating climate change.
2. **Energy Security:** By harnessing domestic solar power, India can reduce its dependency on expensive fossil fuel imports, improving energy security.
3. **Economic Growth:** The solar sector has created jobs in manufacturing, installation, and maintenance. It also attracts significant foreign and domestic investments, bolstering economic development.
4. **Affordability:** Solar energy has become increasingly cost-competitive. Residential installations, supported by government incentives, offer an affordable alternative to conventional energy sources.
5. **Rural Electrification:** Solar energy provides an opportunity to electrify remote and underserved regions, contributing to social and economic upliftment.

Comparison with China

China dominates the global solar energy market, producing more than 80% of solar components, including polysilicon, ingots, wafers, cells, and modules. Its rise as the largest solar manufacturer began in the early 2000s when it rapidly expanded its export capacity and developed an optimized manufacturing infrastructure. By 2010, China's solar exports accounted for 7,500 MW, a clear indicator of its dominance.

China's production costs are remarkably low at around \$0.15 per watt, compared to \$0.27 per watt in India. This cost advantage stems from several factors:

- Access to rare earth materials and established local supply chains.
- Advanced manufacturing technologies.
- Lower labor and electricity costs.
- Economies of scale due to extensive infrastructure and high production capacity.

In contrast, India lags behind due to higher raw material costs, outdated technology, and smaller production scales. While India has made significant progress in boosting domestic solar



manufacturing, it still has a long way to go to match China's efficiency and global reach.

Challenges for India's Solar Power Production

India's solar energy sector faces several challenges that hinder its full potential:

1. **Dependence on Imports:** A major portion of India's solar components, such as wafers and polysilicon, are imported, primarily from China. This reliance increases costs and makes the sector vulnerable to global supply chain disruptions.
2. **High Production Costs:** Domestic solar modules are 10% more expensive than imported ones. This cost gap reduces the competitiveness of Indian manufacturers, despite government initiatives to promote local production.
3. **Outdated Technology:** India's solar manufacturing sector struggles with outdated technologies, which slow down research and development. Modernizing production processes is essential to improve efficiency and reduce costs.
4. **Limited Domestic Capacity:** India has a limited capacity for manufacturing key components like polysilicon and wafers. Existing facilities often operate below their potential due to low demand for locally produced modules.
5. **Raw Material Costs:** Higher raw material costs and smaller production scales further widen the price gap between domestic and imported solar modules.
6. **Policy Implementation Gaps:** While several policies have been introduced to support the solar sector, challenges in implementation, including delays in subsidies and approvals, remain a bottleneck.

Government Strategy and Programmes

The Indian government has undertaken several initiatives to overcome these challenges and accelerate the growth of solar energy:

1. **National Solar Mission:** Launched in 2010, this mission aims to establish India as a global leader in solar energy by achieving significant capacity additions and promoting domestic manufacturing.
2. **Production Linked Incentive (PLI) Scheme:** This scheme incentivizes domestic production of high-efficiency solar PV modules to reduce import dependency and boost local manufacturing.
3. **Basic Customs Duty:** The imposition of customs duties on imported solar modules and cells is intended to promote domestic production. However, this has also increased costs for developers in the short term.
4. **State-Level Policies:** Several states have introduced policies to encourage solar manufacturing and installations, including subsidies, incentives, and streamlined approval processes.



5. **Domestic Sourcing Mandate:** From April 2026, the government plans to mandate the use of domestically sourced solar cells, aiming to reduce reliance on imports and strengthen the local supply chain.
6. **Investment in R&D:** Significant investments are being made to modernize the manufacturing sector, adopt advanced technologies, and foster innovation.
7. **Affordable Residential Installations:** Subsidies and incentives for residential solar installations have made solar energy more accessible to households, further boosting demand.

Conclusion

India's journey in solar energy reflects its determination to transition toward a sustainable future. The country has made remarkable progress in expanding solar capacity and establishing a domestic manufacturing ecosystem. However, to achieve its ambitious targets, India must address the challenges of import dependence, high production costs, and outdated technologies.

China's dominance in the solar sector serves as both a benchmark and a motivation for India. By leveraging its natural resources, fostering innovation, and implementing robust policies, India can become a global leader in solar energy.

The road ahead requires a combination of efforts, including investments in research and development, vertical integration of the supply chain, and a focus on quality improvement. With the right strategies, India can harness its solar potential to power a sustainable and self-reliant future.

Main Practice Question

"Discuss the challenges faced by India's solar energy sector and critically evaluate the measures taken by the government to address them in achieving its renewable energy targets."

Answer Guidelines

Introduction (40-50 words)

- Briefly introduce India's commitment to renewable energy targets, emphasizing the significance of solar energy in achieving these goals.
- Mention the exponential growth of solar capacity and ambitious future targets, such as



280 GW by 2030.

Body (160-180 words)

Challenges in India's Solar Energy Sector:

- **Dependence on Imports:** Heavy reliance on China for components like wafers and polysilicon.
- **High Production Costs:** Domestic modules cost 10% more than imports, reducing competitiveness.
- **Outdated Technology:** Lack of modernization in manufacturing processes.
- **Limited Domestic Manufacturing Capacity:** Insufficient infrastructure for polysilicon and wafers.
- **Implementation Gaps:** Delays in subsidies and policy execution hinder progress.

Government Measures to Overcome Challenges:

- **National Solar Mission:** Focuses on capacity expansion and reducing import dependency.
- **PLI Scheme:** Encourages local production of high-efficiency solar PV modules.
- **Customs Duty on Imports:** Promotes domestic production while creating short-term cost challenges.
- **R&D Investments:** Modernizing manufacturing processes and fostering innovation.
- **Mandatory Domestic Sourcing:** Ensures local sourcing of solar components from 2026.

Conclusion (30-40 words)

- Summarize by stating that while the government has introduced robust policies, overcoming challenges requires technological innovation, investment in infrastructure, and effective implementation to position India as a global leader in solar energy.