



Clean-Tech Path to Economic Growth

This editorial is based on “[Gaining clean-tech edge](#)” which was published in The Hindu on 18/06/2025. The article brings into focus the potential for India to become a global clean-tech manufacturing leader by leveraging green technology and enhancing testing infrastructure and standards.

For Prelims: [Clean-tech](#), [National Manufacturing Mission](#), [Green technology](#), [Electric vehicles](#), [India's solar module capacity](#), [National Critical Mineral Mission](#), [Alkaline Seawater Electrolyzer to Generate Hydrogen](#)

For Mains: Role of Clean Technology Play in Advancing India's Economic Development, Key Issues Associated with Clean-Tech in India.

India stands at a crucial juncture to emerge as a **global [clean-tech](#) powerhouse**, with the **[National Manufacturing Mission](#)'s** focus on **[green technology](#)** offering a strategic pathway to achieve this ambition. Robust testing infrastructure and enhanced standards development will be **essential for international competitiveness in clean-tech manufacturing**. If executed effectively, this clean manufacturing push could position India as a **global leader in clean-tech trade**, transforming both its industrial landscape and international standing.



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GREEN TECH, CLEAN TECH, CLIMATE TECH: WHAT'S THE DIFFERENCE?



GREEN TECH

- Uses science and technology to protect the world's natural resources
- Reduces negative environmental impact of human activity

Examples:

Renewable energy, sustainable agriculture, eco-friendly products



CLEAN TECH

- Improves performance and efficiency while reducing negative environmental impact
- Includes solutions for clean energy, wastewater treatment, waste management, and more

Examples:

Solar panels, wind turbines, recycling programs



CLIMATE TECH

- Specifically focused on mitigating the impact of greenhouse gas emissions and human-induced climate change
- Includes technologies that help reduce carbon emissions and promote sustainable development

Examples:

Carbon capture, electric vehicles, sustainable infrastructure



What Role can Clean Technology Play in Advancing India's Economic Development?

- **Driving Economic Growth through Job Creation:** As India transitions to clean-tech industries, sectors like **solar, wind, [electric vehicles \(EVs\)](#)**, and battery storage will create millions of jobs, crucial for India's young workforce.
 - The energy transition alone could generate **5-6 million jobs by 2030, and 9-10 million by 2047**.
 - This shift is supported by India's focus on a sustainable economy, which sees the clean-tech sector as a job-rich growth engine, especially in manufacturing, R&D, and project execution.
- **Enhancing Energy Security and Reducing Dependency on Imports:** The push for clean technology **directly reduces India's reliance on imported fossil fuels**, promoting self-sufficiency in energy production.
 - By advancing the **domestic production of solar panels, wind turbines, and battery storage**, India can significantly cut down on energy imports, which currently burden the economy.
 - In 2023, [India's solar module capacity](#) grew fourfold to meet domestic demand, aligning with the PLI schemes for solar and battery production, reducing dependence on Chinese imports.
- **Catalyzing Technological Innovation and R&D Growth:** India's clean-tech revolution is spurring technological innovations, particularly in **energy storage, hydrogen, and battery technologies**.
 - The **National Manufacturing Mission and PLI schemes for electric vehicles** and solar components emphasize R&D to keep India competitive globally.
 - These innovations not only enhance manufacturing but also lead to breakthroughs that can position India as a global leader in clean technologies, creating a robust ecosystem of start-ups, universities, and corporate partnerships.
 - The **Bharat Cleantech Manufacturing Platform launched in 2025** aims to boost R&D collaboration in green technologies, facilitating the **commercialization of advanced energy storage and solar technologies**.
- **Strengthening India's Position in Global Clean Energy Supply Chains:** India's focus on clean-tech manufacturing is transforming it into a global hub for renewable energy equipment production.
 - By leveraging cost advantages in labor and raw materials like **steel, copper, and aluminum**, India can position itself as a strategic partner in global supply chains, tapping into markets with increasing demand for sustainable products.
 - The **"China+1" strategy, where nations look for alternatives to China-based supply chains**, presents a window for India to boost exports of clean-tech products.
 - India's clean-tech exports, **particularly solar PV modules, surged to 5 GW in 2023**, expanding market share in the US and Europe, signaling India's rise as a manufacturing base for green energy equipment.
- **Fostering a Circular Economy and Waste Recycling Industry:** Clean-tech in India is not just about renewable energy but also about creating sustainable solutions for waste management and recycling.
 - Emphasizing **circularity, the clean-tech industry can reduce environmental impact by reclaiming valuable materials** from end-of-life products like solar panels and batteries.
 - With initiatives like the [National Critical Mineral Mission](#), India can tap into recycling to address critical mineral shortages, essential for batteries and solar technologies.
- **Accelerating Urban Sustainability and Green Infrastructure Development:** Clean technologies will play a pivotal role in shaping **India's urban future, addressing energy demands, and mitigating pollution**.
 - By adopting **green building materials, electric vehicles, and sustainable construction methods**, India can lead the way in building eco-friendly cities.
 - India is making significant strides in green building practices, driven by government

policies, green building rating systems like **Leadership in Energy & Environmental Design** and **Green Rating for Integrated Habitat Assessment**, and increasing awareness of the need for sustainable development.

- **Reducing Environmental and Health Impacts:** The transition to clean technology significantly improves public health by reducing pollution and carbon emissions, crucial for a country like India, where [air pollution](#) causes over 1.2 million deaths annually.
 - Clean-tech innovations in **energy, transportation, and waste management** can lower carbon footprints while improving the quality of life for millions.
 - The **EV sales surge in India is a key step in cutting vehicular emissions**, which contribute to around **30% of the nation's air pollution**.

What are the Key Issues Associated with Clean-Tech in India?

- **Dependency on Imported Raw Materials:** India's clean-tech sector remains highly dependent on **imports, particularly for critical materials like lithium for batteries, silicon for solar panels, and rare earth elements for wind turbines**.
 - This dependency **creates vulnerabilities in terms of price volatility and supply chain disruptions**, which could affect the scalability of India's clean-tech goals.
 - Despite efforts to bolster domestic manufacturing, **India still imports 80% of its solar components and 75-85% of batteries**, limiting self-sufficiency.
 - Also, recently **China has imposed export restrictions on seven rare earth elements and magnets** that pose supply chain risks for India.
- **Technological Gaps and Innovation Challenges:** India faces significant challenges in developing indigenous technologies in clean-tech, particularly in advanced sectors like **green hydrogen and high-efficiency solar panels**.
 - While the country has made strides in manufacturing, **it lags behind in critical innovations** that would enable long-term sustainability and competitiveness.
 - For example, [India's electrolyzer technology for hydrogen production](#) **remains underdeveloped**, delaying progress towards green hydrogen goals.
- **Insufficient Infrastructure for Clean-Tech Integration:** While India's clean-tech sector is growing rapidly, the lack of adequate infrastructure—**particularly for grid integration and energy storage—remains a major roadblock**.
 - To manage intermittent renewable energy sources like solar and wind, India needs to **develop robust storage solutions and smart grid technologies**.
 - As of now, **India's grid is underdeveloped in terms of handling large-scale renewables integration**, risking inefficiencies and wastage.
 - **India's renewable energy capacity reached 209 GW in 2024**, yet the inadequate energy storage systems hinder the optimal use of this capacity. To fully harness it, **India will require 336 GWh of storage by 2030**.
- **High Capital Expenditure and Financing Issues:** The capital-intensive nature of clean-tech manufacturing requires significant investment, which has been a significant **barrier for many businesses, especially small and medium enterprises (SMEs)**.
 - Despite initiatives like the PLI scheme, funding constraints remain a persistent issue, particularly for emerging technologies like **green hydrogen and electric vehicle (EV) infrastructure**. This financing gap makes it challenging to scale up production and attract global investors.
 - In FY24, **India secured \$2.4 billion in clean-tech deals**, yet it still faces an estimated **\$12.4 trillion investment need to achieve net-zero emissions by 2070**, highlighting the funding shortfall.
- **Lack of Skilled Workforce for Clean-Tech Manufacturing:** India's clean-tech sector is hindered by a shortage of skilled labor, particularly in advanced manufacturing processes like **solar panel production, EV battery assembly, and carbon capture technologies**.
 - While the National Manufacturing Mission addresses some of these concerns, it **still faces challenges in scaling skilled labor pools**.
 - The renewable industry alone **faces a skill gap of around 1.2 million**, with **demand expected to rise by 26%** creating a need for 1.7 million skilled workers by 2027.
- **Environmental Impact of Clean-Tech Waste Management:** While clean-tech aims to reduce emissions and promote sustainability, the end-of-life management of products like solar panels, wind turbines, and EV batteries poses a significant environmental challenge.

- According to **CEEW**, India is expected to generate **600 kilotonnes of solar waste by 2030**, but without robust recycling systems, this waste could exacerbate environmental degradation.
- The **government's focus on circularity is still in its early stages**, and inadequate waste management could undermine the long-term sustainability of the clean-tech sector.
- **Limited Market Demand for Clean-Tech Products:** Although there is growing interest in clean technologies, the **domestic demand for products like electric vehicles, solar panels, and battery storage systems remains insufficient to drive large-scale manufacturing**.
 - The **success of the National Manufacturing Mission depends on creating sustained domestic demand**, which currently faces challenges due to high upfront costs and limited consumer awareness.

What Measures can India Adopt to Accelerate Development of Clean Technology?

- **Strengthen Public-Private Partnerships (PPPs) in Clean-Tech R&D:** India should focus on creating a robust framework for collaboration between the **government, private sector, and research institutions to accelerate clean-tech innovations**.
 - Public-private partnerships can drive investment in **high-risk R&D, reduce commercialization timelines**, and bring cutting-edge solutions to market faster.
 - By incentivizing private companies to invest in R&D through **tax benefits or matching funding**, India can create a dynamic ecosystem for next-generation technologies like **green hydrogen, advanced batteries, and carbon capture**.
 - Development of **Alkaline Seawater Electrolyzer to Generate Hydrogen By IIT-Madras** is a significant step in the right direction.
- **Expand and Strengthen the Circular Economy Framework:** India must prioritize the development of a circular economy that focuses on reducing waste, reusing materials, and **recycling clean-tech products such as solar panels, wind turbines, and EV batteries**.
 - Establishing comprehensive recycling and reverse logistics systems will reduce the environmental footprint of clean-tech products while maximizing resource recovery.
 - The government can create **mandatory recycling quotas for manufacturers and incentivize businesses to design for disassembly and material recovery**, making clean-tech more sustainable in the long run.
- **Revamp Skill Development for Clean-Tech Industries:** To support the growth of the clean-tech sector, India must urgently invest in upskilling and reskilling its workforce, particularly in high-tech manufacturing and maintenance fields.
 - Setting up **specialized vocational training programs**, industry-specific certifications, and university partnerships will help bridge the skills gap in sectors like **solar manufacturing, battery technology, and electric vehicle servicing**.
 - Aligning these training programs with industry needs will ensure the creation of a skilled workforce that can power the clean-tech revolution.
- **Create an Integrated Clean-Tech Financing Mechanism:** India needs to develop a **dedicated clean-tech financing mechanism** to address the funding gap in clean technology startups and large-scale manufacturing projects.
 - A **combination of government-backed loans, venture capital, and green bonds** can help de-risk investments in emerging technologies.
 - The creation of a **Green Bank or Clean-Tech Investment Fund** could mobilize capital specifically for **clean-tech ventures**, supporting long-term growth and innovation while lowering the financial barriers for startups.
- **Implement Green Procurement Policies at Government and Corporate Levels:** The **government and large corporations must adopt green procurement policies** that prioritize clean-tech products and services in their purchasing decisions.
 - Supporting the **scaling of domestic clean-tech startups and providing them with preferential access to government contracts** will incentivize further R&D and strengthen India's competitive edge in global markets.
 - These policies would not only accelerate the adoption of green technologies but also **create stable market conditions for manufacturers**, helping to scale production and reduce costs.

- **Foster Innovation Ecosystems in Tier-2 and Tier-3 Cities:** To promote clean-tech development across the country, India should **incentivize innovation ecosystems in smaller cities and rural areas**, where manufacturing costs are lower and untapped potential exists.
 - By setting up **clean-tech incubators, providing financial support to local startups, and connecting them to national and global markets**, India can harness the creative potential of regional talent.
 - This decentralization of innovation will encourage inclusive growth and create regional hubs for clean-tech manufacturing.
- **Strengthen International Collaboration for Clean-Tech Export:** India should forge strategic alliances with leading clean-tech markets such as the **EU, the US, and Japan to strengthen its position** as a global clean-tech supplier.
 - This can be achieved by **establishing free trade agreements that include clean-tech components and technologies**, ensuring Indian products gain easier access to international markets.
 - In addition, **fostering collaborations for joint ventures, knowledge exchange, and infrastructure development** will allow India to leverage global expertise and technology to accelerate its clean-tech ambitions.
- **Foster Energy Storage and Smart Grid Innovations:** To effectively integrate renewable energy sources, India must prioritize the **development and deployment of advanced energy storage systems and smart grid technologies**.
 - Energy storage solutions such as grid-scale batteries, **pumped hydro storage, and thermal energy storage** will address the intermittency issues of renewable energy sources like solar and wind.
 - Investing in smart grid infrastructure that optimizes energy distribution, reduces losses, and enhances grid resilience will be crucial in maintaining a stable and efficient energy system.
- **Establish a National Clean-Tech Certification System:** India should introduce a **national clean-tech certification system to standardize and regulate the quality of clean-tech products and services**.
 - This certification can ensure that products meet rigorous environmental and performance standards, giving consumers confidence in their purchase decisions.
 - By creating a trusted certification process, **India can differentiate itself in global markets and help Indian companies gain access to international markets** with strict environmental regulations, such as the **EU's Ecodesign standards**.
- **Enhance Research in Low-Carbon Construction and Green Materials:** With the construction sector contributing significantly to emissions, India must accelerate research into low-carbon building materials and energy-efficient construction methods.
 - Government support for the development of green materials, such as **bioplastics, hemp-based concrete, and bamboo**, could lead to more sustainable urbanization.
 - Alongside material innovation, **promoting energy-efficient building designs, retrofitting programs**, and green building certifications will foster sustainable development in India's rapidly growing urban landscape.

Conclusion:

India's clean-tech transformation presents an unprecedented opportunity to drive sustainable economic growth while contributing significantly to the achievement of **SDGs like Affordable and Clean Energy (SDG 7) and Decent Work and Economic Growth (SDG 8)**. By focusing on infrastructure development, skill enhancement, and fostering a circular economy, India can create a **self-sustaining and globally competitive clean-tech sector**.

Drishti Mains Question:

India is at a crucial juncture to emerge as a global clean-tech manufacturing powerhouse, with its focus on green technology through initiatives like the National Manufacturing Mission. Discuss the potential role of clean-tech in advancing India's economic development.

UPSC Civil Services Examination, Previous Year Question (PYQ)

Mains:

- Q.** Describe the benefits of deriving electric energy from sunlight in contrast to conventional energy generation. What are the initiatives offered by our government for this purpose? (2020)
- Q.** India has immense potential for solar energy though there are regional variations in its developments. Elaborate. (2020)

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